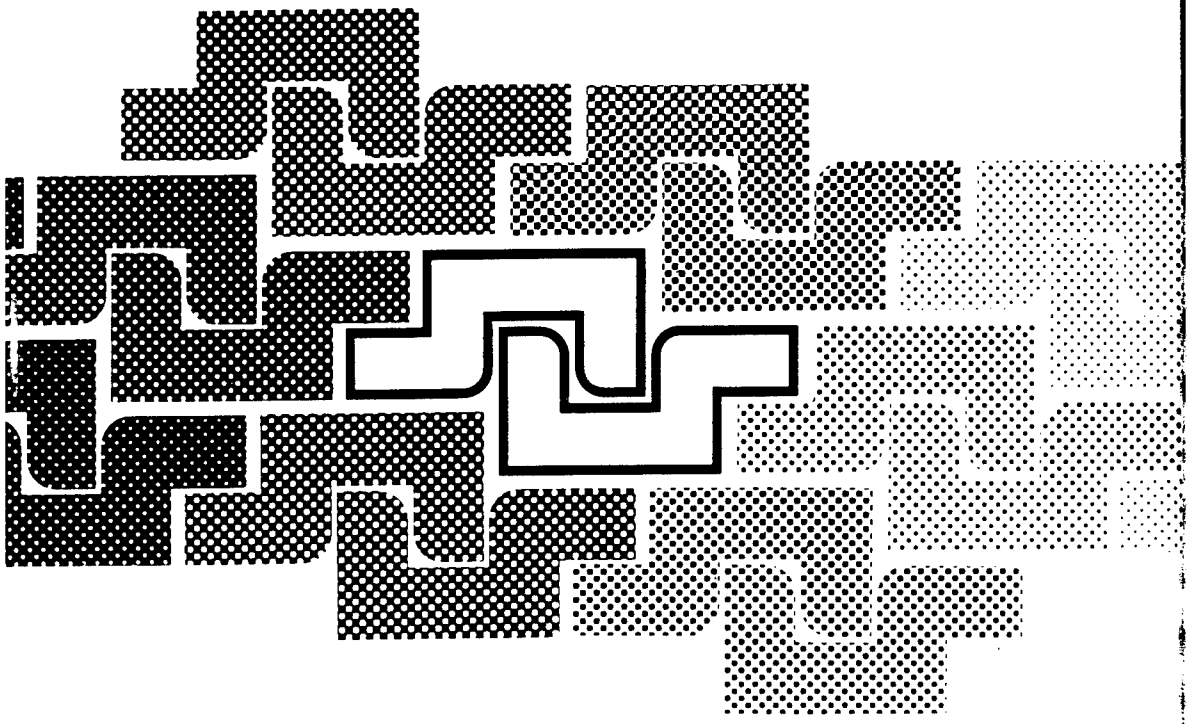


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Defense Conversion Strategies

Edited by

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A North Atlantic Treaty Organization (NATO) Advanced Studies Institute (ASI) on Defense Conversion Strategies was held at the Atholl Palace Hotel, Pitlochry, Perthshire, Scotland, from July 2 through July 14, 1995. The specific aim of the ASI was to identify and study the elements of successful defense conversion strategies through a systematic analysis of the factors influencing them and the common features of specific national efforts. It was to be a combination of theory and practical experience which would explore specific international strategies. The recommendations of the ASI address current approaches to defense conversion in the United States and other NATO countries, the conversion process in Russia and other former Soviet Union republics, and the establishment of a special international committee to deal with the problems of conversion.

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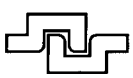
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PREFACE

A North Atlantic Treaty Organization (NATO) Advanced Studies Institute (ASI) on Defense Conversion Strategies was held at the Atholl Palace Hotel, Pitlochry, Perthshire, Scotland, from July 2 through July 14, 1995. This publication is the proceedings of the Institute.

The NATO Advanced Studies Institute program of the NATO Science Committee is a unique and valuable forum under whose auspices over one thousand international tutorial meetings have been held since the inception of the program in 1959. The ASI is intended to be primarily a high-level teaching activity at which a carefully defined subject is presented in a systematic and coherently structured program. The subject is treated in considerable depth by lecturers eminent in their fields and of international standing. The subject is presented to other experts or practitioners who will already have specialized in the field or possess an advanced general background appropriate to the topic. The ASI is aimed at an audience at the post-doctoral level. This does not exclude advanced graduate students or other senior participants with qualifications and achievements in the subject of the ASI or related areas.

This ASI was prompted by several events in the defense environment. The world situation has witnessed dramatic changes in the recent past, as evidenced by such factors as emerging global competitiveness, the declining influence of the military market, the growing recognition that most technology is dual use, the increasing isolation of the military and the civilian technology development cycles, and the increasing dependence of the military on the civilian technology sector. Further, globally, defense-related science and technology were coming under increasing pressure to demonstrate their ability to contribute some value added to national and international economies, which added to the surge in activities aimed at attempting to transfer defense technologies to the civilian sector.

Complicating these attempts at defense conversion is the absence of tested principles on which to base such efforts and any formal training in facilitating the conversion process. As a result, factors such as long-term implications for defense together with a broad range of issues related to economic, political, and social questions are not being adequately addressed. Governments and industries are searching for optimum strategies to guide the defense conversion process without benefit of either historical precedents as models or a complete understanding of the process itself.

It was against this background that this ASI was proposed. Its objective was to identify and study the elements of successful defense conversion strategies through a systematic analysis of the factors influencing them, and the common features of specific national efforts. It was to be a combination of theory and practical experience. Specifically, the ASI attempted to explore the international strategies which stimulate: the conversion of defense technologies to industrial capabilities, global economic growth and stability, the preservation and enhancement of defense technology options, and the ability to capitalize on unique economic, political, and social opportunities afforded by defense technology conversion

The ASI also attempted to respond to an emerging emphasis of NATO to involve nations of the former Soviet Union, especially in a number of institutes dealing with disarmament technologies, the environment, human resources, and selected high-technology areas. These nations, the Cooperation Partners (CP), played a major role in the ASI, as directors, lecturers and participants.

Generally, the problems related to disarmament technologies are perceived to be more acute in the CP nations. For example, in Russia from 1990 to 1993, there was a 47% decline in industrial production and a 38% decrease in GNP. Thus, much attention was given to the situation in the CP nations because of this immediate need for action. As will be mentioned later, the CP participants spoke directly to the difficulties they faced in the processes of conversion, technology transfer, and implementation of dual-use strategies uniquely adapted to their economic development.

While many of these issues were clearly shown to be generic to the process, attention was drawn to the importance of national and cultural differences. At a time of unprecedented global political and economic instability, the collective knowledge and experience of NATO and its Cooperation Partners will be essential to the successful conversion of defense production capabilities to economic tools which can contribute to universal economic equilibrium and prosperity.

The agenda opened with several tutorial lectures on technology, the basics of defense conversion, and the differences between the defense and civilian cultures. This was augmented with historical examples of attempts at defense conversion. Three days were devoted to a full discussion of policy issues, mostly national, that govern the conversion process. This was followed by a series of lectures on the critical role that finance, banking, and venture capital play in the process. Legal protection and legal constraints were then explored, followed by a collective effort to define the measures of success and the barriers to success. The formal program ended with several days of case studies from Western Europe, the CP nations, and the United States.

The pace of the Institute allowed ample time for informal discussion sessions to be organized and scheduled by the participants and lecturers with the encouragement and assistance of the Directors. As the Institute progressed, the interest and demand for these additional sessions grew to the point of consuming most of the unscheduled time. A departure from the normal format of an ASI, and an activity which greatly enhanced this Institute, was the opportunity for the participants to contribute poster papers in two evening sessions. The poster papers remained in place during virtually the entire ASI and served as a catalyst for significant interactions among all of the participants during the breaks. Many of these poster papers were of such a contribution to the purposes of the ASI that they have been selected by the Editors for inclusion in the proceedings.

Of particular note among the unscheduled discussions was a lively and fruitful session organized by several participants from the CP nations. Following several meetings, six of these participants [V. Baryshevsky (Belarus), V. Kuntsevitch (Ukraine), V. Rakhovsky, O. Romanova, L. Rudakov, and G. Zagainov (Russia)] summarized their views on the prospects for international cooperation in the defense conversion process. It is useful here to quote from their summary of these informal discussions:

> A group of CIS participants of the NATO ASI on Defense Conversion Strategies would like to suggest the following proposals, based on the reports presented at the Institute, as well as on informal discussions with the participants.

1. The subject of the current NATO ASI is very important. Now that there is already an experience, both positive and negative, in conversion, reviewing this experience is timely.

2. The approaches to the conversion process have been already formulated in some countries (notably the United States, Germany, France, and the United Kingdom.) There is an understanding that the conversion is an inherent part of the scientific and industrial policy, and that the conversion problems are closely connected with the problems of national security, social problems, and the development of dual-use technologies. Some of the countries have already developed or suggested practical mechanisms for conversion.

It is important that the results of this NATO ASI be summarized as policy recommendations and made available to all interested government bodies of the NATO, Eastern European, and former Soviet Union countries.

3. The conversion process in Russia and other former Soviet Union republics, in practice, led to a very difficult situation facing the military-industrial complexes in those countries. One of the main reasons for that was a background against which the conversion process had been taking place: large-scale changes including democratic reforms, transition to a market-oriented economy, significant decreases in the real incomes of the population, and political instability. Under these circumstances the government, itself unstable, has been unable to implement a consistent conversion program. Without support from the government, the conversion process proceeds in a somewhat disorganized manner.

Since the people who work in the military industry account for about 40% of the CIS population, solution of the most acute problems of the military-oriented industry could make a significant contribution toward political and economic stability in the countries of the former Soviet Union.

Given all that, we would suggest the NATO leadership and the Western governments consider the situation in the CP military industrial complex and undertake some measures which, in our view, will help to diminish the political uncertainty in the former Soviet Union. Such measures might include:

- development of joint programs of conversion. This work must be done in cooperation with the Russian and other CP governments, including the Ministry of Defense.
- more active involvement of various institutions such as the EBRD, OECD, Eximbank, and others, into the conversion process as major sources of investments.

5. To support these initiatives, we would suggest establishing a special international committee, similar perhaps to the AGARD, that would deal with the problems of conversion. Such a committee would include representatives of the NATO countries as well as those of Eastern Europe and the former Soviet Union. The responsibilities of such a committee would include:

- analysis of the situation of conversion in various countries, including the development of models of the conversion process;

- technical support of the conversion programs at national and regional levels;
- technical assistance to enterprises and companies involved in the conversion process;
- analysis of legal barriers that prevent international cooperation in the conversion process;
- developing recommendations aimed at improving the legal environment for the conversion process; and
- providing support to educational programs in management in CP national universities and the supervision of exchange programs.

The major objective of these steps would be to revitalize the relationship between our countries at a new level and to help solve the many social and economic problems our countries face.

The Institute was attended by ninety participants and lecturers representing the NATO nations and the Cooperation Partner nations. A distinguished faculty of lecturers was assembled and the technical program organized with the generous and very capable assistance of an Organizing Committee composed of Miles Faulkner (UK), George Gallagher-Daggitt (UK), Igor Grazin (Estonia), Philip Gummett (UK), and Erno Pungor (Hungary.) A special acknowledgment must be made of the assistance and support provided by Capacity for Research in European Defense Industrial Technology (CREDIT). The Institute was organized and directed by Dr. Anthony K. Hyder (USA), Robert F. Dundervill, Esquire (USA), Dr. Peter F. Gerity (USA), and Dr. Vitaly Bystritskii (Russia). The administrative director of the ASI was Dr. Peter J. Lombardo, Jr. (USA.)

The value to be gained from any ASI depends on the faculty-- the lecturers who devote so much of their time and talents, *pro bono,* to make an Institute successful. As the reader of these proceedings will see, this ASI was particularly honored with an exceptional group of lecturers to whom the directors, organizers, and participants offer their deep appreciation.

We are grateful also to a number of organizations for providing the financial assistance that made the Institute possible. Foremost is the NATO Scientific Affairs Division which provided not only important financial support for the Institute, but equally important organizational and moral support as well. In addition, the following organizations made significant contributions: the Advanced Research Projects Agency Technology Reinvestment Program (US Department of Defense), Argonne National Laboratory (US Department of Energy), the Army Research Office (United States Army), the Ballistic Missile Defense Organization (US Department of Defense), the Center for Continuing Education (University of Notre Dame, US), the Department of Trade and Industry (UK), the European Office of Aerospace Research and Development (US Department of Defense), ICI International (US), the National Technology Transfer Center (US), the Space Dynamics Laboratory (Utah State University US), the University of Notre Dame (US), Utah State University (US), and Wheeling Jesuit College (US). To each of these organizations goes our deep appreciation.

It is a real pleasure to acknowledge the work of the Institute administrative staff whose tireless efforts were critical to the success of the ASI. No words are adequate to express our thanks to Dr. Peter Lombardo, Director of the University of Notre Dame

Center for Continuing Education, for his innumerable contributions to the ASI. It is no exaggeration to say that the ASI would not have been possible without him. And our thanks go also to his assistants at the Institute, Ms. Judy Dean Stewart and Ms. Wendy Wolfe, for their many contributions to the organization of the ASI.

We would also like to thank Mr. Dougal Spaven, the general manager of the Atholl Palace Hotel, site of the ASI, and his gracious wife, Sally, who organized outings for the attendees. They and all of the staff of the Atholl Palace made our two weeks in the Scottish Highlands most enjoyable. Their warm friendliness made all the attendees feel at home, and the Atholl Palace Hotel accommodations, meals, service, and meeting facilities were superb. And to the Tenth Duke of Atholl, our posthumous acknowledgment for the use of the Blair Castle for a magnificent banquet and for an evening that will long remain as a most pleasant memory for all who were there.

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And, finally, all of our thanks go to the people of Perthshire, Scotland, who displayed, in every way, 'Ceud Mile Failte' (Gaelic for 'A hundred thousand welcomes'.)

On behalf of the co-directors and co-editors.

Anthony K. Hyder
Notre Dame, Indiana USA

June, 1996

FUNDAMENTALS OF INTERNATIONAL TECHNOLOGY TRANSFER

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1. Introduction

The term technology transfer appears to have been coined largely in the 1970's. During that time, the concept of technology transfer began to emerge on an international scale and was quickly coupled with efforts to establish global opportunities for cooperation, collaboration, technical exchange and the creation of joint ventures to perpetuate the movement of technologies on a global scale. However, the origins of technology transfer have far deeper roots in our cultures than this recent period in history.

2. Historical Overview

The origins of technology transfer are nearly as old as civilization itself. While our ability to track the early transfer of technologies including fire and the invention of the wheel have been extraordinarily difficult, many other primitive technologies such as the development of metallurgy and the history of explosives and propellants as well as agricultural technologies, including the weaving of fiber, soil tillage and cultivation practices, represent examples of largely traceable technology transfer patterns in the dim and near past. Modern historical perspective seems to verify that peak periods of technology transfer frequently accompany or cluster around the events of warfare. The rapid spread of the sail in naval fleets, cladding of ships hulls with metal, the development of shipboard cannon and the rifled cannon barrel are some of the early examples which were driven primarily by attempts at naval domination through the periods of approximately 1200 to 1900 A.D. During the span of some 700 years these enabling technologies provided the fundamental platform for both international commerce, domestic and international defense and the development of modern commercialization trends as we recognize them today. Without the continuous evolution of these technologies, which ultimately became exchanged through international contact, the development of global trade, world industrialization and economic development could not have occurred on the scale which we experience today.

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In recent times historians, anthropologists and archaeologists have enabled us to piece together the patterns by which emerging technologies have been exchanged from paleohistory periods onward to the present. While a look backward provides an insight to the early origins of technology transfer pathways, processes and procedures, it is not likely to provide a great deal of insight concerning the exchange of technology which is occurring today.

3. The Recent Hundred Years

In order to appreciate technology transfer of the present, it is useful to look back perhaps no more than 100 years. An overview of some events of the past 100 years provides critical points which coincide frequently with regional and global conflict. Numerous examples of technology innovation and application are clustered around the conflicts of the first half of this century. The dates and events leading to WW-I are filled with excellent examples of technology innovation, development and application which saw first light of use in the defense community arena and were embraced by the civilian sector. Some common examples include: 1) the introduction of tracked vehicles or caterpillar-type machines first introduced by the Holt and Caterpillar Corporations, respectively, 2) the application of four-wheel drive technology (4-WD) to wheeled vehicles exemplified by machines such as the Jeffrey-Quad or Nash-Quad 4-WD army truck and 3) the initial introduction of fixed wing aircraft in a surveillance and ultimately a tactical fighter and strategic bombing role. While each of these three technology arenas represents an attempt to address a critical need in time of conflict, all three provide examples of successful, continuous and on-going technology applications to dual use in the greater community beyond the defense sector. Not only can we point to technology transfer succeeding in overcoming the boundaries between initial application and new applications but also in the transfer of this technology among nations during the past 100 years.

4. Conflict and Innovation

It is an interesting exercise to ponder for a moment the development of these three technologies in the subsequent 75 years or so since their initial introduction for warfare up until their use in current times. The history of tracked vehicles began to grow drastically in the time following the end of hostilities around 1920 and began to radically alter the way that industrialized countries began to develop their available land areas. The common and wide-spread utilization of bulldozers or "crawler-type" vehicles in construction, land clearing and to move equipment and machinery into previously inaccessible areas were the hallmarks which generated a continued growth of economic opportunities for many parallel industries such as the timber industry, mining, agriculture, general construction and road building. Looking across the span of time,

these technologies which were first grasped by the civilian sector took permanent hold first in those countries which had exploited this technology initially for warfare. It has taken nearly 75 years for that technology to reach many parts of the world which were not directly involved in the conflicts of the World War I period of history. The use of these tracked vehicles was promoted most rapidly by those who were most ready to receive the technology, i.e. the industrialized portions of the world. It is only during the past thirty-five years that this technology has seen extensive exploitation, indeed perhaps over-exploitation in previously underdeveloped portions of the global community.

5. Parallel Technology Development

During the period from the 1920's until the 1930's, parallel technology development began to occur to address similar problems which utilized fundamentally different technological approaches aimed at solving the same problem; to create vehicles capable of traversing difficult terrain at as high a speed as possible. In Germany, work was underway which resulted in the development of the Volkswagen-based German Scout or command vehicle which indeed utilized not four-wheel drive but rear-wheel drive with the engine positioned directly over the final drive train to provide superior traction to an otherwise conventional vehicle. German development in this period also saw the introduction of the combination of tracked and wheeled drive technologies within the same vehicle. The German Hanomog vehicle typifies this design-type while in the US the hybrid vehicle of tracked and wheeled combined configuration, or "half-track" was designed and developed for Allied Forces by the White Motor Company. However, a look at both of these vehicles demonstrates clearly that their roots indeed evolved much earlier in a design that had been developed, built and demonstrated on an around the world effort by the French Citroen Corporation at a much earlier date. This example of technology transfer demonstrates the concept that convergent technologies may emerge which initially appear to be generated from distinctly separate or individual thought but are indeed evolutionary rather than revolutionary.

6. Introduction of Four Wheel Drive

In the case of the second historical example, the introduction and application of four-wheel drive (4-WD) technology to wheeled vehicles was initiated shortly after the turn of the century with the construction of the Jeffrey-Quad four-wheel drive truck. The initial construction of these vehicles was viewed closely by the military as a way to provide higher speed access to remote areas over varied terrain. The original efforts at building these vehicles proceeded very slowly as the documented need for such conveyances was still viewed in this period with great skepticism. Frequently, ingenious/innovative technologies become stalled as a result of competing with conventional tried and proven

technologies. Competition for four wheel drive vehicles included mundane but proven pack animals such as the mule and the horse.

Frequently, the dominant culture of technology users directly influence and drive the rate at which innovative technology becomes assimilated and disseminated throughout both the directly targeted, as well as ancillary applications arenas. Such was to be the case with the Jeffrey-Quad. Only a small number of vehicles were actually fabricated and commercialized by the Jeffrey-Quad Company for the army. It was soon recognized by a more dominant manufacturing giant of the period, the emerging Nash Motorcar Company, that this technology indeed held promise. The far deeper financial pockets of the Nash Motor Company were able to subsume the Jeffrey patents and absorb the manufacturing know-how to initiate larger-scale manufacturing and production of four-wheel drive vehicles. This in turn, attracted the attention of a strong military personality who recognized the application potential for this emerging technology. A far-sighted individual who recognized the advantages which this tool might provide surfaced within the US Army, and he identified the need to purchase a small number of these vehicles for experimental expeditionary services on a unique conflict front materializing along the US/Mexican border. Today General "Blackjack" Pershing is recognized as one of the more innovative defense community technologists for the first use of four-wheel drive vehicles for troop deployment and munition transport in support of efforts in the Mexican conflict shortly after the turn of the century. It is interesting to note that General Pershing had served as what today would be recognized as a "champion" of the technology for four-wheel drive vehicles. Further examination of the application of this technology reveals that its growth remained incremental in the period from the 1920's until the late 1930's. Once again, the need for fast mobile four-wheel drive vehicles became critical as the events leading to the global conflicts of the late 1930's and 1940's began to unfold.

7. "Dual-Use" and The Jeep Experience

In the late 1930's renewed interest in all-wheel drive vehicles emerged with the now historic competition created by the US Army for the design, development and field test of a 1/4 ton general purpose all-wheel drive vehicle, ruggedized for field use. Initially, approximately 6 vehicle designs were submitted to the Army resulting in approval being issued to three corporations to build prototype vehicles for a field run-off competition to be conducted by the U.S. Army proving ground. Vehicles were submitted by Bantam Motors Corporation, Willys-Knight Corporation and Ford Motor Company. Other designs that were rejected, interestingly enough, and did not come to prototype stage for this program ultimately resulted in a series of heavier all-wheel drive vehicles built on a large scale by the International Harvester Corporation, Dodge Trucks Division of Chrysler Corporation and Studebaker Corporation. In an extremely interesting series of typically unpredictable technology transfer twists and turns, the following scenario resulted from this competition.

Indeed, the Bantam Motors Corporation prototype was designated the most successful design in testing under field conditions as proven by the US Army. The vehicle received the official designation GP or General Purpose which later became contracted to "Jeep." An initial order was placed with the Bantam Motors Corporation for the build of commercial volumes of vehicles. It was soon found that Bantam Motors Corporation had insufficient manufacturing capacity to provide the Department of Defense needs for this vehicle. A license arrangement was then made available nearly immediately to the Willys-Knight Motor Corporation and Ford Motor Company. Of the hundreds of thousands of these vehicles which were manufactured during wartime the Willys-Knight Motor Corporation and Ford Motor Company built the vast majority. Ultimately, Bantam Motors Corporation became subsumed into the newly organized Willys Overland Corporation which survived into the 1950's still building essentially the same product that had been introduced in 1939.

8. Parallel 4-WD Development

During the period following the end of World War II, continued slow commercialization of these technologies persisted. Parallel with the development of these classes of vehicles in Germany and the US, companies in the United Kingdom were pursuing all-wheel drive configurations as well. Examples such as the Humber designed and built all-wheel drive scout vehicles provide numerous examples of high-speed, agile, mobile scout and gun-platform vehicles able to traverse extraordinary terrain while in the service of the British army throughout World War II. The British Austin Company was also active in attempts to produce four-wheel drive vehicles and numerous light four-wheel drive ambulance vehicles were produced for service by Allied Forces during the 1940's. The Austin effort carried on far beyond the war years and was quite successful well into the early and mid 1950's.

However, efforts immediately post-war in the UK saw the emergence of four-wheel drive technology on a large scale with the introduction of the initial prototype Land-Rover vehicles for agricultural use. Ultimately, the success in the market arena of the Rover four-wheel drive systems overshadowed all of the Austin efforts pushing the Austin and other competing technology from the commercial market arena by the mid 1950's.

Up until this of time, the technology employed by the various western nations in commercializing four-wheel drive technology remained remarkably similar in concept, design philosophy and execution. The first to marketplace, the Jeep, achieved nearly global penetration of the commercial marketplace and had established itself firmly by this period of time. The Rover effort followed closely behind with one of the most wide-spread market development examples for any four-wheel drive technology right up to the current time.

9. Ferguson and Full-Time 4-WD Technology Transfer

A unique example of technology licensing taken from the development page of four wheel drive systems introduces a very important concept applied to technology transfer and can be linked to the emergence of contemporary four-wheel drive applications. In the late 1950's and early 1960's the Ferguson developed four-wheel drive systems were undergoing extensive development in the UK for application to both low-speed agricultural and military vehicles as well as some unique applications to extremely high-speed, high-performance racing cars. The Ferguson four-wheel drive system employed many innovative technologies with regard to the manner in which power was divided from front to rear axles in a drive-train as well as left and right sides of the system. This power divider or advanced transfer case system developed and patented by the Ferguson full-time four-wheel drive system formed the basis from which most modern four-wheel drive systems are derived. The Ferguson system was commercialized in only a limited way via low production runs of Jensen- built, high performance vehicles and a one-off Rover LeMans racing vehicle which competed in the 1960's and which also employed innovative gas turbine power. Only a small number of vehicles in the commercial arena actually utilized the Jensen-Ferguson full-time four-wheel drive system. This technology advancement languished through the 1960's until the mid 1970's wherein it was licensed to the then American Motors Corporation in the US for application to the US built Jeep CJ-7 and Jeep Wagoneer models where it was employed from the late 1970's to the present as the "Quadra-Trac" and "Command-Trac" system. This technology was commercialized in a very broad-based way, most successfully by the American Motors Corporation group up through and including the current owners of Jeep Chrysler Corporation, who still employ the base "Quadra-Trac" technology originally licensed in the 1970's from the Ferguson Group.

Once again, this example provides some insight to the relationship between innovation, technology transfer and commercialization over a period of nearly 100 years to bring us to the current time. Today, all-wheel drive systems are employed in an increasingly large percentage of vehicles built on a global basis. Recently, it has not only been utilized for low-speed agricultural, military and construction vehicles, but it has been applied to the high-performance sporting vehicles built throughout the world and is embraced globally today by companies such as Porsche, Audi, Chrysler, General Motors, Ford, Rover, Subaru, Mitsubishi, Isuzu, and most recently BMW and Honda.

10. Aircraft Design and "Dual-Use" Technology Transfer

A third historic illustration of the process of technology transfer began also in the period just after the turn of the century when fixed-wing aircraft became incorporated for the first time in observation or surveillance use by all parties involved in World War I. British, French, American and German forces all utilized bi-plane and ultimately mono-plane technologies in an increasing role during the advent of World War I. Initially, aircraft

were utilized merely as surveillance or observation platforms, ultimately engaging one another in air-to-air combat as well as aerial bombardment and even strategic bombardment as the war continued. The ultimate development and application of this technology continued to be predominantly in warfare and is most easily demonstrated with the events of World War II. In the period from the 1920's, post World War I, up until the 1930's and the events leading to World War II, aircraft saw limited commercial development in the civilian sector. Technology development and transfer was fueled primarily by international aviation racing events such as those provided by Schneider trophy racing through the 1930's. In peacetime, the primary mechanism by which aviation continued to develop was driven by extraordinary publicity events and the world-wide need to demonstrate technology advancement through increased speed and performance of racing aircraft utilized largely in public relations events. The Schneider trophy races as well as the Bendix trophy racing programs continued to provide opportunities to demonstrate and continue the development and refinement of aviation technology during this transition time.

11. International Air Racing and Technology Transfer

Core technologies such as high altitude engine management systems including turbo-charging, super-charging and ethanol injection to enhance overall engine performance at high altitude are examples of evolving technologies of this period. The concominant development of advanced aviation fuels through an enormous chemical industry coordinated effort represent examples of co-development or interdependent technology evolution and innovation. Advances in engine design including liquid cooling systems and the incorporation of glycol under high pressure essential to operation of engines in super-cooled airstreams at high altitude are critical examples of enabling technologies which pushed the development of aircraft rapidly forward. Successful design of efficient and field-hardened cooling systems was a critical element which enabled the high performance characteristics of aircraft such as the ME 109, Supermarine Spitfire and P-51 Mustang which became the dominant fighter aircraft of this era. Each of these aircraft trace their roots to the technology development period between the wars. The fact that these technologies surfaced in three different environments is traceable directly to the technology exchanges which took place during the Schneider trophy cup racing era which permitted mutual examination and observation of systems developed through independent means initially, and ultimately became adapted back to each "home-design" concept and engineering philosophy. It is equally interesting to note that one of the most advanced designs, most frequently copied, and utilized as the base platform for all three of these aircraft is directly traceable to the least successful commercial design which was introduced first during the Schneider trophy races by Aermacchi of Italy.

12. Success and Failure

Once again, technology transfer may provide opportunities wherein technology can be enhanced or improved by those adopting the base technology and can quickly surpass the foundation innovation offered by the original inventor or innovator. As a result of the Schneider cup races aircraft development advanced rapidly in the early days of World War II and became accelerated drastically in the period 1939 through 1945. Experience gained in the development of fighter and multi-engine aircraft during this time became quickly applied to the international aviation arena in the late 1940's and led to the rapid growth of global economies beginning in the mid 1950's and continuing to the present.

Thus, it can be seen that there may be a continuous thread of development and technology growth, expansion and transfer extending over a prolonged period of time. A core technology innovation or idea which represents a breakthrough or departure from the conventional manner in which business may have been conducted previously may take a developmental path that spans a century or more.

13. Definition

The current utilization of the term technology transfer appears to have its origins primarily in the late 1970's. One interpretation of the concept of technology transfer would include the movement of technology, methodology, systems, know-how, goods, services and even individuals across boundaries. These boundaries may include regional, national and international boundaries, and we commonly think of international technology transfer as precisely this type of exchange. However, technologies may also move across fields of use or applications to different arenas as well as the movement of technologies within a corporate structure. In any event, the movement of technology across a perceived boundary such as that defined above will suffice as a general view of the process of technology transfer.

14. Technology Transfer Traditions

Frequently, technology transfer is dependent upon the capabilities of individuals for its success. People are indeed the core by which technology is most commonly moved, transferred or deployed. One of the most frequently utilized methods for technology transfer is the development of technology within an academic environment where advanced research and training may provide the platform for future technology development most often occurring beyond the walls of the academic home of that technology. Subsequently, the traditional way for technologies to move from institutions of higher education or universities is to move the technology by graduating students from the institution and placing them in careers in the private sector outside the walls of the institution. This has probably been the most common system by which

advanced technologies are moved into the private or commercial sector. However, during the 1970's the mechanism by which technology has been deployed from institutions to the private sector became more the subject of newly established pathways by which intellectual properties created within institutional settings are moved out to the larger community or may become shared among institutions.

If one views the process of technology transfer from the period of the 1970's onward, it becomes increasingly apparent that the role of higher education in this process has changed dramatically. Previously, individuals were the main technology transfer export commodity from institutions. Today, it is increasingly the case that institutions play an integral role in developing technology jointly with the private sector and share in the success of those products once commercialized. Typically, technology created within institutional settings will find its initial roots in federal agency sponsorship. Historically, leading edge research often with no immediate apparent application to the commercial sector had been the domain largely of the federal agency structure within the United States and in many western countries. We have seen a transition during the 1970's through the 1990's where federal agency involvement has continued to recede while the expectation has been that industrial support will gradually be incorporated to replace the federal support of this process. This of course has been a chaotic time, if not a historic one, in the transition of technology generation in institutional settings.

15. U.S. Research-I Institutions

During the past ten years evidence of the transition of involvement of universities from one of primarily federal agency support to an increasing mix of industrial and other private sector resources is in evidence. This has largely resulted in the formalization and establishment of offices of technology transfer in virtually all U.S. Research-I Institutions in the United States. These offices typically are staffed by a combination of business development personnel and legal advisors who assist faculty and universities in their interface with the private sector to facilitate technology transfer from the basic sciences to the applied commercial sector.

16. Intellectual Property and The University

The focus of activities within these settings usually includes the establishment of internal guidelines for the institution quite different from those which governed faculty in earlier times. In order to create a successful business development template for these entrepreneurial operations of U.S. universities, increasing emphasis has been placed on patents, copyrights, process technology and know-how as well as the engagement of proprietary protection projects which were heretofore unknown in the academic environment. Appropriate protection for intellectual property has become an extremely high profile segment of activity within our institutions during the past ten years. As can

be appreciated, this transition has not occurred within the institutional setting without great strain since it marks a sharp departure from the activities and focus of universities of the past. Cultural change in the academic environment, and indeed in the corporate environment comes about only in incremental steps. Rarely have we seen change in academe on a scale with that occurring in the current environment. The period from the 1960's through the 1990's has seen an enormous transition in the focus given to technology transfer and applied research within the academic institution setting in the United States. Great academic debates have ensued concerning the appropriateness of these endeavors within academe, with the traditional views vehemently opposed to the more entrepreneurial styles embraced by more progressive faculty and institutions.

17. Technology Transfer Strategies

Within institutional settings, it has become customary to pursue the transfer of technology from agency-based sources to adaptation to the commercial sector. The least successful models of technology transfer usually follow this pattern. In other words, a technology which has been funded out of sources to create base technologies, rarely in the traditional research setting has taken into consideration commercial applications of that technology. Subsequently, the early periods of technology transfer efforts were marked by gross failure since frequently the technologies which had been developed for such basic science purposes rarely were close enough to fruition to enter the commercial sector. Attempting to identify technologies "on the shelf " which also suit routine commercial applications is an extremely counter-productive approach to transferring technology. More often than not the more successful approaches to technology development and transfer have followed a pattern where from the earliest stage of development the industrial or commercial partners are directly involved with the overall technology development program. This will ensure that the technology under consideration is being developed not only to meet its initial objective, which may be in the government or other defense related arena as well, but also applications in the civilian and private commercial sector. In the author's estimation, methodologies which do not take both of these factors into consideration from the outset are doomed to failure because of the effort required, and indeed the capital expenditure necessary to convert a technology from a basic science posture to a commercial application.

In the early days of technology transfer, gross underestimation was given to the investment required to move a technology from the basic science bench to wide-spread scale-up production in the commercial arena. This difficulty still persists today due to the collision of cultures between academic institutions and marketeers in the commercial sector. However, today it is far better understood what order of magnitude of investment is required to convert a technology from one application area to another if the two applications, or dual-use are not considered jointly from the onset of the research and development program. Great efficiencies are captured when technology is co-developed from the beginning by the industrial and academic partners. Further points relating to

this concept will be discussed later in the barriers to transferring technology section of this chapter.

18. Technology Transfer Processes in Academe

Academic research normally is transferred through patents, licenses, copyrights or is conducted under proprietary research contract agreements. Most institutions require disclosure of technologies or concepts via its technology transfer office which will triage the decisions on patent prosecution, copyrighting, trademarking, or gaining other intellectual property protection for its independently developed technologies. Once this decision is reached, the technology typically can be disclosed to external interested parties who may have interest in joining with the university in further development of this technology. Typically, in the case where a patent may be involved, a university may choose to pursue patent protection individually or may share in the cost of gaining patent protection by joining with industry resulting in a shared position relative to ownership of the patented idea, concept, technology or product. Once patents are obtained, typically a license agreement is executed on an exclusive or nonexclusive basis with the commercial partner. Invariably, the technology subject to the license agreement will carry due diligence or performance features permitting mutual evaluation of the technology and the commercialization strategy. The hope is that the commercial partner will be successful in attaining these milestones and therefore limiting the need to identify additional partners for the purpose of commercializing these ideas.

The second most common type of protection used in conjunction with licensing agreements is that of the copyright which normally pertains to books, printed materials and computer software. The control and degree of protection provided by copyrights currently is undergoing enormous scrutiny by both institutions and the private sector due to pressures from the software development community relating to mechanisms to promote and provide shared access and control of copyright materials through software distribution channels particularly in CD-ROM or other related electronic media. As has been observed, international protection of patents and copyrights is a most challenging arena for the legal community and is the subject of content of this text elsewhere.

19. Managing Technology Publication

Many of the technologies being developed jointly with universities currently involve proprietary contract agreements which require mutual nondisclosure documents to be in place for the protection of all concerned parties. In the traditional university setting, proprietary contracts and agreements had been avoided at all costs and were deemed in an earlier time as "unsuitable" for university participation. During the past twenty years there has been an increasing trend among universities to become more intimately involved with the conduct of proprietary research. The traditionalists in the community

still resist this tendency within our institutions, however, it is a landmark feature of the current research environment in most Research-I institutions in the United States. Experience with the conduct of proprietary research reveals that it is indeed possible to conduct such research and accommodate both the teaching missions of institutions as well as the research missions of institutions if the process is managed from the outset in appropriate ways. For example, it is entirely possible to partition the research into basic areas of research which are subject to usual publication in refereed journals and dissemination through traditional scholarly work to accommodate the needs of faculty and the training of graduate students if consideration is given to this factor in the initial contract negotiations. Control on release of this information still may carry a diligence clause where a slight delay, perhaps up to six months, is required prior to the release of such information with the joint oversight of both the commercial as well as the academic partners. However, the final decision under such terms of agreement can be negotiated early on in the contract review stage. Materials which will remain proprietary are set out separately and will remain under the terms and conditions of proprietary information until the proprietary protection period has lapsed. Often this period has become reduced to as little as twenty-four months due to the speed with which technology obsolescence occurs. There may be tendencies in industry to attempt to stretch this period out anywhere from five years to perpetuity. However, the reality is that the commercial viability of such technologies has become shorter and shorter particularly as it relates to the electronics, telecommunications, and computer industries.

Process technology, know-how and proprietary formulation information constitute an extremely specialized area of intellectual property protection and is a far less of a precise science than the protection of patents, copyrights, trademarks and traditional intellectual property. More often than not the transfer of technology on an international level will require vehicles by which know-how, process technology, secret formula and trade secret technologies must be taken into consideration. A variety of mechanisms have evolved during the past fifty years by which such information is both protected and/or shared in order to effect local manufacture of products under international license agreements. A detailed discussion of consideration of these categories of technology will be undertaken further on in this chapter in conjunction with discussion of the creation of joint ventures and strategic partnerships.

20. Post World War II Technology Transfer

Examples drawn from the post World War II era at applying defense technology and know-how to the civilian arena were nearly singly unsuccessful in many areas except those which were noted earlier in this chapter. Many defense contractor community members became actively engaged in attempting to produce consumer products to meet the burgeoning growth of that sector of the economy through the 1950's and well into the 1960's. Perhaps a case study of one of these would be in order where a prominent small arms manufacturer in Springfield, Massachusetts engaged in an attempt to

manufacture consumer home products in the rapidly expanding consumer appliance market of the 1950's. Accordingly, this former defense manufacturer designed and developed a product which was in enormous demand in support of the growing home construction industry developing in that period in the U.S. They selected as their first product a mundane, domestic device known as the washing machine. After enormous investment in engineering, a final product was designed and built and scale-up manufacturing began. It is difficult to conceive that the manufacture of washing machines could possibly have failed in such a growth segment of the economy in America. But characteristically, this product became a noted gross failure for the company. The fundamental reason was rooted deeply in design philosophy where an engineering firm that was used to meeting stringent military specification standards attempted to design a washing machine using the same design philosophy and concept. The device that was ultimately designed, built and offered for commercial sale was over-built, over-weight and over-priced. It nearly required two operators to keep it "field-operational" and it required nearly a half of the kitchen space then available in most of the smaller homes being constructed in America. Although, the device would probably still be operating today if the stringent maintenance schedule had been adhered to by the "household domestic operator," it became rapidly clear that the market targets of price, appeal, ease of operation, size, weight and economy were missed in all respects. Subsequently, the company receded and ultimately disappeared from the commercial and defense community as a viable contractor.

The second example, which relates back to the introductory section of this chapter was played out equally effectively by the Studebaker Corporation following World War II. Studebaker ultimately got the build-contract for the largest number of all-wheel drive, six-by-six army trucks during the war and Wright aircraft engines. Subsequently, Studebaker exited World War II as the single most cash-rich automotive corporation in America. It proceeded to enter the domestic market based on this cash-strong position and to ultimately design a family of vehicles which were far too avant-garde for the commercial arena. Consequently, even the cash-rich position of the Studebaker Corporation could not maintain it far into the 1960's. By this time, its product decisions had committed it to a course from which there was no exit. From this example, it is easy to observe that even a grossly successful military contractor who had provided the platform for many of the vehicles and aircraft engines utilized through World War II could not survive bad management decisions, poor product decisions, and overly exotic engineering solutions to mundane problems. This resulted in corporate failure by the mid 1960's and serves as an excellent example which focuses our attention on the number one drive in technology transfer, ... the marketplace and its identified needs and demands.

21. Dual Use

The second major source of technology transfer frequently is that created by the corporation where pursuit of a particular product may lead to new applications in the commercial arena which were not considered at the outset of product development. Frequently, these may include technologies developed for the defense arena such as those in communications, materials or other related fundamental aspects of military need. Consequently, the concept of dual use in the military arena has become increasingly favored through the mid 1990's in most parts of the world as a result of change in the overall global market environment for defense material needs. Enormous efforts have been underway aimed at adapting existing developed military technologies to the civilian arena under the broad umbrella of dual-use technologies. Indeed, since the onset of the Strategic Defense Initiative (SDI) and now, Ballistic Missile Defense Organization (BMDO), at least one organization was chartered with the dual use mission from its inception, and adheres to the earlier discussed suggestion that technology transfer is most successfully accomplished when dual applications or at least two initial applications are taken into consideration from the concept or development stage. This allows more rapid integration of technology for both intended uses, for example the defense arena as well as the civilian sector. Numerous examples of successful technology transfer out of SDI and BMDO are strong indicators of the wisdom of this approach to technology commercialization and development. Rarely, has there ever been such a grand experiment on an international scale for dual use development in the history of the defense community. Prior to the establishment of SDI and subsequently of BMDO, there had never been a defense program officially charged with dual use development from the outset. This occurrence has provided an extraordinary opportunity for us to explore and exploit commercial technology development with federal government investment and the participation of commercial partners from the earliest possible stage. The template created by this program continues to serve as an example by which dual use commercialization can be efficiently accomplished. Its successes in applying defense technology development to the commercial electronics, communications, transportation, biomedical, optics, materials and other application arenas is a testimony to the methodology employed by this program. When compared to efforts at applying military technology to the civilian sector which were grossly inefficient following World War II, this is a pattern for the future which the author believes will continue to pave the way for future economic development.

22. Technology Transfer and Corporations

Today, it is not uncommon for large defense contractor and other multi-national corporations to look within to transfer technology. This transfer of technology may occur from one division to another typically, or even across corporate division lines on an international scale within a multi-national organization. The automotive industry

provides outstanding examples of this approach to technology and product transfer from international divisions resulting in a product in the "home market" which is outsourced or sourced from numerous captive divisions within a corporative entity. Very few vehicles manufactured on a global scale today owe their engineering design and manufacture to a single country-company based source. Instead, vehicles are assembled from technologies and design concepts emanating from numerous sources both within a corporate structure as well as technologies outsourced through licensing agreements and manufactured at global locations virtually throughout the industrial world. This global exchange and sharing of technology within a single corporation such as that utilized by multinationals in the automotive manufacturing arena include General Motors, Ford, Chrysler, Nissan, Toyota, Honda and most recently Mercedes Benz, Jaguar and BMW. Most often the pattern of technology transfer in this arena occurs within a corporate structure or organization. However, in addition to technologies developed and transferred within a given automotive manufacturing structure, numerous technologies are outsourced from individual vendors who have attained virtual dominance in the fabrication of individual components to meet automotive industry-wide needs. An example of this is the automotive airbag safety device currently fitted to passenger vehicles. Once again, this technology found its roots in the defense explosive and propellants industry and was developed into commercial products predominantly by TRW and Morton International Corporations to provide the rapid gas inflation needs for automotive air-safety bag applications. Consequently, today we observe a great deal of "spin-in" technology development where a technology created for one purpose within a corporate structure may suddenly find further application within its divisional organization or within a market segment within which it is well positioned.

As has been seen, the most common thought of technology transfer model includes that of the "spin-out" or "spin-off" variety where an idea is taken from its core development base to an application outside its normal scope or operating arena. Today, more and more, technology "spin-in" or "spin-on" occurs of the type reviewed for applications within the automotive manufacturing sector.

23. Vehicles for Technology Transfer

The simplest form of technology transfer, whether it is reliant on technology developed initially at a government laboratory, higher education institution or within the private corporate sector, is the direct commercial sale of that technology to an interested party. The direct sale may be a complete one-time transfer of the technology for a negotiated sum, or the technology may be moved under the terms and conditions of a long-term license or royalty agreement. Only a small percentage of technologies seem to be transferred in this mode. More often a technology is jointly developed from the concept stage inferring that the technology will automatically carry some license or royalty arrangement between the innovator and the licensee.

24. The Emergence of Strategic Partnerships

One of the more common vehicles by which technology transfer began to emerge as an industry had its roots predominantly in the creation of "joint venture" strategies achieving particular prominence during the 1970's and 1980's. A joint venture strategy usually meant the development of partnerships in the country of desired manufacture to arrive at local production of a given product. Today, these have become more and more thought of as "strategic partnerships" aimed at selected regional or even global marketplaces. The process by which these have been created from the 1970's until the present usually focused on the identification of a suitable technology for commercialization in a target market, coupled with the identification of a suitable partner to secure mutual funding, manufacture and distribution of products within that market segment. The author participated in the establishment of a number of these arrangements beginning in the mid-1970's and as part of a primer in technology transfer can offer the following insight.

Most often, those new to the arena of technology transfer seek the most complex avant-garde technologies to introduce to the market arena on an international scope. One of the lessons to be learned in the technology transfer arena is that it is not always the case that the "best" or most advanced technologies will gain market posture successfully. One must examine a market carefully and determine at least the initial need for the product within that arena and then begin to identify those who provide the technologies which might successfully compete for that market segment. Often, the organization with the "number one" reputation for product cannot be convinced to enter such a new marketplace. This is typically due to their current dominance in the market arena in the known and identified market fields and occasionally arrogance about either the opportunity or underestimation of the market share which they may ultimately achieve in a global market arena. Frequently, it is necessary to identify second and third-tier technologies for market introduction into critical international markets. The initial task may become one of convincing those with the technology to enter possible new target markets. It is usually easier to convince those with second and third tier technologies to consider this possibility as opposed to those who are the industry leaders. Identification of the technology and interested party is normally only the beginning point for consideration of successful technology transfer. The second decision which must be made is determination of the satisfactory partner in the target market to team with for product and technology introduction and manufacture. This part of the process is, perhaps, the most critical phase regarding technology transfer and successful outcome.

25. Critical Questions for Strategic Partnerships

Most of the time effort and expense devoted to the process of technology transfer should be focused on the careful identification, backgrounding and selection of the international partner to complete the process of technology transfer. Some questions of consideration include:

a. Is the partner strong enough in both financial and political influence in the international market which you have targeted to accomplish those objectives necessary to complete all details relevant to the establishment of local manufacture for these products or technologies?
b. Has there been the establishment of sufficient mutual trust between the potential partners to permit both parties to survive success or failure of this effort?
c. Has there been satisfactory establishment of the relationship between the two key partners to enable them to attain successful cooperative manufacture and distribution of these products?
d. Are there clearly enough established lines of supply for both raw materials and component movement across international borders to permit a uniform, on-going, uninterrupted manu-facturing facility to be established?
e. Are the partners financial pockets deep enough to mutually withstand setbacks which are likely to occur prior to and during the establishment of manufacturing operations?
f. Is there adequate protection for intellectual property, for proprietary materials, process know-how, and secret or trade formulation?

26. Proprietary Property Protection

As was mentioned earlier, mechanisms for the protection of trade secrets, process know-how and proprietary formulation constitute a refined specialization at the international technology transfer level. In the area of technology transfer for pharmaceutical products, certain bio-technologies and other chemical formulations including the most common example, Coca-Cola, the protection of proprietary formulation and know-how rise to the top as considerations for the long-term relationship and success of the joint venture or strategic partnership.

The author was engaged for nearly eight years in protecting such technologies on an international scale on behalf of bio-technology and pharmaceutical manufacturing clients. A generic example of the protection of such know-how is the separation of portions of formulas to be shipped from different sources around the globe into a central manufacturing facility with alternating and continuously changing sites, and the identification of chemical component formulators. In addition to this strategy, another dimension of proprietary formulation protection is added through the introduction of masking agents or compounds to proprietary formulations shipped from such sources as outlined above and continually varied and introduced in multiple permutations so as to stop-gap the analysis and replication of the proprietary portion of a given formulation.

Another strategy which is frequently employed, involves the use of product improvement clauses to ongoing manufacture protocols which force proprietary manufacturing partners to change protocols and procedures under the dictation of the joint venture agreement. These changes in manufacturing protocol are frequently couched in terms of improved product performance, product stability or shelf-life, and therefore

cannot be ignored. This provides an on-going way for proprietary technology protection to be implemented through both minor and major chemical and product formulation changes which require the partners to remain current in meeting all quality control manufacturing standards and specifications for the product group.

While these represent some mundane generic strategies for proprietary product protection, ultimately the most successful protection mechanism is for the joint venture or strategic partners to meet their market goals for product uplift and distribution from the joint venture agreement. Successful market penetration and compliance with mutual financial obligations under any joint venture or strategic partnership must remain the milestones by which the partnership remains viable. Should either partner fail in meeting those obligations it will only provide incentive for one partner or another to consider violation of the international contract, proprietary formulation and other related accords. While this can be a most unpleasant business, it truly provides the only real example by which international commercial protection for technology transfer ultimately remains viable regardless of international patent, license, copyright or other similar law or regulation.

27. Cautions for the Technology Transfer Practitioner

An extremely critical factor in the transfer of technology internationally can be played by an experienced organization accustomed to the business environment of the target country or targeted markets. Frequently, individual technology innovators will attempt to accomplish technology transfer without the assistance of qualified personnel. There can be no substitute for expertise and experienced individuals when it comes to successful efforts to move technology across international boundaries. These experienced personnel may be in the employ of key financial institutions or organizations or may be successful members of the venture community who have succeeded in specific markets previously. In addition, there are a number of specialized firms well postured to deal in the idiosyncracies of individual global markets. Perhaps one of the most critical decisions which can be made in attempting to transfer technology across the international boundary is the selection of the appropriate liaison group to represent the interests of both the technology and the promoter of the technology in the targeted market sector. While no firm rules apply, extraordinary due diligence in checking and verifying the record of such organizations or individuals is extremely critical prior to initiating efforts to introduce technology or product to a foreign market. Selection of such trade representatives to the new market should take into consideration whether the organization is general in nature or specialized particularly in technology areas related to your individual needs. Careful checking of the previous performance record of this organization with regard to deliverables and transfer of financial instruments successfully without major problems evident in their past are considered by the author paramount in the decisions necessary to select a successful partner to assist in the identification of the venture partners, strategic partners, manufacturing partners, marketing partners or others who may be necessary to

complete all steps essential to successful technology transfer. While this is extraordinarily critical for international technology transfer, it may be equally important within domestic markets as well.

In many joint venture environments, complex technologies are being transferred under contractual agreement. In order to ensure smooth transition and successful outcome, it is frequently necessary to consider a fairly long-term involvement and physical presence on the ground in the location of new manufacturing facilities until such time as all manufacturing protocols, compliance standards or quality control specifications have been satisfactorily met. In some instances, an on-going presence may be desirable to continue to coordinate between the partners and to ensure both parties that all operating aspects of the manufacturing organization continue to run smoothly. Thus, even in a situation where the manufacturing and transfer of a technology is done under "turn-key" conditions, those "turn-key" conditions may demand an on-going presence well beyond the initial period anticipated by the technology originator or licensor. These requirements certainly will vary and are highly dependent upon the complexity of the technology involved as well as the individual setting into which the technology is inserted. However, in anticipation of entering into international technology transfer with advanced technology, serious consideration must be given to this aspect of the overall program. Frequently, this is the most overlooked feature of a successful technology transfer program. It is quite common to grossly underestimate the requirement both in time and labor necessary to complete these details in a successful international technology transfer program. The continuous need for a physical presence at the newly established site is considered by the author to be one of the most important aspects of the long-term success and survival of a joint venture or strategic partnership program. The individuals carrying out this portion of the program become among the most critical personnel in the entire process. As is heard so often, technology transfer is a "contact sport," and it must be remembered that those who are in frequent contact must be both technically capable and politically apt for dealing in these unusual settings and circumstances.

28. Problems in Technology Transfer

One of the most common problems encountered in the transfer of technology revolves around the styles, personalities and behavioral characteristics of the technology initiator or originator. Rarely is it the case that the originator of the technology is capable of carrying out all aspects of the endeavor necessary to move the technology into the commercial arena. This fact most often is overlooked by the originator or inventor of the technology, and frequently is the primary cause of the demise of the technology prior to successful transfer. In most instances, the earlier that marketing and management personnel can become afforded and involved in the development and commercialization of technology, the higher the probability for success. Regarding this subject, there is an old adage which says "the people with whom you start in technology transfer and company

building are not the people with whom you finish." Rarely does this old adage become controverted. Thus, it is seen once again that the individuals associated with the technology become the most critical element, particularly in the early stage of entrepreneurial development. It is equally true that those who are naturally and successfully entrepreneurial rarely are adept at the long term overseeing of technology marketeering once the program has become successful. Again, another old adage identifies two classic types of personal behavior, one of the "pioneer" and the other of the "settler." As has been seen, the pioneering or entrepreneurial type individual is rarely suited for the long term management and oversight of operations which have become "non-dynamic" in their view. Their perception is that their work is complete, and that the "settlers" who tend to be extraordinarily competent at this aspect of the business should move in and take over at this stage. Probably, two contrasting personality types which illustrate this best would be to compare a CEO or President of a start-up $5 to $30 million dollar corporation to the accountants who oversee the books for that operation. The CEO or President who took it from $0 to $30M certainly is of the "pioneering" spirit. Whereas, the accounting department would more represent the settlers of the organization. Needless to say, there are many variations in this pattern, but this simplified example may serve as a guideline for looking critically at the individuals who are chosen to become involved in the process.

As with all endeavors, the experience of the individuals and successful track record of accomplishment related to the technology development program at hand is critical. In the early days of technology transfer activities, it was assumed that individuals who had been successful in virtually any area of business could successfully transfer that experience and expertise directly to any other technology transfer program. In the author's observation this was a commission of a "type-I error" as statisticians often refer to it, and frequently leads to disastrous outcome. It is most desirable to select individuals for both their type as outlined above, as well as their general technical acumen regarding the subject technology that is to be transferred.

One final thought to ponder along these lines, it is the author's belief that it is easier to make a good solid businessman into a reputable engineer than it is to convert most engineers into solid and successful business personnel. In other words, it is possible for a bright, capable, successful business entrepreneur usually to learn a sufficient amount of vocabulary, technical jargon, and to develop adequate insight to the operation of the technology to at least fairly represent that technology in the business environment. Most frequently, it is very difficult to convert a technologist in such a manner that this individual is capable of presenting the technology in a way that is clearly understood within the business community.

29. Additional Barriers to Technology Transfer

Another frequently encountered problem with technology transfer of advanced products is that the products are usually incomplete. Most often the product resulting from avant

garde technology may still require grossly more investment in time and resources to become completed than is originally estimated by the technology innovators or potential marketeers. A critically important element of successful technology transfer is to fully understand the state in which the technology currently exists. Even though it may appear that the technology is ready for the marketplace, numerous additional steps inevitably will be required before completion of commercialization. These may range from minor field evaluations of the technology under certain conditions, or they may extend to extensive compliance requirements placed on the technology in the newly identified markets. The extremes of this are exemplified by pharmaceuticals and biomedical devices entering new markets. Lesser examples would focus on automotive products entering a different climatic condition or set of circumstances where comprehensive testing has been inadequate, thus, resulting in frequent field failure of units deployed in that market. This is perhaps one of the most frequently occurring and common types of problems associated with technology transfer. Many of us may have personally experienced this in our selection of automobiles over the past years. Consequently, the completion of a technology may require far greater investment than is initially anticipated. This may be one of the most frequently overlooked and singly most critical elements in moving technology into the commercial arena.

One of the most significant difficulties associated with technology transfer in the international climate includes that of cultural barriers. Examples of cultural barriers might include certain practices, customs and traditions which have been a long standing part of a given society. For example, in the 1970's the author was engaged in an attempt to introduce minimum tillage technology in parts of Eastern Europe for the purposes of cultivation of maize in a much more fuel efficient system. The cultural dictate for the preparation of a seed bed for the planting of maize in that part of the world demands that the soil be worked until it is powdery and very much like that which you would have in your garden at home. This has become the accepted cultural norm and therefore the target of evaluation or "benchmark" as to how well the soil is prepared prior to the planting of maize. When one considers that the scope of our operation was approximately 1.7 million hectares of land area, to achieve this with modern equipment poses an extremely costly and inefficient measurement of success. The cultural norm had required approximately six to seven individual passes of trail-behind implements over the surface in order to deem it satisfactorily prepared for the maize planting operation. Technology which basically could provide successful planting of the crop in two passes over the surface was introduced in an attempt to drastically reduce the fuel intensive operations associated with maize cultivation on this huge land area. After a period of nearly three years of attempting to introduce minimum tillage approaches to soil preparation in this area, efforts targeted at introducing the trail-behind implements to accomplish this, and efforts to demonstrate this technology were abandoned by the company. The barriers among the traditional agronomists of the country were far too powerful of a force to overcome in spite of repeated demonstrations of enormous efficiency gain and increased productivity on the demonstration land areas. Once again, this illustrates that severe

local conditions, cultural overlay and related barriers may indeed impede even the best technology introduction within a market arena.

30. Conclusion

Finally, one of the most critical steps in moving technology across international boundaries relies most heavily on the ease with which currency can move across that same boundary or barrier. Banking stability, economic conditions and willingness of financiers to place venture funds at risk in a given region of the world are finally going to be the determinants which drive or eliminate the opportunity for successful technology transfer in a given target. In our continuously evolving and changing socio-political and economic environment these judgments, opinions and positions regarding availability of funding will continue to be shifting targets. It appears to the author that the increasing global instability will continue to provide both significant opportunity for extraordinary commercial development and success, as well as exceptional opportunity to fail as a result of the difficulty in forecasting and predicting instabilities and their patterns in many areas of the world. Thus, the business of technology transfer will remain one for the "pioneers" and not the "settlers."

DEVELOPMENTS IN THE DEFENSE CONVERSION CONTEXT

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1. Introduction

This paper aims to set the scene for the more detailed discussion of defense conversion strategies that will follow. It does so by addressing the following issues:

- The effects of the end of the Cold War on military planning;
- The consequences of those effects on defense equipment development and production;
- How companies have responded to those consequences; and
- The implications for this discussion of important changes that are taking place in the relations between technologies of defense and of civil origin.

The discussion is deliberately general and, in places, a little sweeping. This is done in the spirit of identifying themes and issues for more detailed and critical presentation and analysis in later sessions.

2. Effects of the End of the Cold War on Military Planning

At least as seen from the perspective of a west European, the end of the Cold War reversed the logic that had applied to defense planning during the preceding four decades. The old logic began from the premises that Soviet conventional forces could not be matched by NATO forces already on the ground in Europe, and that reinforcements from the USA could not arrive before NATO forces in Europe were over-run. Hence, it was argued, NATO needed to be in a position to resort to nuclear weapons at an early stage in any conflict, in order to deter conventional attack.

With the treaty on Conventional Forces in Europe, parity between NATO and WTO forces was established, by means of asymmetrical force reductions. With the further break-up of the WTO and then of the Soviet Union itself, the old imbalance was reversed. [Fig. 1]. That is to say, with the implementation of the reductions agreed in the CFE

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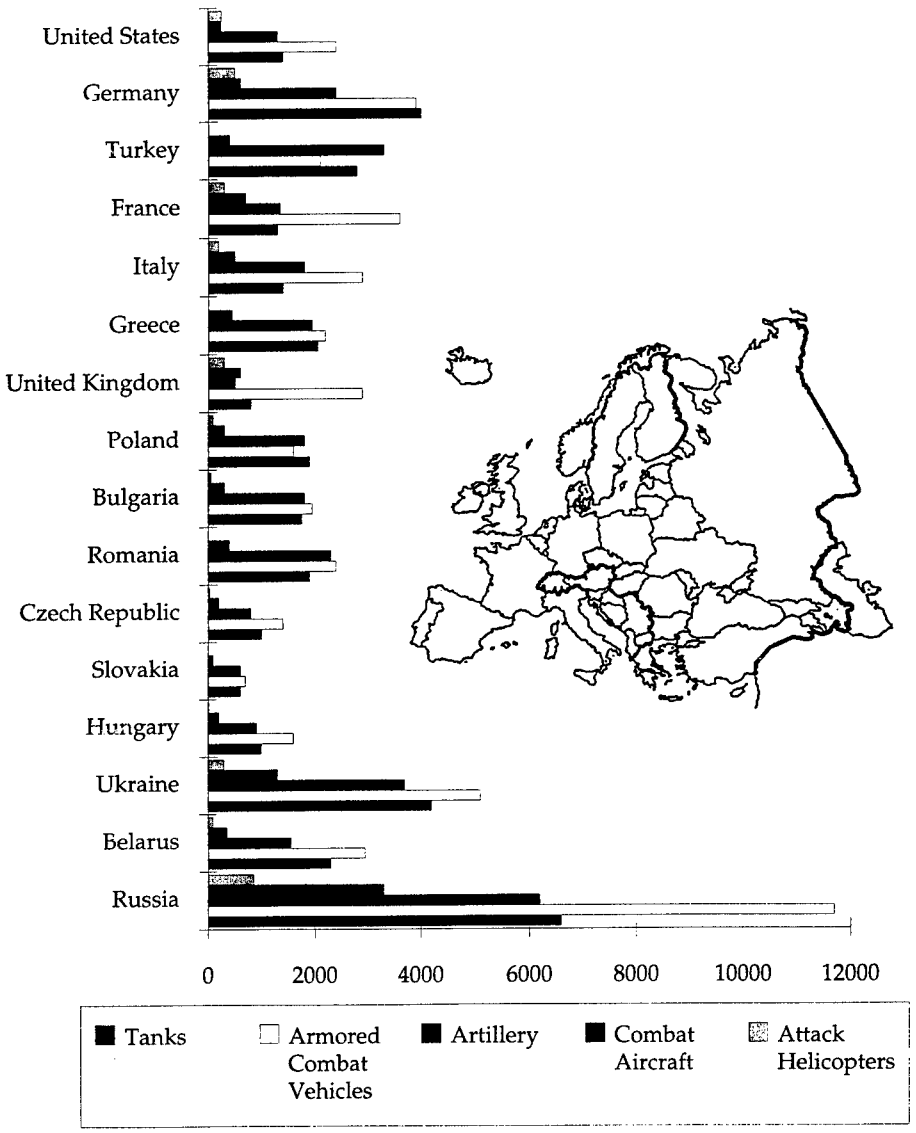


Figure 1. Conventional forces in Europe

treaty, it is NATO, and not longer Russia, that will have superiority in conventional forces in the territory between the Atlantic and the Urals.

At the same time, new types of military intervention have arisen. It has become decreasingly likely that countries will intervene alone against other states (at least outside clearly recognized traditional spheres of influence), and increasingly likely that they will

do so in cooperation with others, typically under the auspices of the United Nations. This has been the pattern in Iraq and in former Yugoslavia. Yet the fact that such interventions depend upon international political legitimation makes them sensitive to the currents of international politics. Moreover, the fact that they also depend upon conceptions of national interest, or international responsibility, that are remote from the immediate concerns of the citizens of the intervening countries, makes them equally sensitive to domestic political support, which can wane rapidly in the event of significant casualties among that country's own armed forces, or among civilians caught in the line of fire.

From a west European perspective, therefore, we can suggest that, until the late 1980s, the size and shape of defense activities reflected the specific geopolitical circumstances of the Cold War. As these circumstances changed, the defense sector suffered not just a loss of demand, but a loss of coherence. The military strategies and force structures pertinent to defending against massed attacks from the East lost their relevance. It became less clear how to organize military forces in response to the more diffuse set of risks that have emerged. Defense planning has become extremely difficult. The problem is not eased by the complexity of international organizations that are now at work on these questions, and the lack of congruence among their memberships. [Fig. 2].

A particular difficulty that all countries face is that of identifying requirements in a coherent fashion, and then of finding the necessary funds at a time of public pressure for cuts. When 'the threat' came clearly from the Soviet Union, it was possible for west Europeans or for the USA to plan fairly straightforwardly. Moreover, because of the scale of forces assembled to deal with that threat, lesser defense problems could be managed with some configuration of forces drawn from the large total. But the single large threat has now been replaced by multiple smaller, but less clearcut, 'risks'. Not only is it difficult to know what to plan for, but the forces available will be much smaller than in the past, thus reducing the scope for withdrawing elements of the total to meet particular eventualities. If it could be confidently assumed by each country that it would meet all conceivable eventualities in the company of the same fixed set of allies, then a division of labor might be agreed. But even this seems implausible at present. Hence the profound uncertainty that defense planners face and, by extension, those responsible for planning defense research and development (R&D).

3. Consequences for Defense Equipment Development and Production

It is important to note that even before the arrival onto the international stage of Mr Gorbachev, there was clear over-capacity in most regions of the world in the arms industry. National variations in the degree of exposure of defense industries to market forces, and the specific arms procurement programs in each country, influenced the rate of response in individual cases. But the overall trend was clearly towards reductions in defense spending [Fig. 3] and in defense equipment spending [Fig. 4].

Expenditure on defense research and development, however, at least in the west, fell at a lower rate than the reduction in overall defense spending. [Fig. 5]. An overall

estimate for western Europe is that since 1990, defense procurement has gone down by about 30%, while expenditure on defense R&D is down by more than 10% [4].

Thus, in the USA, the ratio in 1985 of $1 spent on R&D for every $3 on procurement, was expected to change by 1995 to a ratio of less than one to two [33].

Similarly, in the British case, defense R&D is planned to fall between 1987 and the turn of the century by about one-third. However, within this total, defense research is expected to fall by only 15 per cent by 1998 [5]. Spending on defense as a whole, in contrast, is expected to fall by 14% in real terms between 1992-93 and 1996-97 alone [23].

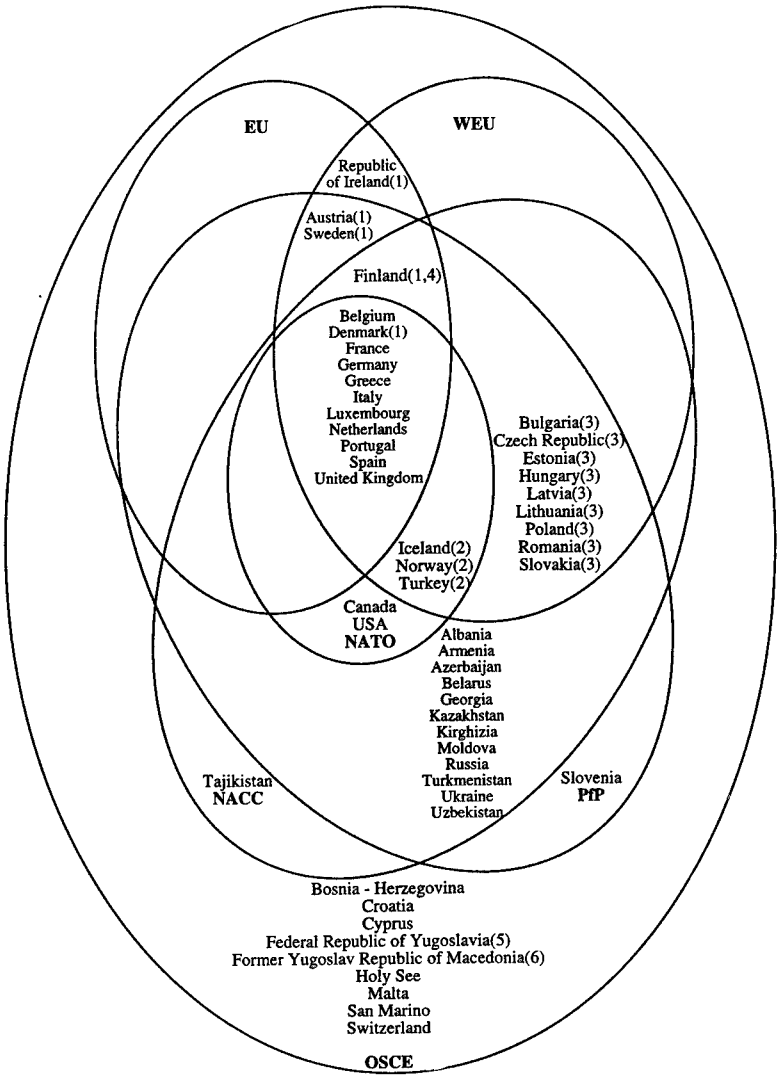


Figure 2. Complexities in the memberships of several international organizations

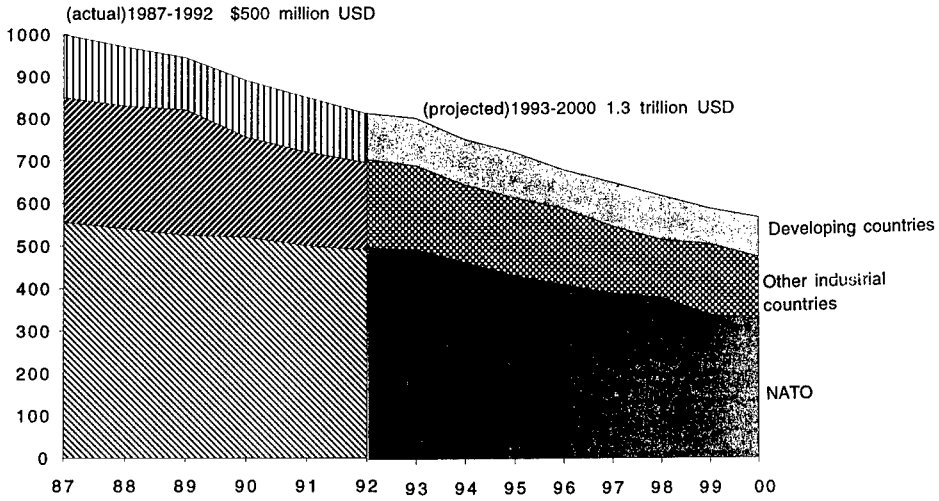
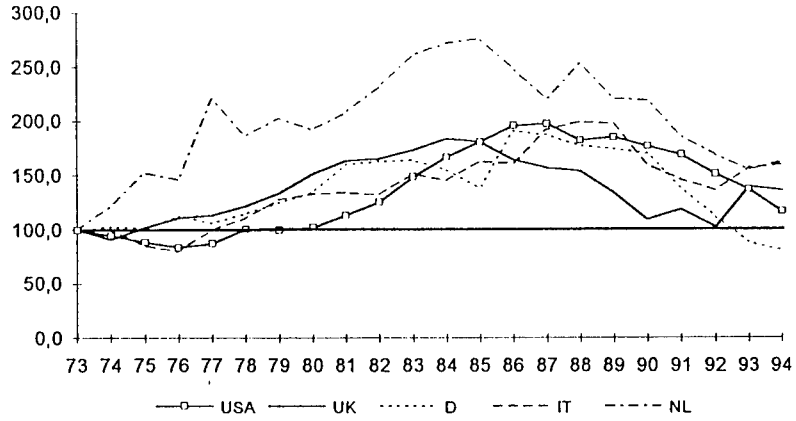
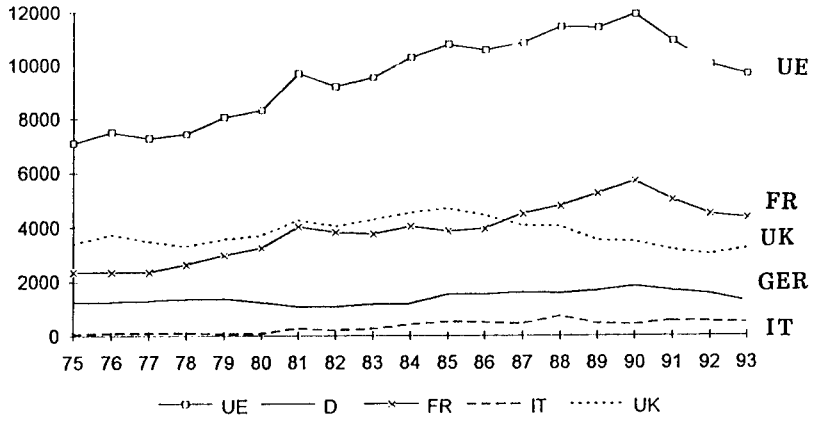


Figure 3. Military expenditure (1987-1992) and the peace dividend actual and projected



Sources: tableau réalisé sur base des éditions successives des "Données économiques et financières de l'OTAN", Communiqué de presse annuel, Service de Presse de l'OTAN. Données 1994 estimées par l'OTAN. L'OTAN ne fournit par de données pour les dépenses d'équipement de la France.

Figure 4. European Defense Equipment Spending, 1973-1994.



Sources: de 1975 à 1990: éditions successives de "Le financement public de la recherche et du développement", Eurostat, Luxembourg. De 1991 à 1993: éditions successives "Recherche et développement: Statistiques annuelles", Eurostat, Luxembourg. UE = les 12 moins l'Irlande, le Portugal à partir de 1991, l'Espagne à partir de 1985, la Grèce à partir de 1977.

Figure 5. Public spending on Defense R&D in the European Union, 1975-1993

This pattern is easily understood in terms of the developments sketched out above. Uncertainty over allies, uncertainty over missions, and the requirement for high technology equipment both to protect one's own troops and to minimize coalition-destabilising casualties among civilians, all point in the direction of advanced technology requirements, without it necessarily being clear what those requirements might be. The point is reinforced by the growing availability of advanced equipment, and of militarily-useful technologies, around the world. Governments have responded to these problems by hedging their bets: they have cut defense equipment spending, but have given relative protection to defense R& D in order to keep technological options open for the future.

Defense companies, however, do not live by R&D alone. They require production, and with demand falling, they have had to develop alternative strategies for survival.

4. Company Strategies

Figure 6 shows in summary form the range of strategies being followed by defense companies, and estimates the relative importance of these strategies in different regions of the world. If we wanted to summarize these still further, we could suggest that they amount to three main (but not mutually exclusive) choices: sharply reduce the scale of defense operations; dig deeper into defense markets; and convert existing resources to new markets. Later chapters examine these options in much greater detail. Here we simply offer a few, unsystematic, observations.

Areas and strategies	USA	Russia	Eastern Europe	Western Europe	China	Developing Countries
Military budget cuts	2	3	3	1	0	1
Military R&D cuts	1	3	-	2	0	-
Industrial adjustments strategies						
-cuts in employment	3	2	3	3	0	1
-closure of plants	2	1	2	1	0	1
-non-military production	1	2	2	2	3	2
-internationalization	1	1	1	2	0	0
-concentration	2	0	0	2	0	0
-arms export						
-planned	3	3	3	2	0	2
-effective	2	1	1	1	1	1
-conversion						
-planned	3	3	3	1	3	1
-operational	1	1	1	1	1	1
Demobilization of armed forces	3	3	2	3	0	2
Re-integration programs for demobilized personnel	2	1	1	2	0	2
Base closure	3	3	2	2	0	1
Base adjustment program	3	0	0	2	0	0
Economic effects - regional - sectional -macro-economic	 2 1 1	 2 3 3	 3 2 2	 2 1 0	 0 0 0	 2 1 1

Figure 6. Profile of adjustment areas and strategies in 1994.

4.1 CUTS IN EMPLOYMENT/PLANT CLOSURES

There has clearly been significant 'downsizing' among western firms, even if, as DeVestel has pointed out, no significant company has gone bankrupt [9].

A recent estimate for western Europe [4] calculates losses of 400,000 jobs between 1990 and 1995, a reduction of more than 30%. The largest absolute number of jobs was lost in Britain, while relative job losses were highest in Austria, Germany and Belgium. To illustrate with reference to just one company: British Aerospace (BAe) recently announced that 1350 jobs were to go over two years at its Dynamics division, which manufactures missiles. This will leave the division with only 2,500 staff, compared with 16,500 five years ago. *(Financial Times,* 16 March 1995). These numbers demonstrate that earlier estimates [2], that were met with considerable skepticism at the time, were actually rather conservative.

These reductions are, in absolute terms, small compared with those in the United States: the fusion of Lockheed and Martin Marietta alone will cost 12,000 jobs and the closure of 12 manufacturing facilities between 1995 and 1997, although out of a workforce of 170,000 *(Financial Times,* 27 June 1995).

The position has been even worse in central and eastern Europe, and in the countries of the former Soviet Union. Tank production in Slovakia, for example, which had been undertaken to supply the Soviet Army, fell in the space of a couple of years in the early 1990s to about 15 per cent of its previous level. Combat aircraft production in Russia has fallen from the level of over 600 aircraft per year in the 1980s to an expected total of less than 60 per year by the end of the decade. ([12], Table. 12.1). Fig. 7 shows the huge scale of reductions in the Russian defense complex. The problem is, of course compounded by such structural differences between east and west as the degree to which a well established non-military industrial structure and market already exists, and, in the Russian and Ukrainian cases, the sheer geographical isolation of some centres of defense R&D and production.

Arms production sector	1992 as % of 1991	1993 as % of 1991	1994 (first 6 months) as % of first 6 months of 1991
Military production [a]	62.0	52.1	31.8
Aircraft (incl. helicopters)		26.3	..
Armoured *matériel*		20.0	..
Ammunition		18.6	..

[a] Figures on the decline in military production include the Ministry of Atomic Energy and therefore differ from the data originating from the State Committee for the Defence Industries. If the nuclear branch is excluded, then military output in the MIC was at 49.5 per cent of its 1991 level in 1992 and 32.5 per cent of its 1991 level in 1993. It was forecast to be 20 per cent of its 1991 level in 1994: see Vitebsky, V., 'Does the military–industrial complex act as a motor of the national economy?', *Military Parade,* Sep./Oct. 1994), p. 95.

Sources: Glukhikh, V., 'Russian military–industrial complex: a view from the inside', *Military Parade*, Mar./Apr., 1994, p. 10; 'Itogi raboty Goskomoboronproma za yanvar–dekabr 1993 goda' [Results of the work of the State Committee for the Defence Industries January–December 1993], *Segodnya*, 1 Feb. 1994; and Centre for Economic Analysis of the Government of the Russian Federation, *Russia–1994*, issue 1, (1994), p. 141.

Figure 7. Russian military production in selected sectors, 1991-94 (By volume of output).

4.2 NON-MILITARY PRODUCTION

Systematic data on the extent to which defense plants have diversified into nonmilitary production are not, to my knowledge, available. This is not surprising, given both the difficulty of collecting such data in practice and, more fundamentally, the difficulties in classifying products as military or civil once one gets some way down the production chain below the level of prime contractors and final assemblers. Anecdotal evidence suggests that smaller enterprises seem to have been more successful in diversification than larger ones, but hard evidence on this point is scarce, and indicates an obvious need for further research.

Some data suggest that in Russia, the percentage of defense complex employees engaged on civilian production and R&D rose in 1992-93 to 6-7% above its 1991 level, but that this did not compensate for a fall in defense related employment of 60% over the same period [30].

I am not aware of any parallel estimate for western countries. What one can note is the degree to which individual companies have reduced their defense dependence (percentage of turnover that depends on defense sales). The picture, however, is patchy, with most major defense firms choosing to concentrate more heavily on defense work (see below), and with data on subcontractors being less readily available. A company such as British Aerospace (Europe's leading defense contractor) has reduced its defense dependence over the past decade from above 50% to 37% in 1993 (see Fig. 10 below). Its French counterpart, Aerospatiale, has similarly dropped from 68% defense in 1980 to 30% in 1993, and the aeroengine firm, SNECMA, has undergone a similar transformation (Fig. 8), though, interestingly, several of the other French firms listed in Fig. 8 have maintained or even increased their defense dependence in recent years. In all these cases of apparent diversification, however, what remains to be established is what really has been going on: has there been genuine diversification into civil production, or merely a reduction in the proportion of defense production or, as in some cases, an increase in the percentage of civil production arising from the purchase of new, civil, businesses?

	1980	1990	1992	1993
Thomson-CSF	61	77	75	70
DCN	100	100	96	97
Aérospatiale	68	47	32	30
Dassault Aviation	88	72	79	80
GIAT Industries	100	95	81	95
Snecma	80	36	32	35
Matra Défense-Espace	76	57	60	70
Dassault Electronique	80	73	67	95
Sagem	22	41	41	37
SNPE	69	55	52	58
RVI	13	9	10	7
Turboméca	75	62	58	63
SEP	55	21	22	19

Sources : rapports annuels.

Figure 8. Armaments as a percentage of company turnover (1980-1993)

4.3 CONCENTRATION AND INTERNATIONALIZATION

As the above discussion suggests, a third strategy widely pursued among leading defense firms has been to aim to strengthen their grip on a shrinking defense market, arguing that increased market share, even in a smaller market, still represents a worthwhile investment. To this end, the past decade or so has seen considerable restructuring and concentration of firms at the national level. In the USA, this has reached the extreme of the merger between Lockheed and Martin Marietta, forming a company with an annual turnover equal to about 15 months of French national procurement spending. On the European scene also there has been a steady process of national concentration, probably in fact running ahead of that in the USA, and reaching the point where, in Germany, for example, the overwhelming bulk of defense orders go to the Daimler-Benz group, while in Britain there was much speculation in mid-1995 about an impending 'end-game' between the two leading defense contractors, British Aerospace and GEC, following the latter's victory over the former in the battle for control of Vickers Shipbuilding and Engineering Limited, the submarine manufacturer.

The restructuring process has not, however, stopped at the national level. In a development that has been commonplace among civilian firms in an increasingly globalised economy, defense firms have latterly begun to form cross-border links. Their governments, moreover, have permitted this, having previously treated the defense sector as one of unusual strategic significance, and therefore as not appropriate for any form of foreign control [35,28,3,17]. International restructuring has been particularly evident in the electronics and aerospace sectors. Restructuring of the warship and land equipment industries has tended so far to remain within national boundaries, although even this is changing.

Two main patterns of international activity can be observed. [Fig. 9]. One pattern has been of major defense contractors taking over second tier firms in other countries. Examples include:

:: *in aerospace*: Bombardier (Canada) and Short Bros (UK); Matra (France) and Fairchild Space (USA); SNECMA (France) and FN Moteurs (Belgium); Lucas Aerospace (UK) and Tracor Aviation (USA); DASA (Germany) and Fokker (Netherlands);

:: *in electronics:* Thomson-CSF (France) and (among others) Hollandse Signaal (Netherlands), Ferranti International Sonar UK), and Pilkington Optronics (UK); Siemens (Germany) and Plessey Radar and Defense Systems (UK); Dowty (UK) and Resdel Engineering (USA).

Further examples could be given in the small arms and ammunition sector, and yet more, although much fewer in number, in land and sea systems. [For a more complete list, see chapter by Skons in 36]. Note also that there are several cases of transatlantic acquisitions.

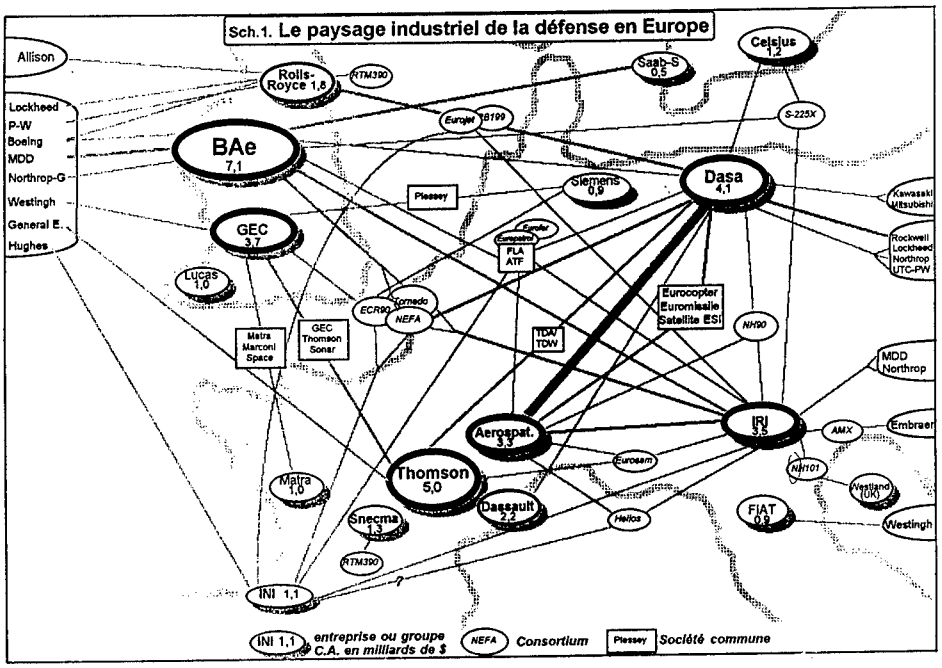


Figure 9. International Activity in Europe Defense

Transatlantic links cease, however, to be so prominent when we move to the other, and arguably more significant, pattern of activity, namely, moves to establish international joint ventures between the major players on the European scene, particularly between British and French, and French and German, firms.

Examples here include:

:: *in aerospace*: Aerospatiale (France) and MBB (now Daimler-Benz Aerospace - Germany), to form Eurocopter; GEC-Marconi (UK) and Matra Defense (France), to form Matra Marconi Espace; BAe and Matra (to merge their missiles divisions);

:: *in electronics:* GEC-Marconi and Thomson-CSF, to form GEC-Thomson Airborne Radar; a subsidiary of IRI (Italy) and Thomson-CSF, to form SGS-Thomson Microelectronic.

Again, these are the sectors that have been most prominent in this type of activity.

These developments taken together, present the prospect of radical reshaping of the European defense industry, which might result in the formation of a few large

multinational 'clusters' of fixed composition [32], but more probably perhaps will take the form of fluid coalitions of opportunity between divisions of the main defense firms [35]. In either event, they will be smaller than their precursor firms, thus continuing the process of down-sizing. They will also be enthusiastic proponents of the next strategy to be considered, namely, arms exports.

4.3.1 *Arms exports*

One crucial reason for the processes of internationalization in the defense sector is the growing pressure of US firms in the international arms market. US firms, as already mentioned, achieve considerably greater scale [Fig. 10] at the upper end of the range than do European firms. This follows from the fact that the (unified) US domestic market is about twice the size of the (fragmented) west European arms market. Hence, although the US has long been the world's main arms exporter, the dependence of individual firms on exports has in the past been very much less than that of European firms, where exports have, on average, been as high as 30-40 per cent of production.

Now, however, as the global market (including the US market) shrinks (with growth at present only in SE Asia), US firms are competing much more actively for exports, both in Europe and in the markets where European firms have themselves traditionally exported. [Fig. 11]. In response, the European firms are restructuring in an attempt to acquire the mass to withstand the American challenge [not to say the threat of US monopoly: see 20], not least by seeking scales of production equivalent to those of their US competitors.

The problem is that an export-led escape from the problem of declining markets cannot succeed for all. Global decline, coupled with tougher competition all round, has raised the stakes enormously.

1	2	3	4	5	6	7	8	9	10	11
Rank[a]					Arms sales		Total sales	Col. 6 as	Profit	Employment
1993	1992	Company[b]	Country	Industry	1993	1992[c]	1993	% of col. 8	1993	1993
1	3	Lockheed	USA	Ac	10 070	6 700	13 071	*77*	422	83 500
2	1	McDonnell Douglas	USA	Ac El Mi	9 050	9 290	14 487	*62*	396	70 016
3	4	General Motors, GM	USA	El Eng Mi	6 900	6 000	138 220	*5*	2 466	711 000
4	10	Martin Marietta	USA	El Mi	6 500	4 400	9 436	*69*	21	92 000
S	S	GM Hughes Electronics (GM)	USA	El Mi	6 110	5 550	13 518	*45*	798	78 000
5	2	British Aerospace	UK	Ac A El Mi SA/O	5 950	7 070	16 161	*37*	– 347	87 400
6	9	Raytheon	USA	El Mi	4 500	4 670	9 201	*49*	693	63 800
7	7	Northrop	USA	Ac El Mi SA/O	4 480	4 960	5 063	*88*	96	29 800
8	6	Thomson S.A.	France	El Mi	4 240	4 980	11 920	*36*	– 705	99 895
S	S	Thomson-CSF (Thomson S.A.)	France	El Mi	4 240	4 980	6 055	*70*	– 405	48 858
9	11	United Technologies, UTC	USA	Ac El Eng	4 200	4 300	21 081	*20*	487	168 600
10	8	Boeing	USA	Ac El Mi	3 800	4 700	25 438	*15*	1 244	125 500
11	19	Loral	USA	El Mi	3 750	3 050	4 009	*94*	228	..
12	12	Daimler Benz	FRG	Ac El Eng Mi MV	3 540	4 120	59 116	*6*	372	366 736
13	13	DCN	France	Sh	3 440	3 790	3 543	*97*	..	26 892
14	15	Rockwell International	USA	Ac El Mi	3 350	3 750	10 840	*31*	562	77 028
S	S	DASA (Daimler Benz)	FRG	Ac El Eng Mi	3 250	4 060	11 266	*29*	– 420	86 086
15	14	GEC	UK	El	3 210	3 750	14 570	*22*	811	86 121
16	16	Litton Industries	USA	El Sh	3 170	3 380	3 474	*91*	65	32 300
17	18	General Dynamics	USA	MV Sh	3 000	3 200	3 187	*94*	309	30 500
18	17	Aérospatiale Groupe	France	Ac Mi	2 860	3 290	8 979	*32*	– 251	43 913
19	20	Grumman	USA	Ac El	2 700	2 980	3 225	*84*	59	17 900
20	23	TRW	USA	MV Oth	2 470	2 600	7 948	*31*	195	61 200

Figure 10. The 100 largest arms-producing companies in the OECD and developing countries, 1993

Number of companies 1993	Region/ country	Share of total arms sales (%) 1992	1993	Arms sales 1993 ($b.)
46	USA	*59.9*	*62.4*	97.4
38	*West European/OECD*	*33.4*	*30.6*	47.8
12	France	*13.1*	*12.0*	18.8
11	UK	*9.8*	*9.2*	14.3
8	FRG	*5.3*	*5.2*	8.1
2	Italy	*2.3*	*1.8*	2.8
2	Switzerland	*1.1*	*0.9*	1.4
2	Sweden	*1.0*	*0.8*	1.2
1	Spain	*0.7*	*0.7*	1.1
9	*Other OECD*	*4.0*	*4.4*	6.9
8	Japan	*3.8*	*4.2*	6.5
1	Canada	*0.3*	*0.2*	0.4
7	*Developing countries*	*2.7*	*2.6*	4.0
4	Israel	*1.5*	*1.5*	2.3
2	India	*0.8*	*0.7*	1.1
1	South Africa	*0.4*	*0.4*	0.6
100	**Total**	***100.0***	***100.0***	**156.1**

Figure 11. Regional/national shares of arms sales for the top 100 arms-producing companies in OECD and developing countries, 1993 compared to 1992.

4.3.2 *Conversion*

What remains, then, is the strategy of direct conversion. This, however, is not a simple concept. We can distinguish its operation at at least three levels: those of the individual plant, the company as a whole, and the region within which the plant is located [31]. That is, we can distinguish between:

:: attempts to change what is produced in an individual plant. Here we encounter all the problems that the literature on technology management, technological innovation, and organizational behavior, would lead us to expect. That is to say, a firm is seen as a highly developed, organic entity embedded in its own history. If it is a successful firm, it will have optimized at all levels to its role. Change, therefore, is far from a trivial matter. The switch from military to civil production will involve all the familiar problems of identifying products, marketing them in an unfamiliar environment, and altering work practices at a variety of levels;

:: attempts to alter the overall product range of a firm comprising many individual factories. This, however, can come close to the diversification strategies discussed earlier. It may well not involve any direct conversion, in the sense of using the same personnel as previously, at the level of individual plants.

:: attempts to generate new foci of economic growth in a region, regardless of the fate of individual factories, in an attempt to absorb displaced labor into new jobs. This approach recognizes the problems of plant level conversion and seeks instead to provide fresh starts for displaced workers. It offers perhaps more scope for intervention by national or regional authorities (as with the European Union's KONVER programme), through training programs and support to new, especially SME, businesses, for example.

These more specific strategies will be discussed in other chapters, as will the very important differences that flow from the different economic systems within which conversion is being attempted. We may note here simply that conversion, especially at plant level, appears to have been attempted more in the east than the west, for reasons to do, perhaps, with the different structures of industrial activity and, in some cases, the geographical remoteness of plants; and that large-scale conversion activities have occurred in the past, notably in declining industries such as coal and steel, or even in the defense sector itself, as at the end of the 2nd World War. What emerges from previous cases, however, is the importance of social and economic conditions. Thus, at the end of the 2nd World War, western Europe and the USA could reduce their defense labor force rapidly for at least three reasons: the large number of women who had been drawn into the war effort were willing to return home; many companies had switched from civil to defense production, and still retained the skills necessary for civil work; and there was pentup consumer demand. Clearly, these factors do not apply today.

5. Changing Relations Between Defense and Civil Technologies

Let us, finally, consider how to avoid a repetition of the current difficulties. How, in other words, to organize so as to be able to meet legitimate defense needs, without developing such large and specialized defense production facilities as in the past, with all the problems that a sharp reduction in demand entails? This, we might suggest, is a question worth bearing in mind when shaping conversion strategies.

The management of technology for defense purposes faces several challenges. It will be less well-funded than in the past. Production runs will be shorter, encouraging international collaboration and/or advanced manufacturing methods in order to keep prices within reach. The industry will be increasingly internationalized, making national control of technological assets more difficult. And the traditional post-1945 assumption that military technology was somehow more advanced than civil is being reversed, in areas from electronics to structural materials, as the (globalised) commercial sector, with its vastly greater size and its growing performance standards, is increasingly making the technological running [15,14]. This last point means, first, that defense suppliers have to learn how to draw more actively on the civil technology base (and may indeed be threatened by civil suppliers in the competition for defense contracts); and second that, again, the process of supply is becoming increasingly internationalized, not to say

globalised, not only at the level of the prime contractors, but right down to the level of suppliers of components and materials.

How, in these circumstances, can governments and firms maintain technological dynamism? How can defense equipment of adequate quality be acquired at an affordable price?

The way ahead is not easy, but depends, we may suggest, on recognizing the need to switch to a new defense technological "paradigm". This term is borrowed from economists of technological change, who increasingly speak in terms of technological paradigms, by analogy with Thomas Kuhn's well-known characterization of scientific paradigms [10,25]. The term is intended to convey the idea of fundamental differences in approach, at the levels of theory and practice, in the development and organization of technological activity. Among the features to which the concept points are the modes of design and production that are used, the range of technologies that are drawn upon, and the manner of their acquisition. Thus, the term embraces both products (such as electronic components) and production processes (such as the "lean" production techniques now being imported from the car industry into the aircraft industry) [See 8]. The prime example of the new paradigm is, of course, Japan.

Japan has become a major producer of high quality defense equipment (as well, of course, as a prime supplier of components to western defense equipment), without having developed a specialized defense industry. Hence, Drifte [11] has described Japan as having defense production without a defense industry. That is, defense production is managed as a small part of the work of large, technologically dynamic companies, whose main competencies and markets lie elsewhere. (See also [6]).

The best account of the Japanese case is that by Samuels [27], who shows that Japan has a long history of military technological development. The title of his book, which is found on coins from the 1860s but can ultimately be traced back into the 4th century BC, became the slogan of the Meiji government. "Rich nation, strong army" signified the ideological beliefs that economic strength and military security were inseparable, that the one fed upon the other, and that they should be cultivated jointly.

This "technonationalism", as Samuels calls it, comprised then (and still does) three elements: import-substituting indigenisation (the identification and acquisition of foreign technology in order to stimulate local development); diffusion of this knowhow throughout the country; and nurturance of a capacity to innovate and manufacture. Hence, fact-finding, technology-acquiring tours by visiting Japanese are nothing new. There is a long history of sending engineers abroad to acquire new techniques, and apply them in Japan. There is also a long history of active government intervention in this process, not least in the military sector.

But, goes the popular myth, surely this history applies only to the period up to 1945 and not beyond? Not in Samuels' view. It is, of course, true that Japan's defense options were abruptly altered by the outcome of the second world war. Nevertheless, arms production attracted considerable attention from economic planners and business leaders even in the early 1950s. In fact, says Samuels, "military procurement was an engine of Japan's postwar reconstruction and ever since has been an important source of

technology." Crucially, however, he continues: "Perhaps more than any other nation, Japan has successfully embedded a defense industry in a commercial economy."

A critical factor was the Korean war. The US needed to re-arm rapidly, and turned to Japan for help. Procurement by the US military was nearly 70 per cent of Japanese exports between 1950 and 1952. It not only contributed significantly to the rehabilitation of the Japanese economy, but it also resulted in much transfer of technology from the US to Japan to support the rapidly reestablished military production facilities.

After the Korean war, there was intense debate in Japan over the future of arms production. Some favored a return to the pattern of defense companies on the pre-1945 model. Others argued that the defense industry as such needed to be kept small if the economy as a whole was to grow big. The result was movement towards a highly diversified industry, capable of both civil and military production.

Samuels' detailed case studies show how, within this framework, companies rotate engineers across functional fields. Thus, an aircraft engineer might be moved between materials, manufacturing, fuselage design, personnel, fighter design and aeronautical testing, giving depth and breadth to an individual's experience and resulting in cross-fertilization across applications. But technology diffusion is also organized through moving project teams across sectors, through common machinery on the shop floor, and through common engineers in the same sector who are not expected to distinguish civil from military tasks. In some firms, he found the same workgroups, on the same machines, on the same days, producing parts for jet fighters, missiles, and for Airbus or Boeing. In another firm, civil and military radars are made with the same design teams in the same facilities.

In addition, when, by the 1970s, the relations between technologies of civil and military origin began to change in the ways already indicated, Japan found itself in an exceptionally strong position. As the world leader in the introduction of advanced electronics into a huge variety of products, and in the development of advanced manufacturing capabilities, Japan assembled an impressive commercial technology base which could be applied to military purposes, while continuing to reinforce it with work arising from military funding. To give but one example: the Japanese claim that their air-to-surface missile performs better than US missiles because it has better gyrocompass technology. The reason, they say, is that their bearings have smoother surfaces and are made to higher tolerances because they were first produced to the exacting standards required for video tape recorders.

Samuels argues that "The fundamental lesson from the Japanese experience is that a full-spectrum commercial capability helps defense production as much as focused defense industrial policies. Each of the pieces, up and downstream, meshes together, and the diverse commercial economy that results is **a huge 'knowledge generator' for society."** How different the debate over the future of defense industries in the West and in Russia would be were they starting from such a position.

Debate on this question is now organized in several countries around the concept of dual-use technologies. There has already been extensive analysis of this concept in the USA, as shown, for example, by the publication in 1992 of the results of a major study

from the Harvard project on dual-use technologies [1]. Since the election of President Clinton, the theme of dual-use technologies has moved from the level of analysis to the level of policy. It has become a central pillar of defense technology policy [33,13], with the 1995 Department of Defense budget containing over $2 billion for work of this type, much of it under the Technology Reinvestment Program (TRP).

It must be added that the US programs remain controversial, especially after the election of the new Congress in November 1994. (See *Defense News, 9* January 1995, p.8). Strong defense of the TRP has come from the Administration [34], from academic analysts [26], and from sources such as the leading defense weekly newspaper, *Defense News.* In a leading article on 13 February 1995 (p.22), this newspaper argued that Congressional critics failed to recognize the long-term benefits of the program in linking defense companies with commercial activities, and that the TRP is already producing important defense technologies at a fraction of what it would otherwise cost the DOD As they wrote:

> "Much of the US defense industry finds itself today largely segregated from the commercial world. Fusing the technology and marketing and distribution panache of commercial vendors with the technological expertise of the defense industry will pay off in the Pentagon and the marketplace.
>
> This is critically important today when, increasingly, technologies underlying commercial products can be used to improve weapons systems."

Current opinion appears to be that much of the TRP and other dual-use programs will probably survive, though with reduced budgets, but that they will be re-packaged and presented to Congress as "defense" programs. We will have to wait and see. From the perspective of other countries, however, the lesson to draw is that there will continue to be substantial sums devoted to these activities in the United States, regardless of the label under which they are presented in public.

A variety of positions on this subject can be seen in western Europe, deriving from different conceptions of the status of defense affairs, at one level, and of the relations between the defense and civil sectors, at another.

In certain respects, Britain, after earlier reluctance to discuss together the development of civil and military technologies, is becoming increasingly active on this subject. Industry is pressing strongly for a greater national effort in the development of dual-use technologies. The government, through the Defense Evaluation and Research Agency (DERA), is acting to develop new Dual Use Technology Centres, and related initiatives which will align the programs of the DERA more closely with those of industry [19,24].

A similar debate has also been underway for some time in France, but in a more positive tone than in the UK. For several years there have existed large annual meetings to draw together defense and civil scientists (so-called "Entretiens science et defense"). Civil agencies, such as the national space agency (CNES) are much more closely involved with defense programs than would be the case in, say, the UK. The willingness

to place defense interests firmly in the forefront of wider national technological development is a theme that was much developed in the highly detailed November 1993 report of the Groupe de strategie industrielle of the French Commissariat general du plan. [17]. It is also noteworthy that the Ministry of Defense has begun to produce a newsletter on potential dual-use opportunities available under the European Union's Fourth Framework Programme, in order to encourage defense officials and organizations to bid for this funding.

In sharp contrast, however, is the German case. The most powerful economy in Europe is also one of the most heavily constrained politically in terms of defense equipment spending, relative to its size. In this context, it has been policy since 1985 to draw on civilian-developed technology as far as possible [22]. Moreover, in contrast to the USA and UK, Germany has not maintained large state-owned defense research establishments. Instead, it makes heavy use of other research institutions with primarily civil interests (such as the Deutsche Forschunganstalt fur Luft- und Raumfahrt, and the Fraunhofer Gesellschaft), and of private companies. These are on the whole less militarily dependent than their British or French counterparts, and in that sense much more like Japanese defense producers.

Among the smaller defense spenders of western Europe, where the volume of defense R&D is already quite limited, there has also tended to be implicit if not explicit attention to the cultivation of dual-use approaches, which now are being reinforced. Thus, in Sweden new dual-use networks are being created to link civil and military R&D organizations [17].

It is unclear where all this activity will lead, it being unclear in the first place how deeply the enthusiasm for dual-use technology runs and, second, how far the concept can be applied in practice. Nevertheless, at a time when a new equilibrium is being sought in the balance between technologies of civil and of military origin, when the technology needed for military purposes comes increasingly from civil or dual-use sources, and when those sources need increasingly to be accessed on a global scale, the scope to develop in the dual-use direction deserves consideration. This is so for two reasons: first, in order to maintain capabilities needed for any future defense activity; and second, in order to provide a platform for conversion into new products and markets. The Japanese example therefore offers not only a challenge, but also an encouraging example. It is the example of a defense industrial base that is so strongly rooted in a wider technological and industrial base that it does not present the kind of conversion problems that are faced by so many others today.

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DEFENSE CONVERSION AT BOEING

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1. Introduction

The issue of conversion is certainly one that has occupied the attention of the defense industry worldwide in this era of changing alliances and refocused priorities. With the symbolic tearing down of the Berlin Wall and all it represented, the rules changed for an entire industry preoccupied for nearly a half-century with maintaining the balance of power between East and West.

Now, with fewer resources available for traditional defense acquisitions, many companies are looking at alternative markets for their technology in hopes of regenerating revenues and, in the worst cases, staving off the unthinkable - going out of business altogether. For many, it is an uncertain future.

To help shed some light on an otherwise dim and unfocused picture, I will discuss the experience of The Boeing Company with past attempts at defense conversion. I will specifically focus on four periods in the company's 79-year history when it was forced to confront the prospects of conversion and diversification, and the outcome of each attempt.

Hopefully, this Boeing case study will provide a useful perspective that can contribute to future discussions of defense conversion and aid in rational decision-making. But first, I think it would be appropriate to provide some background on Boeing to help those of you here today who are not quite so familiar with my company and the historic role it has played in defense.

If you asked the average person on the street what they knew of Boeing, they would probably relate in some way to the commercial jet transports it has produced so successfully for nearly four decades. For much of the jet age, Boeing has been - and continues to be - the world's leading manufacturer of commercial airplanes.

Since 1958, Boeing has built more than 7,700 commercial jets as part of its "700" series, which started with the 707 and includes the 727, 737, 747, 757, 767, and the newest - the 777. More than 80 percent of Boeing jets are still in service, flown by more

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than 400 airlines, businesses, and governments. Boeing takes particular pride in the fact that its commercial jets have carried about eight-billion people, and the number grows daily.

But probably what the average person doesn't know is that Boeing is a very active participant in the defense industry, with specific capabilities in military airplanes, helicopters, missile systems, electronic systems, and information systems management. Boeing is also active in the space arena and is, among other things, the prime contractor on America's current space station program.

Boeing currently employs about 110,000 people, the majority of whom work at plants in and around Seattle in the northwest corner of the United States. Boeing also has major plants at Wichita, Kansas, and Philadelphia as well as space-related operations at Houston, Texas, Huntsville, Alabama, Cape Canaveral, Florida, and other locations.

Like many aerospace companies, Boeing has undergone some serious downsizing over the last five years as a result of the combined effects of a major reduction in American defense spending coinciding with the end of the so-called Cold War, and the airline industry recession of the early 1990s.

As some of you may already know, more than 1.1 million U.S. defense-industry workers have lost their jobs since 1987. Since 1990, the Boeing workforce has shrunk by approximately 50,000 jobs, and more downsizing could occur before the year is over.

This is certainly not the first time in the company's history that it has been forced to reduce employment and cut costs. In fact, as severe as the cuts of the last five years have been, they pale in comparison to previous episodes in Boeing's history, such as the end of World War II and the so-called "Boeing bust" of the early 1970s.

But unlike those previous episodes, Boeing of the 1990s has not pursued diversification into other fields. Rather, the company's leaders, in essence, "hunkered down," pursued orderly downsizing, launched process-improvement efforts, and remained committed to Boeing's defense work along with the commercial market.

In fact, after three straight years of losses in the company's defense and space business between 1989 and 1991, the decision to remain an active player in the shrinking defense arena has already paid off in at least one way for Boeing. While commercial airplane sales have continued to drop since 1992, defense revenues actually improved to the point where they represented 26 percent of total company sales, and 23 percent of profits, for the first quarter of 1995.

Boeing is currently active in several significant defense programs. It is a partner with Lockheed on the F-22 fighter program, a partner with Bell on the V-22 Osprey tiltrotor program, and a partner with Sikorsky on the RAH-66 Comanche helicopter program. Boeing also has launched a new generation of Airborne Warning and Control System aircraft - or AWACS - on the 767 airframe, and it continues to produce twin-rotor Chinook helicopters. Boeing also provides ongoing support to a number of other programs, including the B-2 stealth bomber, first-generation AWACS aircraft, and others.

Boeing is actively pursuing new defense business with its work on unmanned aerial reconnaissance aircraft such as the turbofan-powered "Dark Star" U-A-V and the prop-rotor-driven Heliwing. Boeing is also active in the Joint Advanced Strike Technology

program, which seeks to develop a modular fighter/attack aircraft design that would satisfy future aviation needs of the U.S. Air Force, Navy, and Marine Corps.

For Boeing, this defense role is as old as the company itself and pre-dates by several years any real attempt to develop commercial products. William Boeing started the company in 1916 with the idea of developing seaplanes for the U.S. Navy. I'm sure the fact that Seattle is situated along Puget Sound and is in close proximity to several lakes had something to do with his thinking.

Also contributing to the decision to start in this direction was the fact that Boeing's partner on his first airplane was U.S. Navy engineer Conrad Westervelt - hence the name B & W for that first seaplane. Before the B & W could be finished, however, Westervelt was recalled by the Navy to fleet duties and Boeing continued on his own. One can only imagine what Westervelt would think today were he still alive to see where the B & W ultimately led.

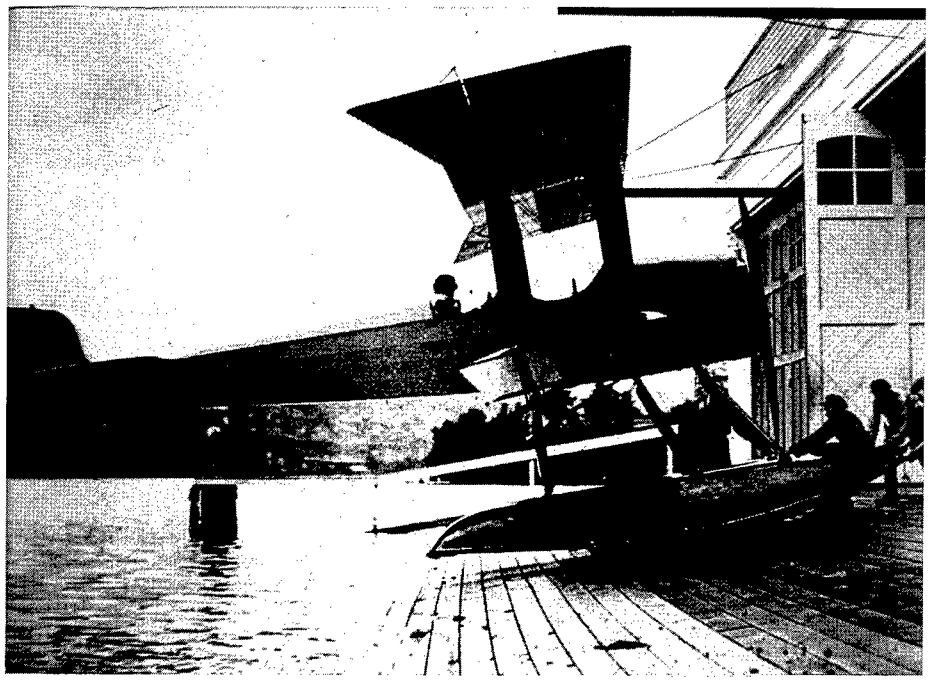


Figure 1. Early Boeing-developed seaplane named "B&W" after William Boeing and early partner Conrad Westervelt

At any rate, from that humble beginning, the company that still bears William Boeing's name has pursued defense business through two world wars, a cold war, and the occasional periods of peace in between. During those nearly eight decades, The Boeing Company has experienced several reversals of fortune, causing its focus to shift not only to new commercial airplane markets, but to markets altogether outside of the aerospace industry.

With few exceptions, these efforts at conversion met with little or no success and Boeing always returned to defense work, even when commercial aircraft sales finally took off in a big way - as they did in recent years - and came to dominate the company's business, as it does today. As former Boeing Chairman T. Wilson put it a couple of decades or so ago: "It is not easy to become established in a new field. And those fields to which Boeing's capabilities might be adapted already are occupied by reputable companies with the required technology, facilities, manpower, money, and marketing outlets."

Wilson made that comment in 1970 as Boeing experienced one of its most severe reversals and was forced to lay off more than half its workforce in order to survive a recession that gripped both the defense and commercial sectors. This period is one of the four episodes in the company's history that I will discuss.

2. Post-World War I

But first, I want to delve into the post-World War I era, which occurred very early in The Boeing Company's history and represented its first attempt to convert away from dependence on defense work.

William Boeing's fledgling airplane company built only two B & W seaplanes, which were given the names "Bluebill" and "Mallard." The two B & Ws eventually were sold to New Zealand for $3,750 each, representing Boeing's first international sale, by the way.

Based on that first design, Boeing developed the follow-on Model C trainer, which won the company its first military contract. To win it, however, workers had to disassemble two completed Model Cs, crate them, and ship them by train all the way across the country to Pensacola, Florida, for Navy tests. Fortunately, the two seaplanes came through with flying colors, despite a 35-mile-per hour wind and four-foot waves on Pensacola Bay.

The U.S. Navy's order for 50 of the Model Cs came shortly after America's entry into the First World War and was soon followed by another military contract to build 50 Curtiss-designed HS-2L flying boats. With the company well involved in the war effort, armed soldiers took up position outside the Boeing plant, marking the first appearance of guards at a company facility.

At the peak of wartime production, the Boeing Airplane Company employed 337 people, up considerably from the 23 people employed when the company was originally incorporated as Pacific Aero Products in 1916. Some of them are seen here in this wartime view of the Boeing machine shop.

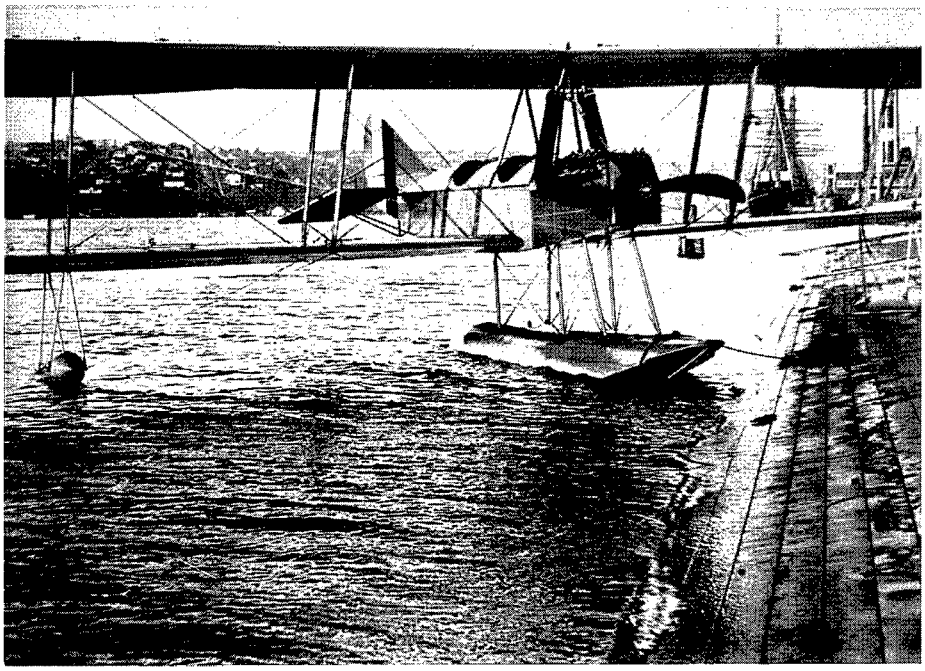


Figure 2. The model C trainer, follow-on to the B&W Seaplane

That name, by the way, was changed in 1917 to the Boeing Airplane Company as work shifted from a small converted boathouse to larger quarters at a shipyard site that had been purchased by Boeing seven years earlier.

But with the sudden end of the war in late 1918, existing orders were quickly cut back and the Boeing Airplane Company soon saw its Navy seaplane business evaporate. In response, William Boeing began seeking other markets for his company's woodworking expertise. Among the items produced by Boeing workers were a line of bedroom furniture and phonograph cases. His woodworkers also built counter surfaces and other interior furnishings for a corset company and a confectioner's shop.

These efforts represented the company's first attempt at defense conversion, as did a scheme to build a speedy square-bowed, flat-bottomed boat called the "Sea Sled." As it was, only 10 of the boats were sold, with at least some of the probable buyers being liquor smugglers who responded to a newspaper advertisement placed by the company. Prohibition was, after all, just around the corner.

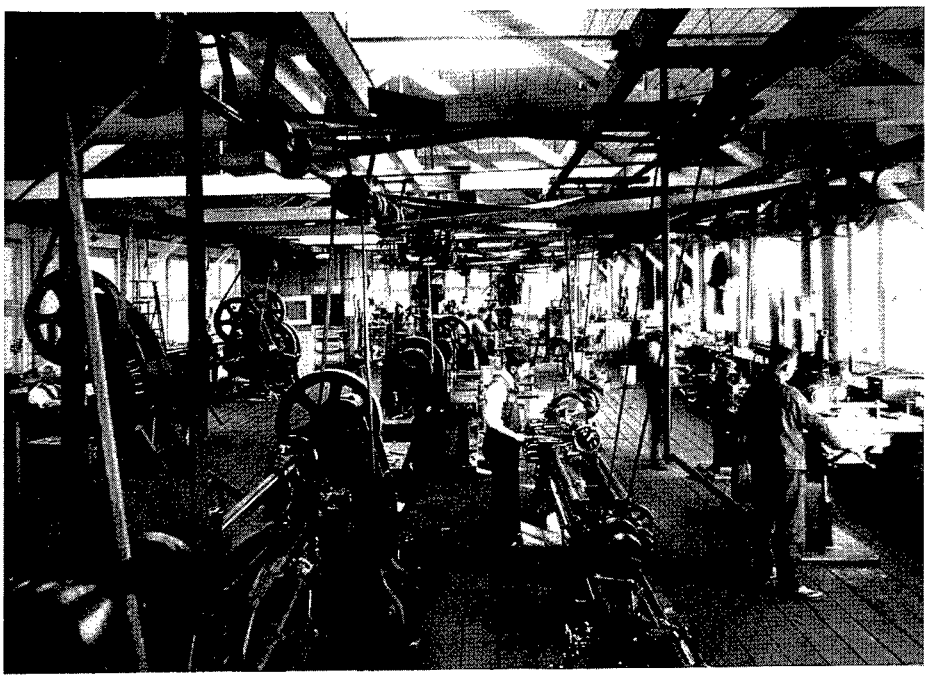


Figure 3. War-time view of the Boeing machine shop

The company's workforce plummeted from that wartime high of 337 to just 67 employees by 1919. The situation got so bad that company managers expected to go out of business at anytime. The entire aviation industry, such as it was in this period, was in a deep recession, largely because of a post-war glut of airplanes on the market. Even though Boeing and others tried to develop commercial models, they could not sell them because of surplus military stocks. These surplus airplanes, some of which were still in their original crates, could be had by anyone for just a few hundred dollars. It would take fully seven years for this surplus to finally evaporate.

While Boeing's various woodworking projects kept employees busy, they were never really profitable. Fortunately, Boeing had hired a man by the name of Joe Hartson, who became the company's eastern representative in Washington, D.C. Through Hartson's efforts, the Boeing Airplane Company eventually won a hard-fought contract in late 1919 to begin modifying de Havilland DH-4 biplanes for the U.S. Army. This, by the way, was to be the first of many Army contracts for Boeing and essentially returned the company to its original focus of defense work.

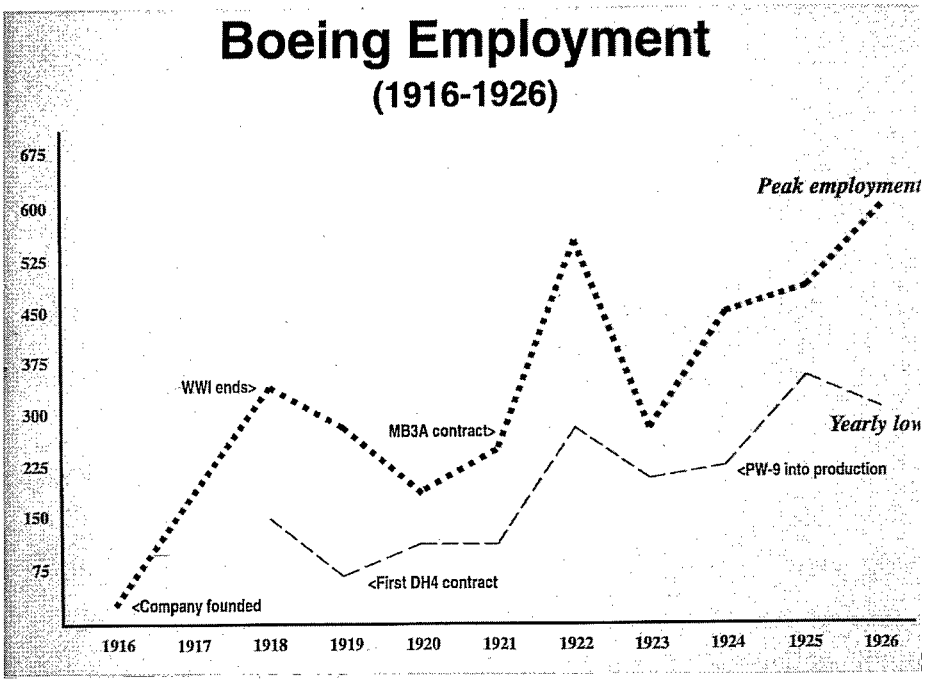


Figure 4. Boeing employment during the period 1916 to 1926

The DH-4 work involved interchanging the position of the fuel tank with the cockpit in order to reduce fire hazard as the airplanes were deployed along the Mexican border. The DH-4 had been nicknamed by some the "flaming coffin" during the war, hence the decision to make the modifications. One of the jobs Boeing performed on the DH-4s was to retrofit some of the planes with steel-tube fuselages joined together with a new company-developed arc welding process. Altogether, the Boeing Airplane Company rebuilt 298 of the de Havillands.

Due in part to the de Havilland work, Boeing achieved another significant milestone in 1921 when it won another Army contract, this time to build 200 MB-3A fighters designed by the Thomas-Morse Aircraft Corporation. At the time, the originator of a military airplane design did not necessarily get to build it if the U.S. government could find someone else to do it cheaper. Such was the case with Thomas-Morse, which was underbid by Boeing. As a result of this contract and other work, Boeing employment soared to a new high of 549 workers by 1922.

In May of that same year, the company held a final closeout sale to employees, selling each remaining piece of unsold furniture for $15. In contrast, it was also in 1922 that Boeing Aircraft began experimenting with the use of aluminum as a replacement for wood in the construction of airplanes.

The Thomas-Morse contract, which totaled the then-princely sum of $1,448,000, firmly established Boeing as a reliable "builder" of military aircraft and helped lay the groundwork for Boeing's successful effort two years later to sell the Army on a pursuit model of its own design, known as the PW-9.

In Army jargon, the "P" stood for pursuit and the "W" for watercooled. Boeing was actually in a competition with Curtiss to build a new pursuit plane, and while Curtiss won an initial order for 25 of its PW-8s, two weeks later the Army agreed to buy three of the Boeing airplanes. After a year of tests, the Army decided to purchase 12 more of the PW-9s .

Ultimately both the Army and Navy together purchased more than 200 P-W-9 variants, including these F-B models shown here under construction, as well as a number of derivative trainers. This established Boeing along with Curtiss as the nation's two premier designers of military fighter aircraft for the rest of the decade.

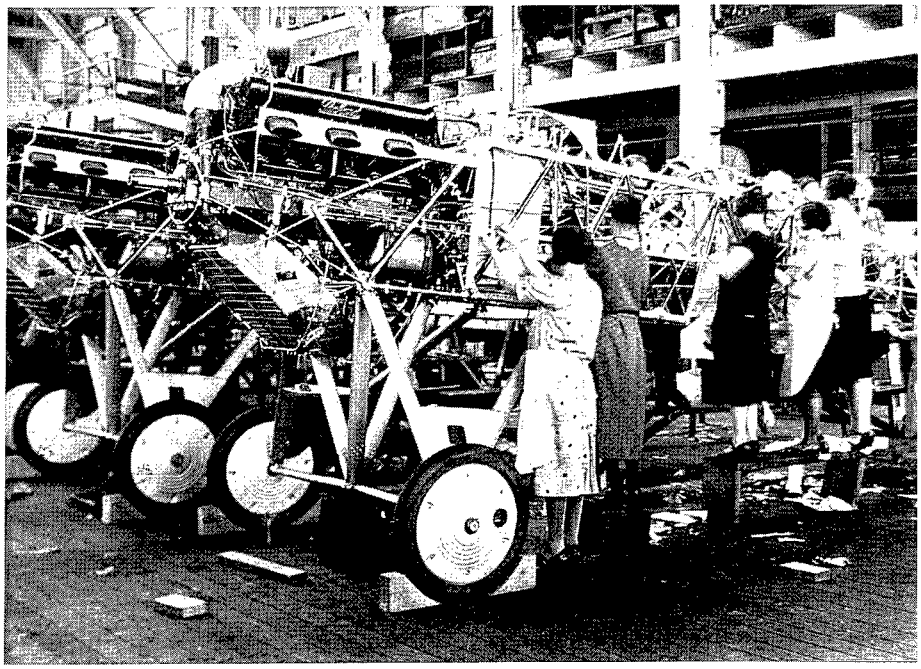


Figure 5. PW-9 (F-8) model under construction

3. Breakup of United Aircraft & Transport

The next period I will deal with in the company's history involves the breakup of William Boeing's United Aircraft & Transport Corporation in 1934 and its repercussions. But I must first digress in order to set the scene.

After several years of dependency on military contracts, the Boeing Airplane Company finally decided to test the commercial market in 1925 with its Model 40, which was designed to meet U.S. Post Office specifications for an aircraft to deliver the mail over preestablished routes.

This, by the way, was not William Boeing's first experience with the mail. Back in 1919, he and pilot Eddie Hubbard made the first international airmail delivery to the United States when they flew 125 miles from Vancouver, Canada, to Seattle in a variant of the Model C seaplane. They carried a pouch containing 60 letters.

Boeing engineers thought they had a sure winner in the Model 40, which also had the added novelty of being able to carry two passengers in a tiny compartment forward of the pilot. But the Post Office only ordered one of these somewhat-underpowered airplanes and the project seemed destined to end there. Later in 1925, President Calvin Coolidge signed a bill that transferred some of the Post Office's established airmail routes to private operators and William Boeing decided to bid for the western section of transcontinental airmail service.

By the time the contract was put out to bid, the Model 40's original heavy water cooled Liberty engine had been replaced by Pratt & Whitney's new air-cooled Wasp engine, which was 200 pounds lighter, enabling the Boeing airplane to carry considerably more mail than competitors. Boeing's airmail bid of $2.89 per pound was half of what the Post Office expected to pay, prompting a skeptical postmaster to require Boeing to personally underwrite a $500,000 bond in order to get the job. He did and Boeing was firmly in the airmail business, and on the way to creating the ill-fated conglomerate to be known eventually as United Aircraft & Transport Corporation.

With an airmail contract in hand, Boeing promptly launched his first subsidiary in 1927 in the form of an airline known as Boeing Air Transport, which successfully carried 837,211 pounds of mail,149,068 pounds of express packages, and 1,863 passengers during its first year of operation. Successful from the start, Boeing also began buying out such competitors as West Coast Air Transport and Pacific Air Transport.

During this time, William Boeing and Pratt & Whitney President Fred Rentschler had developed a close business relationship and in early 1929, they took the big leap by founding United Aircraft & Transport, which would soon grow into the massive holding company of a number of ventures, including:

- Boeing Airplane Company.
- Boeing Air Transport.
- Pratt & Whitney.
- Hamilton Standard Propeller Corporation.
- Chance/Vought Corporation.



Figure 6. Boeing's model 40 mail carrier

- Stout Air Services.
- Varney Air Lines.
- Pacific Air Transport.
- Stearman Aircraft Company.
- Sikorsky Aircraft Corporation.
- National Air Transport.
- United Aircraft Exports.
- United Airports Companies of California and Connecticut

While it's not on this particular organization chart, one of the business decisions of United Aircraft & Transport was to incorporate a company known as Northrop Aircraft

Corporation, Limited, which oversaw the development work of John K. Northrop. During this period, Northrop was doing some of his preliminary design work on the same flying wing concept that would later be so closely linked to his name. Northrop eventually went off and started another company in 1939, and the rest is history.

After the creation of United Aircraft, what followed were essentially six years of prosperous growth for Boeing and everyone else connected with the holding company, and not even the Great Depression had much of an impact. With the inclusion of the Boeing School of Aeronautics, United Aircraft & Transport became a fully integrated manufacturing, transportation, and pilot training enterprise that carried nearly a third of all airmail and air passengers in the United States.

For Boeing Airplane Company, these were also years of business growth. By 1929, the company had seven commercial and seven military models in production and employment totaled nearly 1,500 - a big jump from the 313 employees on the books only three years earlier. After the success of the Model 40 came the Model 80, which first flew on Sept. 12, 1929, and sported three engines and the capacity to carry 12 passengers in a fairly roomy cabin.

On the military side, the company developed the highly successful P-12 fighter, which helped offset what, if any, post-1929 employment slump did occur at Boeing as a result of the Great Depression. The P-12 resulted in the ultimate sale of 586 variants to the Army and Navy.

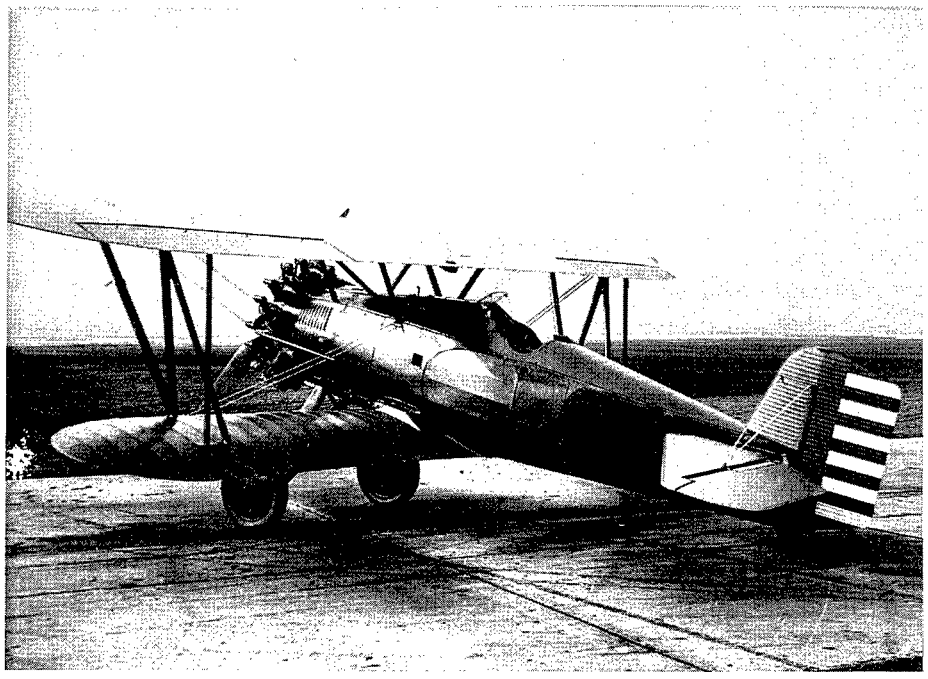


Figure 7. The Boeing P-12 Fighter

And there was the P-26 "Peashooter," which would be the last fighter to go into production at Boeing until it commenced work more than a half-century later on the F-22 Fighter. Boeing built 136 Peashooters, some of which saw service in the early days of World War II as obsolete but still-rugged fighters.

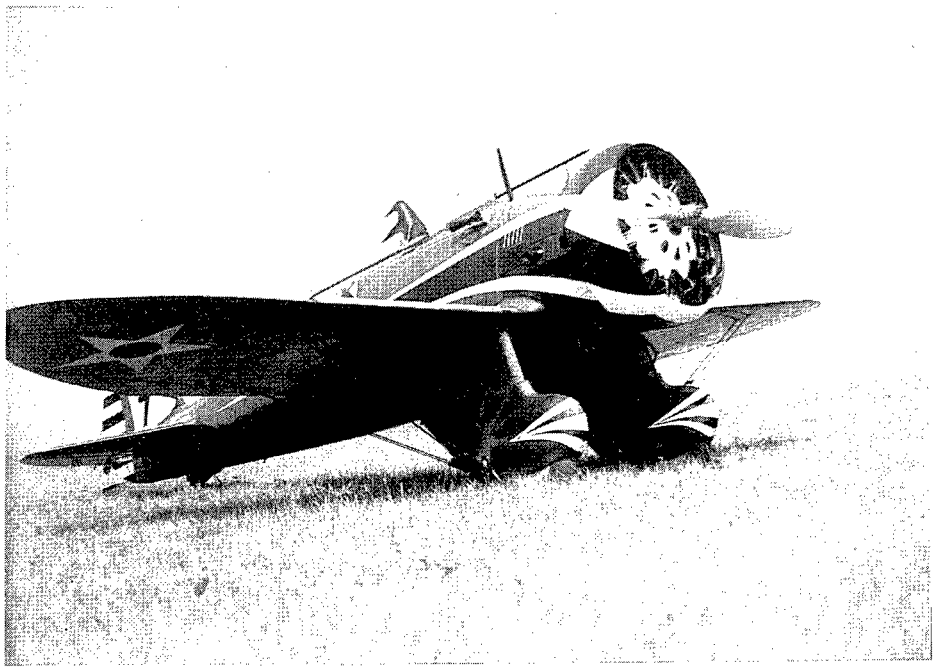


Figure 8. The Boeing P-26 "Peashooter"

Success also fueled development of innovative Boeing aircraft such as the Monomail, which was the company's first all-metal, low-wing monoplane and featured a retractable landing gear and cantilevered wing construction.

There was also the Model 247, which was dubbed the first modern airliner because it could cruise at 180 miles per hour and offered a plush alternative to the hard seats, engine vibration, and fumes of existing passenger airplanes. As a side note, it was Boeing Air Transport that employed the first flight attendant back in 1930 when it put a trained nurse on a flight to San Francisco.

But William Boeing's aviation empire came crashing down in 1934 amid congressional efforts to reform the system for awarding airmail contracts by making them more competitive. One offshoot of this move was the disastrous decision by President Roosevelt to have the Army Air Corps temporarily take over airmail service. Within the

first week, five Army pilots were killed, six critically injured, and eight airplanes destroyed in accidents.

Eventually, the postmaster general issued temporary orders authorizing the letting of new airmail contracts to private companies, but he prohibited anyone previously involved in airmail delivery to bid on them. Soon thereafter, a new federal Airmail Act prohibited any airline from being associated with a company that built airplanes, forcing the breakup of United Aircraft & Transport into three survivor companies: United Air Lines, United Aircraft Corporation, and Boeing Aircraft.

As a result of all these forced changes, William Boeing sold his stock and left the aircraft industry for good, although not before collecting a prestigious Guggenheim medal for the Model 247. The newly reorganized Boeing Airplane Company, with its workforce cut by more than half to just 839 employees, decided to aggressively pursue the commercial market with its 10-passenger Model 247. But this airplane never fulfilled expectations because it was followed closely by the Douglas DC-1, which was larger and faster and later refined into the famous DC-3 - an airplane which, along with its predecessors, would dominate the commercial airline market for many years.

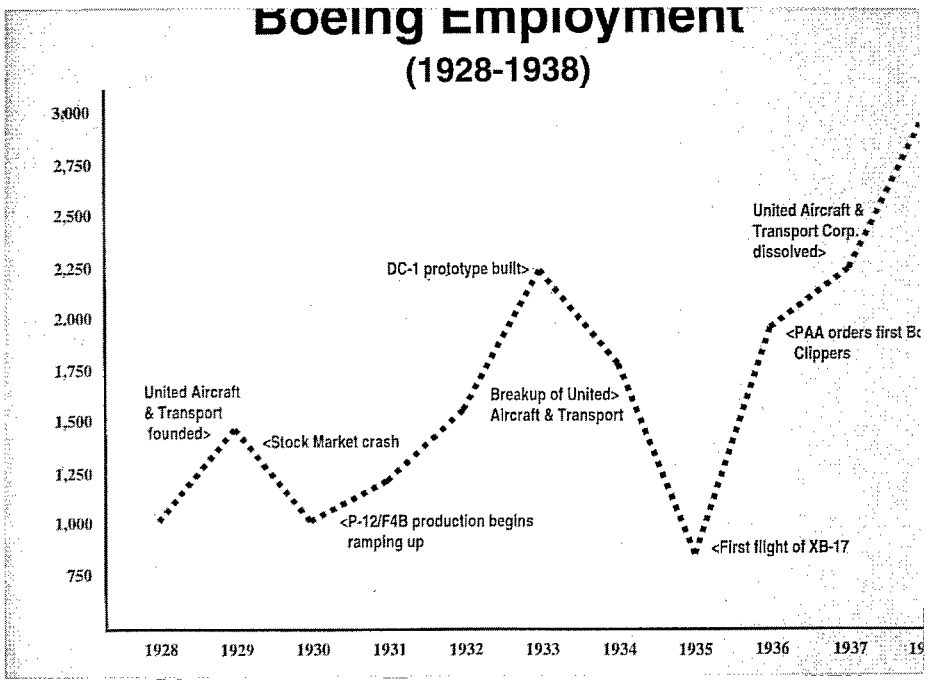


Figure 9. Boeing employment during the period 1928 to 1938

With Boeing essentially blown out of the commercial waters by Douglas, new President Claire Egtvedt found himself in 1934 at the helm of a struggling company that was only a mere shadow of its former United Transport self in terms of sales. Egtvedt declared that success for his company would come "only by spending fairly substantial sums in the development of new models in those fields which hold forth promise of producing future business."

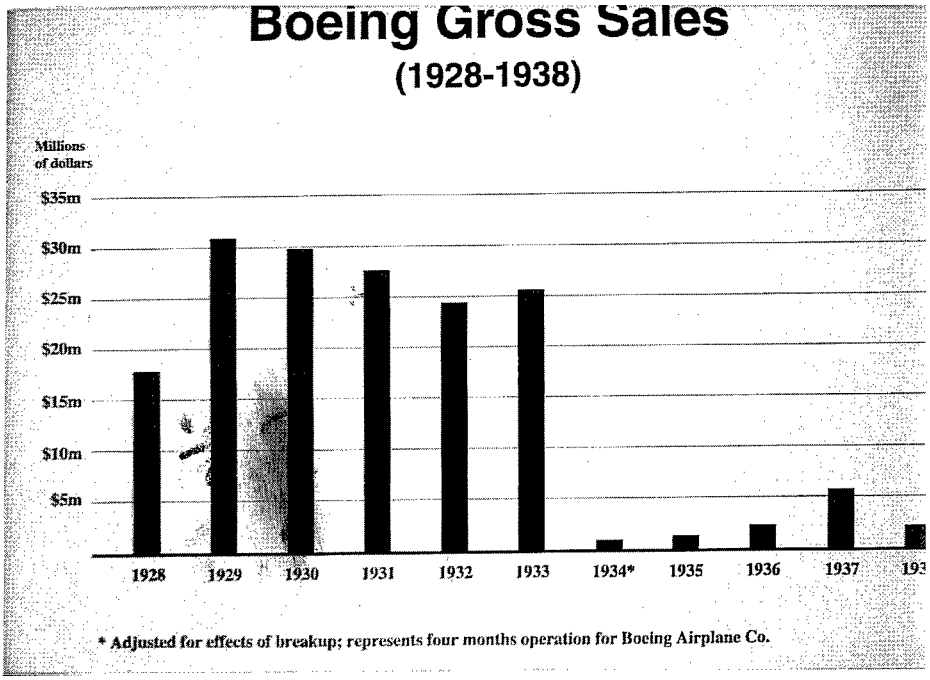


Figure 10. Boeing gross sales during the period 1928 to 1938

As a result, Egtvedt gave top priority to his company's experimental Model 299, which would eventually receive the Army designation B-17. With its focus once again turned to defense business for survival, Boeing would soon use this legendary airplane to establish itself as the prime American builder of multi-engine military aircraft for more than two decades.

4. Post-World War II

One of the "machines" that powered Boeing's emergence as the premier builder of multi-engine bombers was World War II, which also paradoxically resulted in yet another significant challenge to the company's survival. But I'm getting ahead of myself.

Back in the late 1930s, Boeing continued to pursue commercial options with its Model 307 Stratoliner, and Model 314 Clipper, which was built on the company's earlier seaplane experience and evoked a truly romantic image of overseas air travel. But only a total of 21 of these two airplanes were built and the company bet on the B-17 to be the vehicle for returning Boeing to a pre-1934 level of prosperity.

The bet paid off because the B-17 turned out to be the right airplane in the right place at the right time. World War II ultimately created a demand for 12,726 of these "Flying Fortresses" - so many that the Army pressed Lockheed and Douglas into making them as well as part of a unique manufacturing partnership. I'm sure there are still some people alive here in Scotland who remember seeing B-17s overhead during those dark days a half-century ago. Unfortunately, only a handful of these grand airplanes are still around - one of them at the Seattle Museum of Flight.

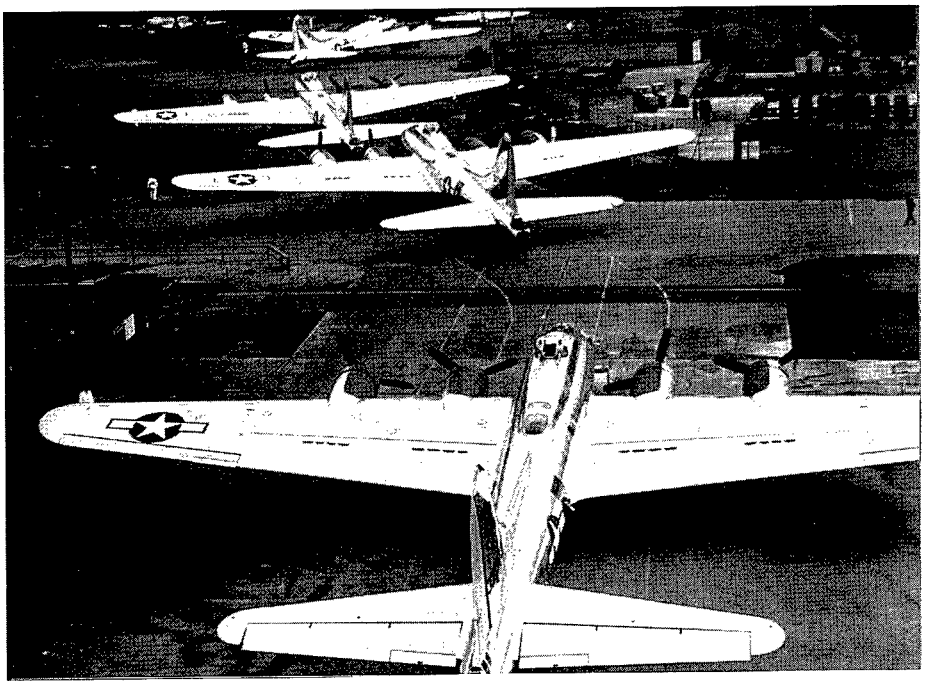


Figure 11. The Boeing B-17 "Flying Fortress"

As B-17 production intensified, Boeing began development of the first "superbomber" in the form of the XB-29. Ultimately, 3,627 B-29s were built by Boeing, Bell, and Martin as part of another shared wartime construction arrangement. Because of their greater range and payload, B-29s were used almost exclusively in the Pacific Theater of the war and were ultimately immortalized when two of their kind - the "Enola Gay" and "Bockscar" - each dropped an atomic bomb.

Boeing assembled B-29s at its Renton plant near Seattle and at its Wichita facility, which was acquired as part of the agreement that let Boeing keep Kansas-based Stearman Aircraft after the 1934 breakup. Stearman produced a popular biplane trainer called the "Kaydet," of which more than 10,000 were built.

Needless to say, wartime production sent company sales through the roof. In 1944, Boeing revenue peaked at more than $600 million - fully 20 times the largest amount ever generated in any one year during the United Aircraft & Transport era.

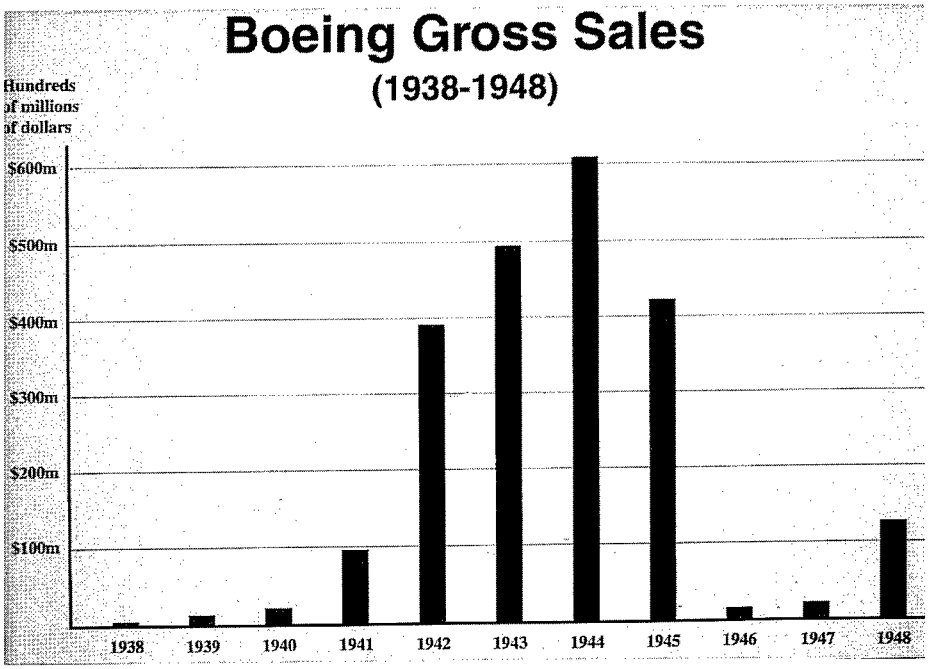


Figure 12. Boeing gross sales during 1938 to 1948

But with the end of the war in August of 1945, Boeing abruptly found itself without a market for its two key products. V-J day resulted in the cancellation of more than 5,000 B-29s still on order, and B-17 production ceased altogether. The resulting impact was predictable: Boeing employment plummeted from a wartime peak of more than 44,000 to less than 7,000 - all in the same year.

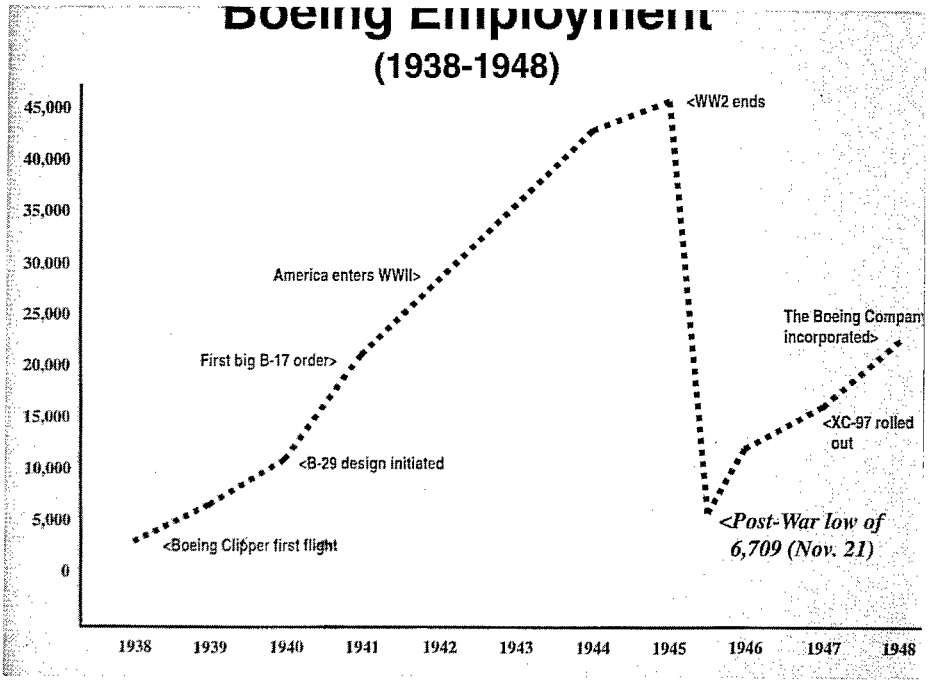


Figure 13. Boeing employment durig 1938 to 1948

Newly-named Boeing President William Allen told employees still on the payroll that non-aircraft production would be likely in order to keep the company going At one meeting, an employee noted that people needed washing machines. But while the exact reasons were never quoted, it's not difficult to guess why the company failed to pursue efforts to diversify into any area other than commercial aviation. Airplanes were what Boeing knew best, and the lessons of the First World War were also still there to remind a new generation of Boeing executives.

In the immediate post-war period, Allen pinned the company's hopes on the Stratocruiser, which borrowed heavily from the B-29. In November of 1945, Pan American Airways placed the first - and largest - order for 20 Stratocruisers as part of a

$25 million deal that was hailed as the opening of a new era in global mass transportation. The Stratocruiser could accommodate between 55 and 100 passengers on flights ranging as far as 4,600 miles. It included sleeper bunks and a luxury lounge on its lower deck.



Figure 14. The Boeing Stratocruiser

But in a series of events reminiscent of the Model 247, only 56 Stratocruisers were sold in the face of stiff competition from the Lockheed Constellation, and the Douglas DC-4, and Boeing once again turned to the defense market for salvation.

Fortunately, the company had also developed a military version of the Stratocruiser in the form of the C-97, which ultimately proved to be quite successful in both the cargo and aerial tanker version seen here. Employing a Boeing-developed flying boom, the KC-97 revolutionized aerial refueling at a time when the American military desperately wanted to extend the range of its strategic bombers. More than 800 KC-97s would be built by Boeing, helping to enable the company to slowly increase employment and improve sales to levels approaching wartime highs.

Boeing also used a defense program to soar into the jet age when it rolled out the first B-47 bomber in 1947. With its swept-back win and six jet engines, the B-47 represented perhaps the most radical departure ever from traditional aircraft design. Even so, the Cold War was on and the new U.S. Air Force liked the airplane sufficiently to order 2,032 of them and bridge the strategic bombing gap until the airplane it really waned - the B-52 - arrived on the scene in the mid-1950s.

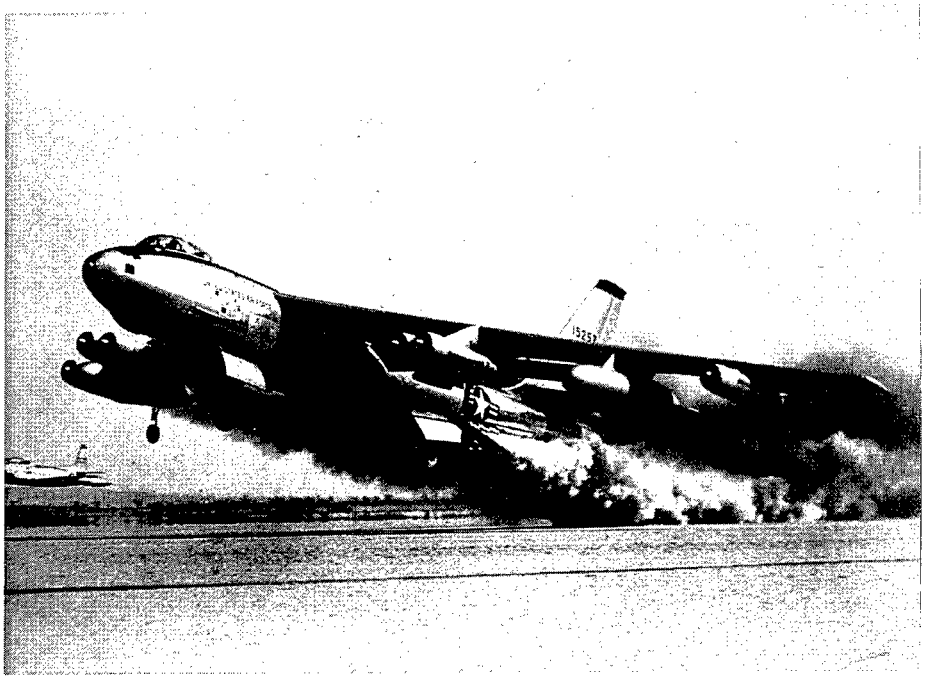


Figure 15. Boeing B-47bomber

The Boeing B-52 grew out of a 1946 requirement for a new propeller-driven heavy bomber, but as the B-47 was shattering conventional wisdom, it became apparent that this new airplane would also have to be jet powered. In one of the truly legendary stories of aircraft design, a group of Boeing engineers closeted in a Dayton, Ohio, hotel developed an entirely new eight-engine bomber during a weekend in 1948. They even carved a scale model from balsa wood obtained from a nearby hobby shop so that they could present their design at nearby Wright Field first thing Monday morning. Boeing ultimately built 744 B-52s, some of which are still in service.

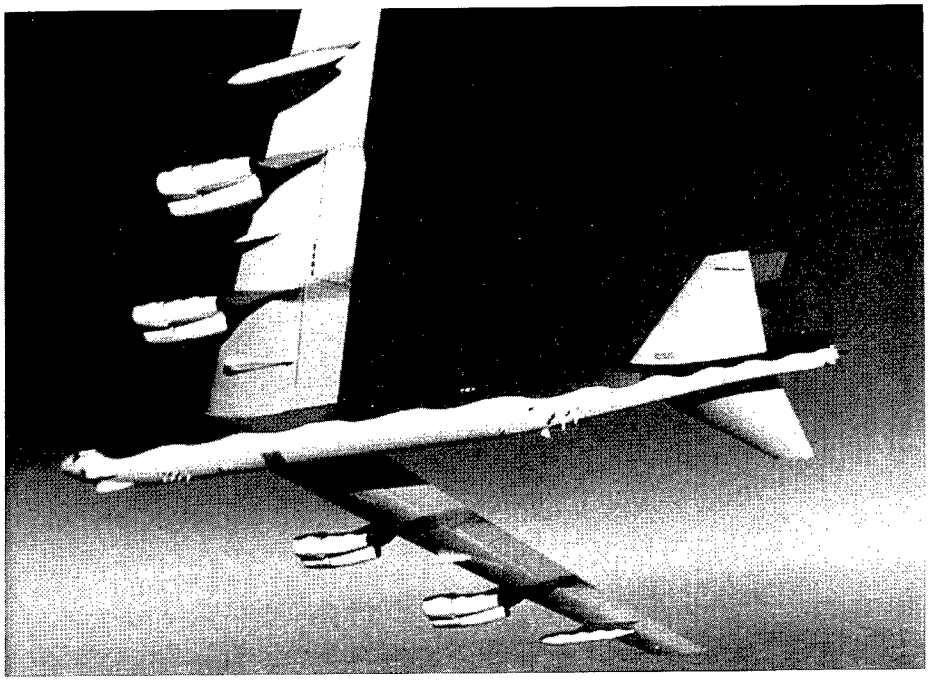


Figure 16. Boeing eight-engine B52 bomber

In 1954, a particularly significant event occurred for Boeing when it unveiled the so-called "Dash-80" prototype jet transport. Even though it ultimately led to the legendary 707, its initial purpose was to sell the Air Force on the idea of a jet transport/tanker to go with its new jet bombers. At the time, most airlines were still firmly wedded to the propeller and William Allen knew it would be a hard sell to convince them to make the leap to jet power. But he envisioned a strong military need for a jet transport, which was ample justification for the company to invest $16 million of its own money to build a prototype.

Allen's assessment proved accurate because while it would take 17 months from the Dash-80 rollout for Boeing to receive its first commercial order for a 707, it took less than three months for the Air Force to place its first order for the KC-135 tanker variant. Ironically, Lockheed won the design competition for a jet tanker, but Boeing was so far ahead at the time that it could make delivery guarantees that no other company could match. Boeing ultimately built 820 jet tanker-transports of this model, most of which are still in service with the U.S. Air Force.



Figure 17. Boeing KC-135 tanker-transport

As an aside, you might wonder why the original prototype, which proved to be so important to Boeing's success in the jet age, was called the Dash-80. In keeping with the company's constantly returning defense focus, this airplane was, in fact, first envisioned as a replacement for the KC-97,which was referred to within Boeing as the Model 367. Partly to maintain secrecy, the new jet retained the same model number, with the final design being the 80th variation. Thus, the new jet transport bore the Boeing model number 367-dash-80.

With production of KC-135s and B-52s in full swing, the company also embarked in the 1950s on what would be the first of many guided missile programs. Its "ground-to-air pilotless aircraft" - or GAPA - led to Boeing building 631 Bomarc missiles to protect the United State from invading bombers or missiles.

With the help of the Cold War, Boeing was once again firmly established as a major defense contractor, and would be for most of the 1950s, enabling it by 1955 to top the $1 billion mark in sales for the first time - and by 1957 to top the 100,000 mark in employment for the first time.

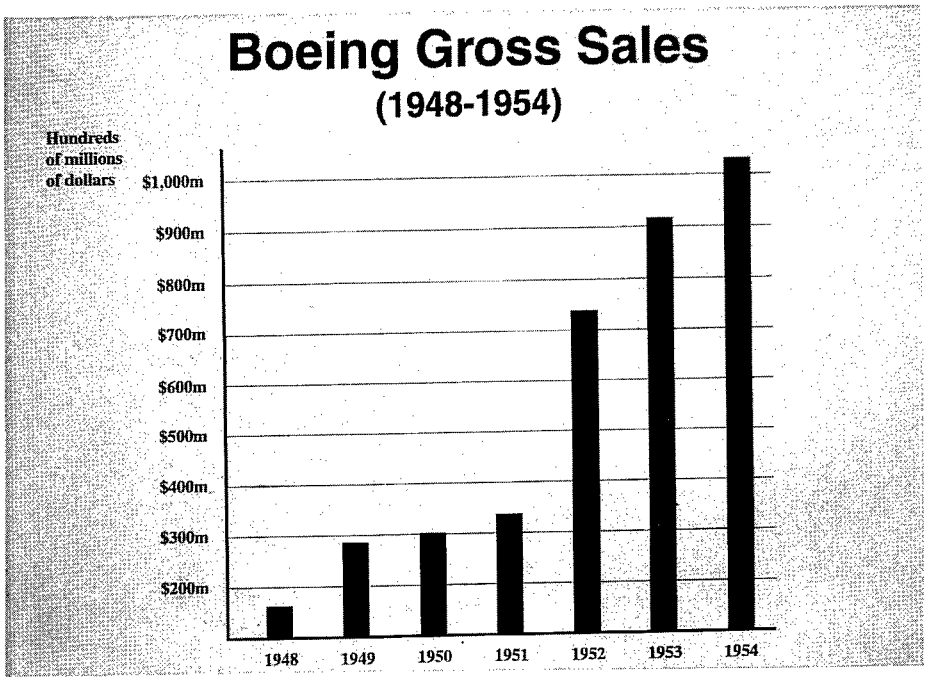


Figure 18. Boeing gross sales during 1948 to 1954

5. Early 1970s Recession

For virtually all of the 1950s and 1960s, Boeing was heavily involved in government work - both for the military and space program - but it would all come crashing down in the form of an event still known around Seattle as the "Boeing Bust" - and one strongly linked to an early 1970s recession in the airline industry.

By 1968, The Boeing Company employed more than 148,000 people, and while it was no longer building bombers or military transports, its commercial business had finally taken hold with the growing popularity of the "700" series of Boeing airliners, beginning with the 707 shown here at rollout.

Even so, Boeing was still firmly entrenched in the defense business. Based in part on the success of the GAPA seen here, and the Bomarc program of the 1950s, Boeing had won a major contract in 1960 to produce 1,000 Minuteman intercontinental ballistic

missiles. Still active today, this project turned out to represent just about the longest-lasting military contract ever received by Boeing, and perhaps its most complex. At its peak, nearly 40,000 Boeing employees were assembling the missiles and designing and building the launch-control centers.

In the same year the Minuteman contract was first awarded, Boeing got back into acquiring subsidiaries for the first time since the breakup of United Aircraft & Transport with the purchase of Vertol Aircraft Corporation and its subsidiaries. Vertol traced its roots back to 1943 when engineers Frank Piasecki and Howard Venzi began developing twin-rotor helicopters. By the time Boeing purchased the company in 1960, Vertol was developing what was to become its most famous helicopter - the Chinook.

Eight years later, Boeing was also heavily involved in the government-financed space program, particularly the Apollo manned mission to the moon. Boeing had built this lunar orbiter and others like it to first map the moon's surface; then built the first stage of the giant Saturn rocket that would be used to get the Apollo astronauts to the moon; and finally would build the lunar rovers they would use to get around on the moon once they got there. Boeing also served as the overall technical integrator and coordinator of the Apollo program, at the request of NASA.

These were certainly heady times for Boeing, but unfortunately the need for the company's involvement in Apollo had diminished considerably by the time this Boeing-built lunar rover was roaming about the moon. To make matters worse, a recession gripped the commercial airplane market and Boeing executives saw deliveries for 707s, 727s, and 737s drop from a then-record 378 in 1968 to just 97 four years later. For one 17-month period, Boeing failed to win a single order from any U.S. airline.

During this same period, Boeing was trying to launch its new 747 jumbo jet after incurring several years of huge developmental costs, including the construction of an entirely new wide-body manufacturing facility that boasted - and still does - the world's largest building by volume. While the 747 would ultimately change the very nature of air travel, it would be several years before it would really "take off" to become the major money maker for the company that it is now.

Boeing was also trying to build its first government-sponsored supersonic transport during this time. Though not necessarily a major blow in and of itself, the 1971 cancellation of the SST program for largely environmental reasons served to punctuate what become known as the "Boeing Bust" and helped fuel perhaps the company's most widespread attempt to diversify beyond its traditional aviation markets.

There was certainly ample motivation for Boeing executives to attempt to convert some of the company's technologies and expertise. By the end of 1971, they had to slash employment from a 1968 high of 148,672, to less than 54,000 - a loss of two out of every three jobs. A famous billboard at the time asked the last person leaving Seattle to please turn out the lights. While conditions didn't get that bad, they were certainly bad enough for Boeing, which, at one point, suffered a negative cash flow and was $1 billion in debt.

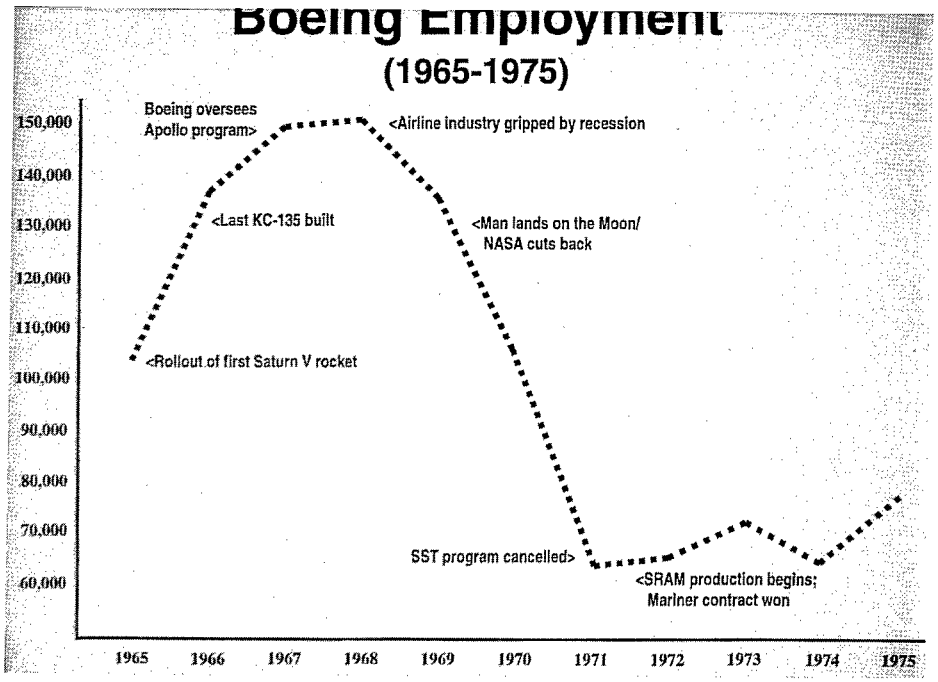


Figure 19. Boeing employment during 1968 to 1975

Then-Chairman T. Wilson declared that Boeing would explore "every possibility" for broadening its business base, which resulted in a vast expansion of subsidiaries beyond the three that existed prior to 1969.

Among the first ventures pursued by the company was a computer services subsidiary to take advantage of the expertise developed during such programs as Apollo. Besides supporting other Boeing divisions, this subsidiary sold hardware and software programs to government agencies and private industry. It also established computer training centers throughout the U.S., and it offered time-sharing computer service. At the outset, T. Wilson acknowledged that computer services would involve a whole new way of doing business.

By 1971, Boeing was also involved in such "non-traditional" businesses as joint-venture water reclamation and desalination projects through two subsidiaries - Boeing Environmental Products and Resources Conservation Company. It was also irrigating Oregon farm land that was originally planned for use to test rockets, installing digital controllers on the generators of a Montana hydroelectric dam, and developing various mass transit concepts for some of America's cities.

Within the company, the Naval Systems Division was pursuing the market for hydrofoils that would lift a boat out of the water and allow it to cruise more smoothly and rapidly than a conventional hull would. Besides developing missile-carrying vessels for the U.S. Navy, Boeing also introduced the "Jetfoil" pictured here as a commercial passenger-carrying boat. On land, the company began building mass transit rail cars. Some of these were for a Boeing-managed automatic personal rapid transit system in Morgantown, West Virginia, while others were installed in Boston, Chicago, San Francisco, and at the Okinawa World's Fair.

The list of subsidiaries and non-traditional ventures continued to grow in 1973 and while some - like Boeing Financial Corporation - were directly involved with traditional airplane sales, others were not. The Keenwood Corporation, for example, was a housing finance operation. Though not listed here, Boeing also about this time incorporated a venture in its Aerospace Division known as the Institute for World Needs, which was set up to research mankind's problems. It never did and was dissolved by 1979. The Keenwood Corporation, by the way, was dissolved two years earlier.

Making use of its experience with electronics, Boeing developed this police voice scrambler, which was designed to prevent the crooks from listening in on conversations between law enforcement officers. As this advertisement notes, Boeing then had thousands of engineers at work on "new systems and inventions that can make this a healthier place to live." Unfortunately, the market for scramblers never matched the company's expectations and production eventually ceased.

Another subsidiary established by Boeing during this period was an Agri-Industrial company, which managed the rapidly expanding farming/ranching/industrial complex on 100,000 acres of leased land in Oregon. Some of the company's employees were literally learning how to grow plants.

But no matter how bizarre some of the company's diversification attempts seemed, they were often rooted, as I mentioned earlier, in some previous aspect of the company's business. In the case of managing housing projects for the Department of Housing and Urban Development, for example, Boeing had gained experience in this area while establishing Minuteman missile bases. And the Boeing Engineering and Construction Company merely applied expertise gained on Boeing plant expansion projects to energy and environmental projects outside the company, including the largest wind-powered turbines ever built. B.E.& C. also sold a portable asphalt plant.

But even in those dark days of the early and mid-1970s, Boeing never gave up on seeking defense work. In fact, it was this very type of work that really helped keep the company going at a critical time, such as when it got a U.S. Air Force order for 19 of these 737s to be used as navigation trainers, breathing new life into this particular production line. Also coming at the right time was another Air Force contract to build a new short-range attack missile as well as a NASA job to build the Mariner 10 space probe.



Figure 20. Boeing as a Agri-Industrial company

Yet another big job that landed in Boeing's lap at a critical time was the 1970 contract to build AWACS, which married a 707 airframe with a sophisticated look-down radar system. Still other Boeing employees were assigned to develop avionics for the B-1 bomber, and the 747 program got a shot in the arm when the U.S. Air Force ordered four of them for use as airborne command posts.

Throughout the 1970s, Boeing recovered in the only way it could - slowly. It was still building helicopters, the Minuteman, and SRAMs, along with a new Air-Launched Cruise Missile for the Air Force, and it later kept busy modifying Boeing-built KC-135 tankers, like the one seen here, with new engines and other systems - perhaps not as glamorous as building a new airplane, but substantial work, just the same.

As commercial sales also improved - thanks largely to a low-cost scheme to modernize the 727 and create new customer interest - so did the employment picture. From a low of 53,300 employees in 1971, Boeing finished the decade with 102,042 employees after steady, year by year job growth. Revenues were also up - from a low of $2.3 billion in 1972 to more than $8.1 billion by 1979.

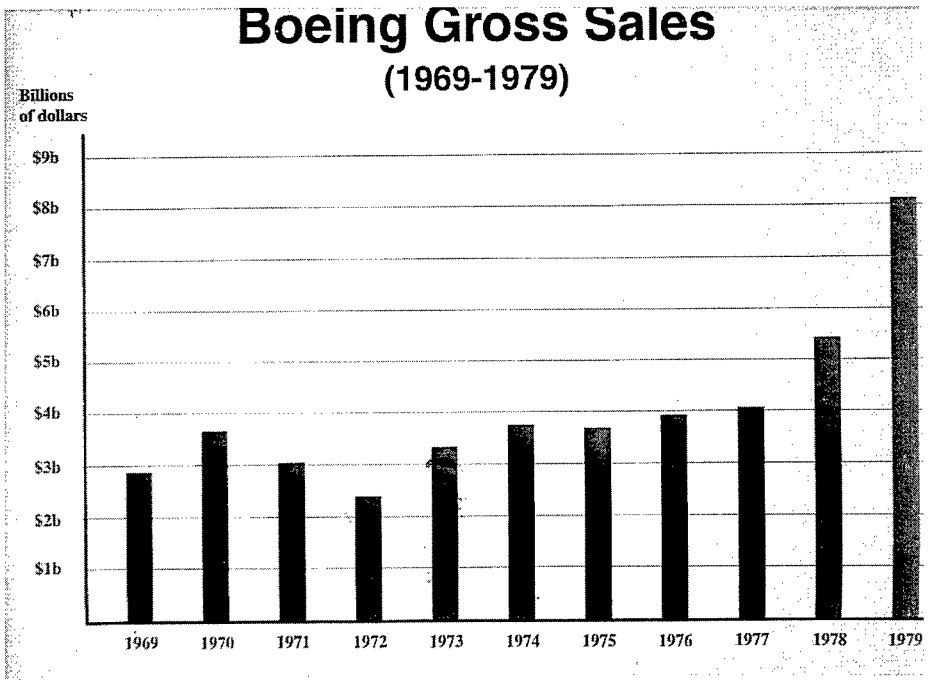


Figure 21. Boeing gross sales during 1969 to 1979

And what happened to all those subsidiaries? With the exception of its computer services operation and possibly its engineering and construction group, virtually all of the company's diversification efforts proved to be only stop-gap measures designed to keep employees occupied until the company's traditional defense and commercial business began picking up again - just as furniture-making and boat-building had been for Boeing employees a half-century earlier.

Boeing was finally out of the housing business by 1986, and a year later it dissolved the same Environmental Product Company that had pursued all those various water reclamation projects. Both the Construction Equipment and Airport Equipment subsidiaries were sold in 1982, and the Marine Systems Division ceased to exist by 1985 after selling only six to the U.S. Navy and 24 to commercial customers. Also by then, Boeing had delivered its last rail car and was out of this segment of the mass transit business.

As former Boeing Chairman T. Wilson indicated in the early 1970s, it is not easy - and perhaps nearly impossible - for a company to try to enter new markets as part of a

conversion or diversification attempt, particularly when those new markets are already populated by companies with existing industry-specific expertise.

In the early 1970s, Boeing established one particular subsidiary in an attempt to capitalize on computing expertise it had gained through a variety of high-tech aerospace projects, including the 1960s space program. While Boeing Computer Services still exists, it is no longer a subsidiary and it no longer engages in selling hardware and software programs such as the heartbeat analyzer it once tried to market. As it did with other ventures, Boeing encountered stiff competition in the already fast-paced computer industry and discovered it was often trying to operate in areas where it didn't really belong.

The company's experience with Boeing Computer Services, while perhaps representing the most successful Boeing attempt at defense conversion, still demonstrates the difficulty an aerospace company can encounter when attempting to move outside its traditional business base. After 25 years, this organization is now primarily focused on providing the kind of sophisticated computer support Boeing engineers need in order to develop high-tech defense products such as the F-22 advanced fighter.

Even though Boeing's current financial statement shows a majority of its revenue coming from commercial transport sales, it still remains committed to pursuing the same defense business that founder William Boeing first sought for his young company 79 years ago.

POLICY DRIVERS AND ISSUES IN EUROPE

Facts and Figures

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Abstract. *This Panel considered in detail the background to defense conversion strategies in five varying European countries - Russia, the UK, Germany, Spain and France - in terms of the perceived drivers of local change, the issues of policy and management that result, and the main facts and figures indicating the scale and direction of change.*

1. A Framework for Discussion - Peter Healey, Science Policy Support Group - UK

Figure 1 shows a framework for discussion of policy drivers and issues in Europe, reiterating some points made earlier by Professor Gummett. In the framework four major drivers - geopolitical change, Europeanization, and pressure for both economic competitiveness and increased military competitiveness - can be seen, singly and in combination, as prompting a range of issues.

Of the drivers, Geopolitical change, in terms of the ending of the East-West military confrontation in the cold war and the collapse of European socialism, can be said to have had the major single impact. Instead of an ideological competition between two major blocks we now had radically new sets of agendas and competing and collaborating partnerships in Europe. Their military consequences were the substitution for the earlier single predictable threat of a newly perceived series of diverse risks - national, ideological and religious terrorists, drug barons, and regional conflicts.

In some cases the perceived change does represent genuine new developments. The increased propensity for regional conflicts appears in part to be driven by national identities which seems stronger once the larger forces of the former ideological conflict were removed - forces that had a certain unifying role *within* the ideological camps - and now that smaller jurisdictions have the opportunity to compete for the political space left vacant by the Soviet Union. In other cases change may be largely a case of change of perception: the finer detail of possible world conflicts - including the risks associated

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with nuclear proliferation - may simply be more evident to us once the larger polar conflict scenario is cleared away (as suggested by Professor Mike Gibbons).

The changing patterns have left defense forces more interested in the speed and geographic range of their response to the uncertain pattern of threats: rapid reaction forces, available out of area. They have a prompted a new policy interest in conversion, not only as a one-way street from military to civil, but as a broader concept of *convertibility*, including the capacity to gear up to rapid military production to meet the unexpected should peace dividends not prove permanent. And as the peace dividend takes effect they have focused attention on regional issues of training and investment to reduce the economic dislocation of plant and site closure. Finally, they have excited interest in verification of arms reduction and destruction, including audit trails for nuclear materials, and given policy attention to the question those involved in work on the social construction of technology have raised about the possibilities of deliberate planning for loss of technological capacity as part of a disarmament process.

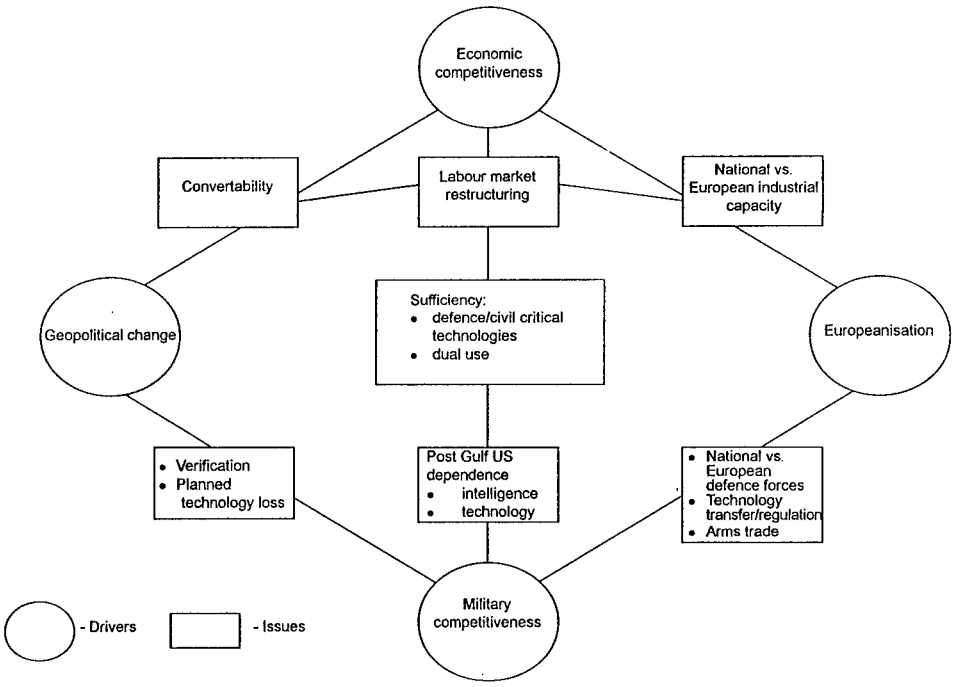


Figure 1. Reshaping the European defense capability

The next driver to be considered is Europeanization. To those of us in Europe, all these changes, which of course demolished a front line in our continent, can be seen to have had a distinctive European character. They have been accompanied by a restructuring, and cross-ownership, of European defense industry, particularly at the second level, below the mostly nationally owned prime contractors; by hesitant steps towards a European common defense and security policy and European defense forces; and by questions of what technical capacities are to be shared within Europe, and between Europe and the widening range of countries from which future threats may come.

This brings us on to the two central drivers of Economic and Military Competitiveness. Economic competitiveness is seen as a key defense and civil issue now. With the techno-economic capacity which effective competitiveness in world markets brings comes the civil technology base on which much contemporary military kit depends, and the ability to project diplomatic and ultimately military power. These relationships - and the idea of economic security behind them - raise sharp policy issues about techno-economic sufficiency - about how necessary it is, about how it can be developed and maintained, and what part dual-use research and production facilities, and more procurement policies stressing generic technologies and new technology demonstrators, can play in that process. Consideration of military competitiveness sharpened after the Gulf War, when the West's general dependence on a new generation of sophisticated United States weapons systems and US military intelligence became very evident. Debates in Europe about long-term policies in this area and about shorter-term procurement decisions for new military equipment have notably acquired this dimension of analysis of what might best promote, or least damage, European competitive capacity in military and civilian terms.

These interacting developments provoke interesting questions about the contemporary role of the state. When military technology was seen as *sui generis*, or even leading civilian innovation, and at a time of perceived sustained threat from the other armed camp in Europe, there were few fundamental political questions raised around the using of high level of public resources for defense R&D and defense procurement. This expenditure may have had direct spin-off benefits for the civil sector, but may also have helped more generally to develop and maintain leading edge technological skills that contributed more generally to economic competitiveness. Now the much more politically and economically sensitive question arises as to whether, looking at conversion in its most strategic sense, the state has a role in civil or dual-use technology development that may help incubate or maintain new technologies. Can the state do this without stunting the free market's ability to deliver these technologies in an efficient way that enhances the international competitiveness of the producer, and thus enhances also its ultimate ability to project economic or military power?

2. Defense Conversion in the Perm Region of Russia - Tarja Cronberg, Technology Assessment Unit, Technical University of Denmark

This region has traditionally been very defense-dependent, with 40% of industry concentrated on defense. Some key indexes are:

	1991	1994
defense production	93.6	11
civil production	105.9	134
production value of consumer products (in constant roubles)	101	107
employment	93.6	70.2

The general changes taking place in conversion in Russia can be seen in Figure 2 as a variant on the original framework for the Panel. There was an element of vicious circle about the adjustments taking place, with long-term structural unemployment likely to be one outcome.

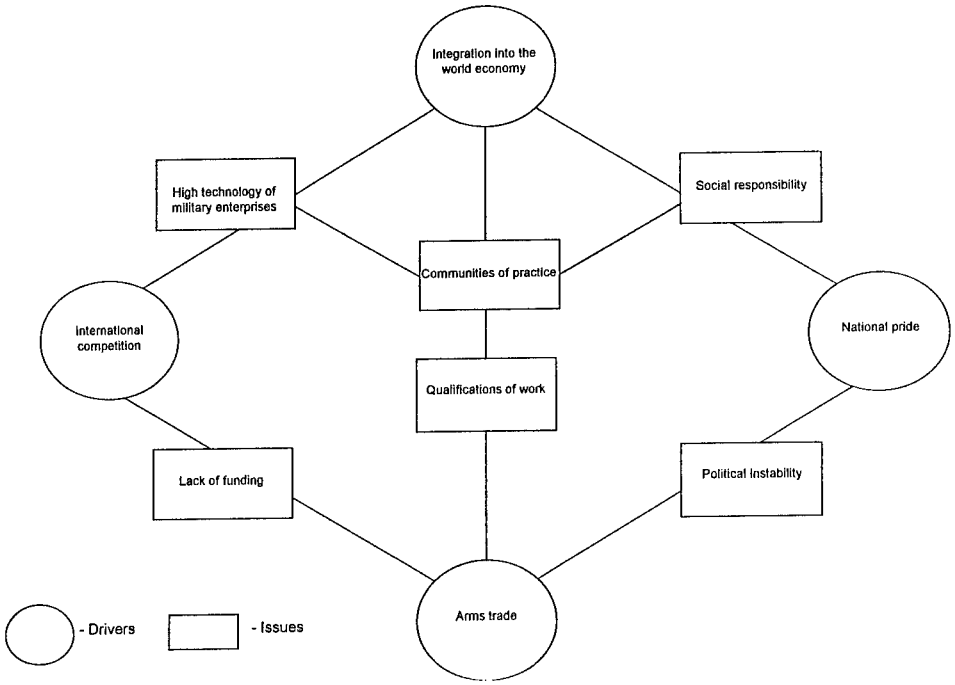


Figure 2. Reshaping the Russian defense technologies

The goal of conversion is integration into the world economy using the high-tech of the military enterprises. This process is hampered by a complex set of factors, which include:

- the traditions of practice in military communities i.e. the scientists'/engineers' way of thinking;
- the historical fact of the social responsibility of Russian enterprises in general and especially defense enterprises; and
- international competition in the civilian field (consumer products, investment goods).

In discussion of the presentation, members of the Russian delegation warned about the potential for the unreliability of source data and gave their view that the process taking place in regions of high defense dependence was not so much conversion but wholescale destruction of technological capacities and employment prospects.

3. The UK Case - Professor Philip Gummett, Preset, University of Manchester, UK

The context of change in the UK is a major review of defense needs, taking account of the reshaping of NATO, maintenance of a nuclear force; maintenance of high-quality multipurpose armed forces, and the growth of peacekeeping operations, with a debate in progress about future defense architecture in Europe.

The main *facts and figures* are:

Armed forces:	reduced by about one third between 1991 and 1997.
Defense budget:	in real terms (1993/94 prices) down from £26B in 1991/92 to £20B in 1997/98, then stabilizing. This represents a fall in proportion of GDP from 4.2% to 2.8%.
Def. procurement:	now at £9.6B - not much changed, possibly slightly increased.
Military R&D:	now £2.5B - showing a 8.5% decline between 1989-93, but with some measure of protection of research in the period between 1987-2000, when D is due to fall by a third and R by only 15%.
Employment:	unclear, but at least 30% down since 1990, for example drop in staff of BAe Dynamics from 16,500 to 2,500 between 1990-97. The official claim is a loss of 400,000 jobs directly or indirectly, but this figure hasn't changed recently and may be too high.

The main UK *issues* are:

For industry: Survival creates the need for restructuring, to gain the advantages of scale and advanced technology, but it is unclear how far the basis of this will be with the US or in Europe. The main factors currently in play are:
- the future of NATO, and how close the US will stay to Europe;
- the growth of a European defense identity; and
- the role of procurement policy, which may relax competition, or favor Europe.

For government: Ministry of Defense needs to maintain a reliable supply of high quality and affordable equipment. Government may:
- modify competition policy a little to reflect some concern about the survival of the industrial base, or
- possibly tilt towards Europe.

Conversion is not seen to be part of government's concerns, but best left to the market. The minor exceptions to this are:
- Department of Trade and Industry seminars on conversion, and
- some small assistance to the geographically isolated area of Barrow-in-Furness.

4. The German Case - Peter Lock, European Association for Research in Transformation, Hamburg, Germany

As far as employment in defense production was concerned, the figures were:

Height of the 1980s: 300,000
1995: 120,000
prediction of the near future base: 100,000 or a bit less

Cuts can be seen as much sharper in Germany rather than in Britain or in France. This is largely a result of unification which imposed a "double burden" on German defense: first, on the general position of government finances, and second, by requiring the restructuring of the armed forces. These restructuring costs were met by the armed forces within their existing budgets; this in turn pressured the only really flexible budget item, procurement, which operated in a very constrained financial situation. German procurement was halved, through a combination of a deliberate policy of downsizing, and these severe budgetary constraints unique to the German situation.

Nevertheless, a confidential periodic Ministry of Defense review of defense production capabilities concluded that the country was not likely to lose defense technological capabilities in the next few years, at least as a result of these financial constraints.

To compensate for the reduced level of national orders required an ad-hoc industrial policy. The government had to introduce sectoral export policies which contradicted the declared policy of export restraint. The most visible examples have been naval exports and their tacit promotion via credit guarantees. The politically accepted cascading of equipment in support of smaller NATO countries, namely Turkey and Greece, was also used to support the naval and tank industries.

Industry has been restructuring in anticipation of a European defense market and in order to meet the challenge of global competitiveness, although this process started late and was politically sensitive. The political sensitivities from Germany's past also meant that Germany never created a centralized defense research agency. However, there were benefits: because it abstained from nuclear weapons, it avoided the culture of defense technology secrecy associated with them, and was able to create a successful organization, the Fraunhofer Gesellshaft, that has developed a good mixed funding and role between government, academia and industry. Fraunhofer institute funding is now split: 1/3 core funding - from the Ministry of Research; 1/3 government contracts won; and 1/3 industry contracts.

The industry funding brings a market element into institutes that have developed this diversified funding mix from a situation in the 1960's and 1970's when funding was predominantly defense based.

In looking at the downsizing and restructuring of the German defense industrial base, distinctions have to be drawn between three types of company:

> *The Bavarian type*, classically having its origins in the successful lobbying by F-J Strauss for defense contracts as a base for industrial development. Currently undergoing restructuring and takeovers. Losing 50-60% of their staff and introducing new civilian product lines and environmentally safe methods of decommissioning weapons systems in the hope of tapping subsidized markets in Eastern Europe.
>
> *Companies operating at the NATO level* which had established a civilian heritage before 1955, when Germany was able to resume arms production, as well as a strong tradition in military production until 1945. During the late 1970's these had typically diversified by asset acquisition.
>
> *Transnational global giants*, such as Daimler-Benz and Siemens. Defense interests had a place in such companies, the military share in turnover hovering around 5% or less. A wave of concentration in anticipation of the integrated European market and in the case of Daimler-Benz of diversification away from the manufacture of automobiles gave the two giants control over more than half

of the German industrial base. In the naval sector Thyssen, the large steel conglomerate, is playing a similar role. Both Daimler and Siemens pursue a policy of 'Europeanising' their defense related branches, Daimler with Aèrospatiale and Siemens with GEC-Plessey, partially closing down facilities in Germany.

The naval sector has had several success stories, all of them involving private capital. Blohm and Voss built the MEKO frigate, based on a product architecture derived from advanced civilian shipbuilding, whilst smaller yards like Lürssen successfully established themselves in the fast patrol boat sector on the basis of private risk capital rather than exporting government subsidized designs.

German manufacturers also have a strong position at the level of components and subsystems where there is considerable communality with civilian products. Given increasing cost constraints and the fact that civilian industry is becoming increasingly the dominant driver of innovation, this strong opportunity for civilian market leaders to win large segments of the value added in military production is likely to strengthen further. At present heavy diesel engines, heavy gears and transmissions, but also electro-mechanical components and above all, electronic chips demonstrate a clear transnational dominance of the civilian market leader replacing traditional national second tier suppliers.

5. The Case of Spain - Jordi Molas-Gallart, Science Policy Research Unit, University of Sussex, UK

Scale. This is a very small country in defense terms, with a defense industry having only 30,000 - 60,000 employees, depending on estimates, with defense goods comprising only about 1% of industrial product, and with a defense budget taking up less than 2% of GNP. These figures alone make conversion problems in Spain different from the other cases presented in this panel.

Policy drivers. The mid 1980s was the first time Spain had a defense industrial policy, with two objectives:

- to develop sufficiency in military production "to the greatest extent possible";
- to use military demand to strengthen the domestic technological base.

Four measures were planned to meet these aims:

- a minimum 4% per annum growth in procurement budgets
- acquisition policy favors buying Spanish and, if not, collaboration on offset agreements

- defense R&D budgets was to be built up from negligible to almost 25% of total government R&D budgets by 1989
- defense exports were to be supported

By 1989 this policy had collapsed under the pressures of geopolitical change and domestic economic crisis. Largely due to economic drivers, the defense market collapsed in four years. Between 1989 and 1993 Spanish defense procurement fell by 32%, exports collapsed (between 20% and 90% according to source), and defense R&D at first levelled off then fell. The net result is a fall in military production of between 30-40%, with very different patterns across sectors (munitions falling by 90%, but aerospace fairly stable).

The response to change. There was no explicit government policy to these changes.

In industry there was no conversion in the strict sense and little diversification policies. In any case firms were forced to rebalance the defense-civilian mix, and accept specialization in components and subsystems within the framework of international production.

The changes over time in the relationship between military systems, subsystems and components in the Spanish system can be summarized figuratively:

The technological base between civil and military can be seen to be more common at the level of components. By moving down the production hierarchy, Spanish military-related industry may, inadvertently, have introduced an effective capacity for diversification.

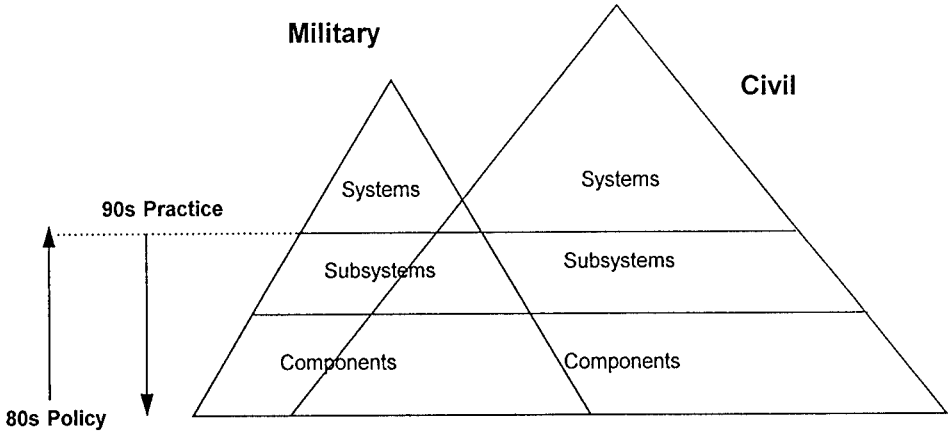


Figure 3. Spanish policy and practice in managing defense industrial capacity

6. The Case of France - Roland DePenaros, Centre for Marine Law and Economics, University of Brest, France

It is necessary to distinguish between the "official position" on French defense policy and the reality. The 1994 White Book on defense, prefaced by the then Prime Minister and Defense Minister, gives the official position:

- France maintains her current effort on defense at least until the end of the century;

- This implies that all the main defense programs would be maintained. These are:
  - Rafale aircraft program (86 for the navy and 234 for the air force). Estimated cost - 257 billion francs at 1993 prices.
  - Leclerc tank (650). Estimated cost 260 billion francs at 1993 prices.
  - Nuclear powered aircraft carrier *Charles de Gaulle*. 22 billion francs excluding aircraft.
  - Tigre (210) and NH90 helicopters for an amount of approximately 85 billion francs at 1993 prices.
  - Second, third and fourth SNLE (nuclear missiles launcher submarines of the Triomphant class) at 82 billions
  - Nuclear ballistic missiles M45 and M5 whose costs are estimated at 36 billion and 48 billion francs respectively (excluding the estimated 4 billion francs cost in adapting each submarine for the new missiles).

The Pecht Parliamentary Report of 1993 already denounced the financial unreality of such schemes. Yet this official policy for the next five years is due to be expressed in a financial military programmation law which was voted by the French Parliament in spring 1994.

The reality is quite different, with the defense budget diminishing for the last 5 years for between 4-8% per year in real terms. In 1960 defense expenditures represented more than 6% of GDP; it is now less than 4%. Furthermore, the Juppé government has decided to push through an additional budget law for 1995 in which the defense budget will be reduced by up to 8.4 billion francs. Since wages cannot be cut, and it is considered dangerous to reduce R&D expenditure, this means a reduction of 8% in equipment procurement. This makes it clear that last year's military programmation law will not be applied, and it is now a matter of that law being reconsidered. In consequence, the M5 program, the fourth SNLE and the future large aircraft are all likely to be canceled, and other programs under construction postponed. In addition, the *Charles de Gaulle*, which was originally due to be finished in 1996, but will probably now not be completed until the second half of 1999, unless these recent cuts postpone its commissioning until the next millennium.

The reduction in procurements is not good for the French arms industry because the State is by far its biggest customer. The situation is worsened by the fact that since the Gulf war French industry has lost its previous best export industry, Iraq. Between 1989

and 1993, export of conventional arms fell by 66% (from 2.8 billion dollars to 945 billion dollars, 1989 prices). As a result of this market loss, French arms industries have had reducing turnover since 1990.

There are four main consequences of this reduction of military activity:

- it contributes to the maintenance of an element of conversion, particularly in the aeronautics sector where it had already started;
- it fosters research into new export markets;
- it encourages the regrouping of companies on a national or European basis; and
- last but not least, considering the historic dominating role of the State in this sector, it is accompanied by the disengagement of the State from the field of industrial defense activity. At the same time we are seeing a 'demilitarization' of the State industrial establishments and a process of opening the nationalized companies to private capital.

THE ECONOMICS OF DISARMAMENT AND CONVERSION

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Abstract. *Disarmament involves reductions in Defense spending. The conversion challenge is to achieve a re-allocation of resources from the military to the civilian sectors of the economy. Questions arise as to whether disarmament and conversion raise special problems unique to the Defense sector. A starting point in any analysis requires a definition of the Defense industrial base. Disarmament is then analyzed as an investment process involving costs and benefits. The problems, costs and prospects for conversion involving both Defense industries and Armed Forces are analyzed and various policy options are reviewed.*

1. Introduction

Disarmament involves major reductions in Defense spending. It creates the associated challenge of successfully re-allocating resources from the military to the civil sectors of the economy. The prospects of a Peace Dividend arise from a reduction in so-called "unproductive" military activities allowing the resources released to produce more hospitals, schools or roads, or to lower taxation allowing greater private consumption (e.g., cars, videos, housing, etc). Attractive though this re-allocation appears, it is not without its problems. Questions arise as to whether such a change is socially desirable bearing in mind the time required and costs involved in adjusting to change, and whether the potential losers will be compensated or otherwise form major interest groups opposed to disarmament.

This Chapter focuses on the problems of defining the Defense industrial base, the costs, benefits and prospects for conversion in both Defense industries and the Armed Forces, and the policy options. At the outset, consideration needs to be given to whether disarmament and conversion are special and unique problems and who are the likely gainers and losers from such changes.

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1.1 DISARMAMENT: DEFINITIONS, CONCEPTS AND UNIQUENESS

Disarmament involves major reductions in a nation's Defense spending. However, such reductions can take a variety of forms, each with different implications for arms races and arms control initiatives. For example, cuts can occur in aggregate Defense spending or in particular components such as Defense research and development (R&D), manpower or equipment; or in specific types of equipment, forces and numbers (e.g., chemical, biological or nuclear weapons; or delivery systems; or numbers of troops, etc); or in the geographical distribution of Armed Forces (e.g., withdrawal from certain regions, such as Germany). This taxonomy is further complicated because cuts in Defense spending can be part of an international treaty between two or more nations or they can be unilateral voluntary initiatives [17].

Reduced Defense spending involves reductions in government expenditure and a supply-side release of resources for alternative uses. The task of finding alternative uses for the released resources represents the broad conversion challenge. In this sense, disarmament and conversion are about the economics of change and adjustment. Such problems are neither unique nor specific to Defense and disarmament. Al dynamic economies are continuously adjusting to changing consumer demands, to new technologies and to the emergence of new sources of supply (e.g., newly-industrializing nations). Change means that firms and industries are subject to growth and decline [10]. Examples include the decline of such UK industries as coal, shipbuilding, steel, textiles, tobacco, pedal cycles and motor cycles and the growth of the aerospace, computer, telecommunications and information technology sectors. Significantly, the declining UK industries are rarely the focus of conversion solutions. This raises the interesting question of what, if any, is "unique and special" about the Defense sector such that it often leads to demands for a conversion strategy to solve the adjustment problem.

In private enterprise economies, one obvious difference between Defense and other industries reflects the role of government. Within nation states, governments are the only buyer of military forces and the major, if not the only, buyer of Defense equipment. Governments can use the buying power of their Defense Ministries to determine the size of their Armed Forces and, through procurement policy, the size, structure, conduct and performance of their national Defense industries [14,6]. In contrast, industries in the civil sector are affected by the demands of large numbers of individual consumers. For example, my decision to buy a Saab motorcar has an insignificant impact on both the losing UK car industry and the winning Swedish car company. But, if a government decides to reduce the size of its Army by 50%. Or to award a major equipment contract to a foreign company, the effects are substantial and visible and can be seen to be the "responsibility" of government.

Figure 1 outlines the economic impacts of disarmament, distinguishing between impacts on the Armed Forces and impacts on Defense industries. All too often, the focus is on Defense industries and their adjustment problems to the neglect of similar adjustment problems for the Armed Forces. There are also likely to be significant

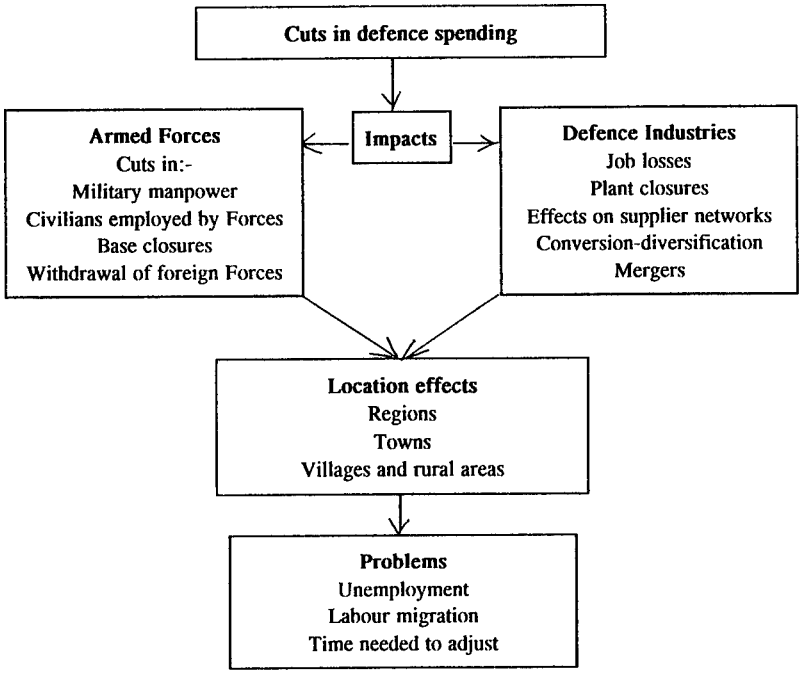


Figure 1. Impacts of Disarmament

regional impacts of disarmament. Some towns and regions might be highly dependent on Defense companies as major employers (e.g., UK examples include Barrow, Plymouth and Yeovil). Similarly, military bases might be major sources of local spending in remote rural areas where there are few alternative employment opportunities. In such rural economies, the closure of a military base will have local multiplier effects reflected in reduced local spending (e.g., local suppliers of services to the base; spending in shops, garages, pubs and restaurants, etc). The initial result will be a depressed local economy with fewer job opportunities, higher unemployment, outward migration and adverse impacts on the local housing market. Over time, recovery in the local economy will depend upon how well and how quickly local labor markets work.

Once the importance of government is recognized as a distinctive feature of Defense and disarmament policy, there will be the inevitable emergence of interest and pressure groups seeking to influence public policy in their favor. Faced with the prospect of the closure of a major military base or Defense plant, there will be pressure for the government to "do something". Government as the buyer of Armed Forces and Defense equipment appears as the sole consumer able to change the fortunes of a local military base or Defense plant suddenly and unexpectedly. All markets are characterized by uncertainty, but the uncertainties in the Defense market result from the decisions of the government as its sole customer. These features increase the attractiveness of lobbying,

since an interest group can easily identify the government as the agent to be influenced. All of which suggests the need for a model of the role of government in the political market place.

1.2 DISARMAMENT AND PUBLIC CHOICE ANALYSIS

The economics of politics and public choice applies standard economic concepts of self-interest and exchange to analyze the political market place comprising voters, political parties, governments, bureaucracies and interest groups [11]. In this model, voters allocate their votes to the party offering the greatest benefits; political parties are assumed to be vote-maximizers; governments seek reelection; bureaucracies are assumed to be budget-maximizers; and interest groups aim to create or preserve monopoly positions (rent-seeking).

A public choice approach to disarmament identifies some of the agents most likely to oppose policies to reduce Defense spending. It shows the types of arguments used by the Armed Forces and Defense Ministries to protect budgets and how domestic Defense contractors are likely to respond to cuts and the cancellation of major equipment programmes. For example, following the end of the Cold War, Defense Ministries and the Armed Forces have focused on out of area threats to national interests reflected in regional arms races in what is presented as an increasingly unstable and uncertain world: hence the need to maintain "strong Defenses" to meet some future unknown and unknowable threats. At the same time, faced with cuts in Defense spending, the Armed Forces as major interest groups will seek to protect their traditional monopoly property rights (Armies protect the land, Navies the sea and Air Forces protect a nation's air space) and their prestige and high technology weapons projects. In return for accepting smaller Armed Forces, the emphasis will be on smaller but better equipped Forces (high technology equipment replacing personnel) offering flexibility and rapid reaction capable of operating anywhere in the world (including contributions to UN peace-keeping missions). As a result, the Armed Forces will obtain a share of the Peace Dividend.

Disarmament means the cancellation of equipment projects, delays in ordering, the "stretching-out" of development programmes and smaller production orders. Defense contractors will become increasingly active in competing and lobbying for a smaller number of contracts. The possibility of awarding a Defense contract to a foreign firm will be greeted with howls of protest from domestic industry and threats of large-scale redundancies, plant closures, the loss of "vitally important" technologies and of a "key" part of a nation's Defense industrial base. Similarly, faced with threat of closure of a major military base, the local politicians and unions will lobby government to keep the base open; and governments seeking votes and re-election might be persuaded of the need to maintain such a base as a vital part of the nation's Defense infrastructure.

Public choice analysis provides a theoretical framework for analyzing the role of government and other groups in the political market place. It has already been suggested that the importance of government makes Defense unique and different. Furthermore, through its spending power, including the award of contracts, government can allocate

monopoly positions. For example, firms operating in protected national Defense markets and receiving cost-plus or cost-based contracts might pursue a "quiet life" characterized by organizational "slack", luxury offices for managers, high technology research programmes, the hoarding of valuable scientists and favorable terms and conditions of employment for the labor force. To such groups, disarmament is a threat to their vested interests. However, welfare economics suggests that for a change like disarmament to be socially desirable, the potential gainers must be able to compensate the potential losers and still be better-off: hence, the need to offer adequate compensation as a price for "buying-out" the monopoly powers of the losers from disarmament.

2. Defining the Defense Industrial Base

What is known; what is not known; and what is it necessary to know, for sensible public choices about disarmament? As a starting point, information is needed on the size and importance of Defense industries in a nation's economy. Answers are needed to the following questions:

- What is the Defense industrial base (DIB)?
- How large is the DIB in terms of output and employment?
- Is the DIB a major exporter?
- Which are the Defense-dependent industries, firms, regions and local communities?
- Are contracts concentrated on a small number of large prime contractors?
- How does the performance of Defense industries compare with other industries in the economy?

The concept of the DIB has been the victim of various definitions. Consider the following examples:

a. The DIB comprises the wide range of firms which supply the Ministry of Defense with the equipment and services it requires [16, p 1].
b. The DIB consists of those industrial assets which provide key elements of military power and national security: such assets demand special consideration by government [8, p xxxvii].
c. "Superficially, the idea of the DIB is fairly straightforward. It constitutes those companies which provide Defense and Defense-related equipment to the Ministry of Defense. But if we try to operationalize this definition, there are clearly many problems" [2].
d. The DIB embraces industrial sectors that unequivocally manufacture military goods (e.g., artillery, missiles, submarines) as well as sectors which produce civil goods. Designation as a Defense industry depends upon the destination of the bulk of the industry's output: should most of it be earmarked for Defense markets, the industry is classified as a Defense industry [18, pp 14-15].

e. The DIB refers to "those sectors of a country's economy that can be called upon to generate goods, services and technology for ultimate consumption by the state's armed forces". A DIB has to fulfill two requirements: it must provide the "normal peacetime material requirements of the country's military; and it must be rapidly expansible to meet the increased demands of wartime or emergency situations" [5, pp 1-2].

f. For the USA, the DIB comprises prime contractors, sub-contractors and parts suppliers operating publicly and/or privately-owned facilities supplying air, land and sea systems. In addition to ensuring that the USA is self-sufficient, the Defense industry is required to expand rapidly in times of national emergency (surge capability: [4, Chapter 8]).

g. A further US definition of the DIB applies the following rules:

   (1) select the top n industries ranked by Department of Defense dollar purchases (where n involves the selection of a threshold); and
   (2) add to the list other industries considered vital to Defense production [12, p 59]. Examples include ball bearings and semiconductors.

h. "The Defense industry is not defined in the usual way by its product; rather it consists of those firms from a number of different industries that sell to the Department of Defense. The nature of this governmental customer is the single most important determinant of the characteristics of the industry..." [13, p 25].

i. Defense contractors can be classified into four categories, namely, weapons systems firms (i.e., delivering a complete weapons system); subsystem firms providing major subsystems such as engines; parts firms which supply the tubes, gauges, valves etc, for subsystems; and the material makers which supply aluminum, titanium, etc, for weapons [3].

Firms in the DIB have a number of distinctive features:

- an emphasis on high technology and performance of equipment rather than costs;
- risks often borne by the government, which also supplies most of R&D funding;
- elaborate rules and regulations for contracts with the emphasis on pubic accountability;
- close personal relationships between major Defense contractors and the MoD [15, p 58; 13, p 26].

Inevitably, these various definitions have been criticized for being too broad, too vague, too arbitrary and subjective and for omitting some important firms and sectors (e.g., they emphasize equipment and exclude Defense-related services such as security, cleaning, etc). Sometimes, the different definitions reflect the nature and purpose of

studies of the DIB. Nor is any effort made to distinguish between industrial capabilities in R&D, in production and for in-service support and to identify those industrial capabilities which are Defense specific. For example, at one extreme, some Defense industries supply lethal equipment which can destroy, threaten or deter (e.g., combat aircraft, warships, tanks, missiles); whilst at the other extreme are products bought by the armed forces but which are also produced on a large-scale for the civilian population (dual-use items such as computers, food, motor cars: [16, p 2]).

Data problems abound. For example, total employment cannot be estimated accurately without identifying all firms in the DIB, including the network of suppliers involved in subcontracting and the suppliers of materials, parts and components (i.e., the supply chain). Some suppliers might not be aware that they are involved in Defense production. For example, ball bearing manufacturers are unlikely to know whether their products are used in motor cars or main battle tanks. Even at the prime contractor level, it is difficult to obtain published data showing the proportion of the firm's labor force involved in Defense work. Often major Defense contractors are large conglomerates with a range of military and civil products (e.g., British Aerospace, GEC); and where company Defense sales data are published, they are usually report sales for a range of Defense products for both home and export sales. Elsewhere, firms might be involved in dual-use technologies. In addition to the firms directly and indirectly involved in Defense work, there are induced multiplier effects reflecting the spending of Defense workers in their local economies. As an indication of the extent of the UK DIB, the Ministry of Defense (MoD) Defense contractors list contained over 11,000 firms in 1991.

It is also misleading to refer to the DIB as a single, homogeneous entity. The supply side of the Defense market consists of varying numbers of small to large-sized firms, either publicly or privately-owned, with different degrees of specialization (e.g., in the UK, DERA and the Dockyards are publicly-owned; the rest of the UK DIB is privately owned). Indeed, it is misleading to refer to a single Defense market and industry. There are, in fact, a set of related markets for air, land and sea systems supplied by firms, some of which specialize in one sector or in a sub-sector (e.g., components) with different degrees of dependence on Defense sales. For example, the UK aerospace industry has aircraft, helicopter and guided weapons sectors and comprises firms supplying equipment, electronics and engines to final assemblers which might be building both military and civil aircraft [7]. The efficiency with which a firm supplies equipment determines its unit costs and the quantity which can be bought from increasingly restricted Defense budgets. On this basis, Defense industries are a major element in national Defense. However, their efficiency cannot be assessed independently of procurement policy since governments have created an administered and regulated market which departs substantially from the economists' competitive model. This also raises the wider issue of whether governments should intervene to support their DIB either for military and/or wider economic benefits (jobs, technology, exports, etc).

2.1 DEVELOPING A DEFINITION OF THE DEFENSE INDUSTRY: A UK EXAMPLE

The various definitions reviewed above have their deficiencies:

- some are too vague and difficult to operationalize;
- they fail to distinguish the design, development, manufacturing, repair, servicing and support functions of Defense companies (a life cycle approach to defining the DIB);
- they often focus on the readily and easily identified elements of the DIB, namely, the prime contractors of specialized Defense equipment (e.g., aircraft, tanks, warships) to the neglect of (a) the supply chain and (h) the variety of suppliers of other goods and services to MoD and overseas Defense Ministries and overseas Defense industries;
- they focus on sales to the MoD and neglect the exports of UK Defense equipment and related services. Over the period 1990-93, exports of identified UK Defense equipment averaged some £3.5 billion per annum, representing 3.7% of UK visible exports over the same period.

2.2 A TAXONOMY

A variety of frameworks can be used to define and classify the DIB. For example, distinctions might be made between lethal and non-lethal equipment; between equipment and services; or between the use of the products, their strategic significance, their technology and the dependence of the producers on military markets. An example is shown in Figure 2 which distinguishes between dependence on Defense sales and the type of Defense equipment. In this Figure, firms in area X (high Defense dependency and

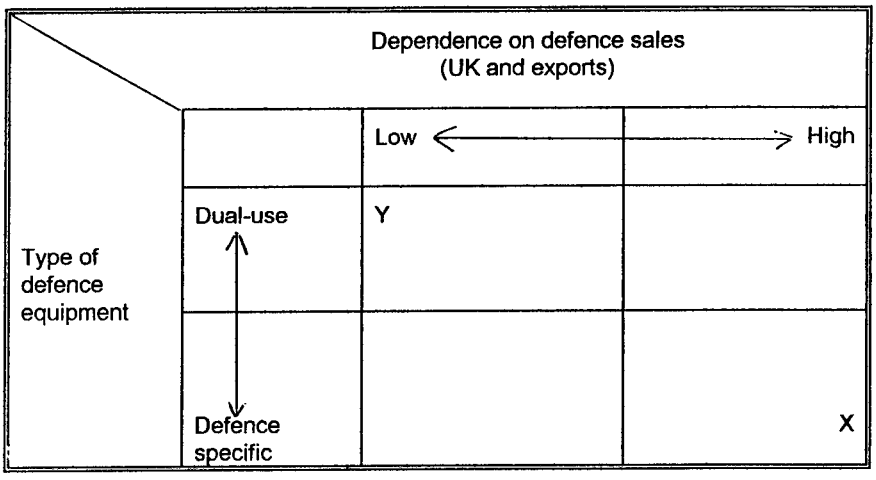


Figure 2. Frameworks in which to Classify the DIB

Defense specific equipment) are clearly in the DIB, but the problems of classification arise with diagonal movements towards region Y. A further distinction might also be made between sales to MoD and sales to overseas Defense Ministries.

2.3 SOME SOLUTIONS FOR THE UK

Various solutions to defining and measuring the UK DIB could start from the available published data and definitions. These include MoD Defense expenditure in the UK by industry group; MoD estimates of UK employment dependent on Defense spending; and MoD major contractors. These various approaches to defining the DIB can be summarized as follows:

a. Ministry of Defense expenditure in the UK by industry group. This shows UK industry annual sales to MoD. In 1993-94, the top six UK industries supplying MoD in terms of absolute sales were:

	£m (1993-94)
Aerospace	2,427
Electronics	1,309
Construction	1,208
Shipbuilding	1,202
Motor vehicles and parts	423
Ordnance, small arms	318
Total: all industries	10,355

The top six accounted for about 65% of MoD Defense expenditure in 1993-94. It can be seen that construction is included in the top six suggesting that this sector cannot be ignored in any broad interpretation of the UK Defense Industry (note: ordnance, small arms was in the top five in 1991 -93).

b. Ministry of Defense estimates of UK employment dependent on Defense expenditure. Data are provided for UK employment dependent on MoD expenditure on equipment and non-equipment (e.g., fuel, food, clothing) and on exports. The employment data show direct and indirect employment but not any induced multiplier effects.

c. Ministry of Defense published list of UK-based contractors paid £5 million or more by MoD in a specific year. This list includes suppliers of food, fuels and services as well as equipment. It provides company data for sales to MoD in different sales bands (£5-10 million; £10-25 million, up to over £250 million). In 1994-95, companies paid £250 million or more by MoD comprised British Aerospace, the General Electric Company, Hunting, Rolls-Royce and VSEL - out of a total of 186 contractors paid £5 million or more by MoD.

d. UK Defense exports need to be included in any definition of the UK DIB. For example, in 1993, UK Defense exports were some £2.97 billion, with aerospace

exports accounting for 90% of the total. Summary statistics for the UK DIB are shown in Table 1.

TABLE 1. UK Defense Industrial Base, 1993

MoD defense expenditure in UK	£10,307 million
UK defense exports	£2,967 million
Total defense sales	£13,274 million
Defense industry employment	405,000

Source: UK Defense Statistics, 1995, HMSO, London.

3. Conversion: Definitions and Concepts

The immediate impact of disarmament is reduced Defense spending reflected in a reduced demand for resources in the Defense sector. The Armed Forces will require fewer personnel and will close some of its army, navy and air force bases. Similarly, smaller Defense industries will require fewer scientists, technologists and production workers, together with fewer R&D establishments and manufacturing plants. But releasing resources from the Defense sector is only the start of the adjustment process requiring a re-allocation of resources to alterative civilian uses.

Re-allocating resources from Defense to the civilian sector takes time and involves costs. Markets for labor, land, capital (e.g., factories) and entrepreneurship do not always adjust and clear instantly. Instead, adjustment takes time and costs arise in the form of unemployment and under-employment of labor, capital and other resources. As a result, disarmament resembles an investment process involving short to medium term costs to achieve long-run economic benefits in the form of a greater output of civil goods and services (the Peace Dividend).

To illustrate the concept of disarmament as an investment process, consider two contrasting scenarios, as shown in Figure 3. First, a successful scenario (scenario 1) where disarmament occurs slowly and predictably in an expanding economy where governments intervene with policies to correct for major market failures, so assisting the adjustment process. Scenario I shows a successful investment with low costs incurred over a short period of time (e.g., months), followed by substantial economic benefits resulting in a high social rate of return from disarmament. Scenario II is a poor investment involving high costs in the form of massive unemployment and a lengthy adjustment process (e.g., years) leading to a low or negative social rate of return from disarmament. In this scenario, the high costs might reflect disarmament occurring on a large scale, suddenly and unexpectedly, whilst an economy is in recession with the government leaving adjustment to market forces where markets are failing to work

properly. The adjustment problems are likely to be even greater for economies which are experiencing both disarmament, and the transition from a centrally-planned, to a market system. Furthermore, disarmament in the 1990s is different in that it is occurring without a prior major war.

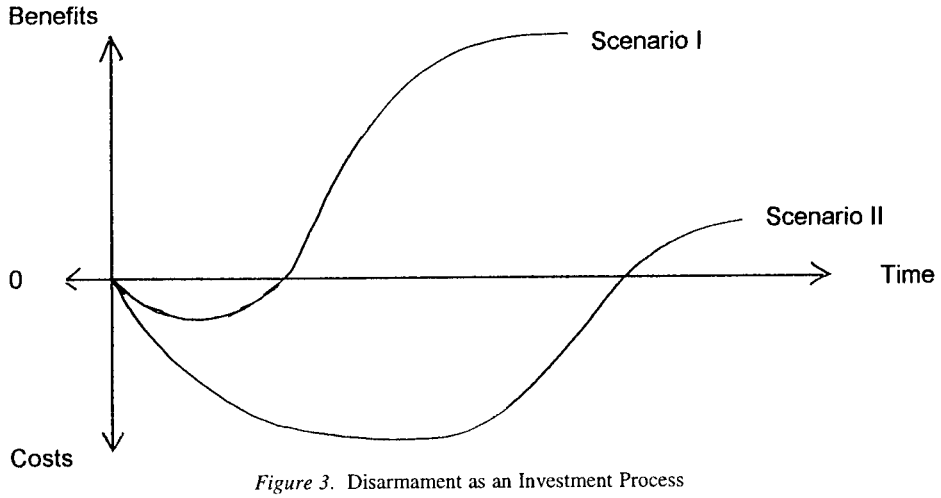


Figure 3. Disarmament as an Investment Process

The re-allocation and adjustment process associated with disarmament forms the subject area of conversion which has at least two interpretations. First, there is the narrow definition which focuses on converting Defense plants into establishments manufacturing civil goods. Such direct conversion requires product substitution in which the same plant and workforce produce goods for civilian markets instead of military products. On this view, workers and factories would convert their production facilities at their existing locations from, say, warships to oil tankers, combat aircraft to airliners, missiles to microwave ovens. Similarly, scientists in military R&D establishments could be used to work on the myriad of challenging problems facing society in fields such as health, the environment, poverty and space exploration. Such conversion appears attractive: it avoids wasting valuable physical and human capital through plant closure and unemployment and it uses the resources for meeting society's needs.

Second, there is a broader interpretation of conversion focusing on the process of reallocating resources from the Armed Forces and declining Defense industries to the expanding sectors and regions of the economy. This factor re-allocation process is occurring continuously in all dynamic economies and its success depends on the operation of the markets for labor, capital, land and entrepreneurship and on the general state of the economy (e.g., whether it is growing or in recession).

3.1 DIRECT CONVERSION: MYTHS AND REALITY

Although attractive, direct conversion (tanks to tractors) is not without its problems. Previous experience in market economies suggests that such conversion often represents the triumph of hope over experience: this is a field characterized more by failure than by success. Usually, advocates of direct conversion focus on the supply side completely ignoring the role of market demand and entrepreneurship. This approach resembles a centrally-planned economy where resources are allocated by command and not by market forces and unless the central planner has perfect information, the inevitable results are surpluses and shortages. But applying a centrally-planned approach to the conversion of Defense firms in a market economy encounters all the problems faced by the transitional economies.

There are sound economic reasons why direct conversion is difficult. Typically, Defense firms seeking to use their technology, resources and skills in new civilian markets have to identify potentially profitable civil markets. Identifying and entering new civil markets involves costs (e.g., retraining managers and workforce) and the new entrant has to compete against existing firms which have established reputations in the market. This raises particular problems for those Defense companies which have been highly dependent on Defense sales, relying on a single known customer, namely, the Defense Ministry, operating in a protected market with non-competitive, cost-based contracts, government-funded R&D and guaranteed profits. As a result, such Defense firms operate in a culture of dependency rather than an enterprise culture where entrepreneurship is required to search for market opportunities and where markets comprise large numbers of consumers [14].

Defense firms face further direct conversion problems if their resources of capital, technology and labor are highly specialized with few opportunities for transfer to the civilian economy. For example, some Defense plants and technologies have few, if any, direct civil applications such as plants for building ballistic missiles and nuclear powered submarines as well as armour and stealth technology. Other Defense firms and technologies have extensive civil applications such as aircraft plants which can build combat aircraft or civil airliners together with civil applications of radar, flight control systems and electronics. In these circumstances, and not surprisingly, some specialist Defense companies (e.g., prime contractors) have decided that their expertise and comparative advantage remains in the Defense field. Since they are good at Defense work, they have decided to remain in the Defense market and possibly seek a larger share of a declining market (e.g., via mergers and acquisitions creating large Defense contractors with a range of air, land and sea systems business - e.g., British Aerospace, GEC in the UK: [9]).

3.2 CONVERSION AND THE ARMED FORCES

Much of the debate about conversion focuses on Defense industries to the neglect of the conversion problems facing the Armed Forces. Disarmament results in base closures and

redundancies for Armed Forces personnel raising questions about the marketability and transferability of military capital and military personnel.

Armed Forces are not-for-profit organizations so that they have not organized their bases and manpower on commercial, profit-maximizing principles (i.e., they operate in a different culture). Also in democracies when military bases are no longer needed, any alternative civilian use requires a transfer of ownership (is base commanders cannot diversify into private civilian markets). Nonetheless, experience shows that, following a transfer of ownership, there are alternative civilian uses for surplus military bases. For example, former military air bases have been converted into civil airports, into leisure facilities (e.g., gliding clubs; motor racing circuits), into prisons, and industrial estates.

Questions also arise about the alternative use value of military manpower. Some military personnel acquire skills which are highly marketable and transferable to the civilian economy. Examples include computer operators, air traffic controllers, engineers, drivers and medical personnel. Other military human capital is highly specific and non-transferable such as missile operatives, paratroopers and tank gunners. For these groups with non-transferable skills, disarmament renders their human capital obsolescent.

3.3 THE ENVIRONMENT COSTS OF CONVERSION

The environmental costs of disarmament and conversion are often neglected. However, closing military bases, Defense R&D establishments and Defense plants can involve substantial "clean-up" costs, some of which is needed before the bases and plants can be reused for civilian purposes. With military bases, the contamination of soil and groundwater can result from chemical and nuclear weapons storage and leakages from underground fuel tanks. Cleaning the site and restoring it for civilian use might involve additional clean-up costs from the demolition of buildings and the removal of debris. Clean-up is not cheap. US estimates indicate that the Department of Defense spent $11 billion on investigating, studying and cleaning-up contamination on American military bases over the period 1984 1994 and that finishing the job could cost as much as $30 billion [1].

4. The Role of Public Policy

Questions arise as to whether disarmament means that governments need "special" public policies aimed at the Defense sector and, if so, what might be the distinctive features of such "special" policies? At first sight, the case for "special" treatment seems convincing and persuasive. Governments are responsible for Defense spending so that they are inevitably involved in the adjustment process. Moreover, the impact of disarmament can be particularly severe for firms, industries, towns regions and rural economies which are dependent on Defense spending. Without appropriate public policies, the adjustment process for such Defense dependent sectors and regions might be long and painful. On this basis, public policies aimed at promoting efficient adjustment to disarmament can

minimize both the time and costs involved in the transition. But efficiency and equity requires that such policies need to be part of a government general adjustment policy available to ali sectors and regions vulnerable to plant closure and job losses (i.e., available to the civilian sector as well as the military-industrial sector). In other words, the appropriate solution requires a public policy towards assisting the re-allocation of highly specific and non-transferable resources throughout the economy, rather than focusing on the particular resource-specificity problems of Defense industries.

Disarmament creates both resource allocation and distributional issues. Welfare economics suggests that for a socially-desirable change, the potential gainers should be able to compensate the potential losers from the change and still be better off (the over-compensation test). Indeed, public choice analysis suggests that major interest groups in the military-industrial complex will oppose disarmament and lobby for specially-favorable policies to compensate them for their losses of rents. Here, though, there is a real danger of public policy being dominated by special interest groups and governments responding with policies favoring producers rather than consumers and taxpayers. The result could be subsidies and contracts being used to support jobs in Defense industries, thereby hindering the adjustment process needed to re-allocate resources out of Defense into alternative civilian activities.

Various policies are available for assisting an economy to adjust to disarmament and convert to civilian uses. Examples include manpower policy (e.g., training, retraining, mobility); capital policy (e.g., investing in new plant and equipment): technology policy (e.g., new civil R&D programmes); and regional policy (e.g., infrastructure, communications, enterprise zones). Throughout, the pursuit of efficiency and equity objectives requires public policies which assist the reallocation of resources from Defense to civilian sectors whilst offering income-deficiency payments to compensate the losers from disarmament. In the final analysis, the Peace Dividend cannot be obtained without a shift of resources from Defense to the civilian sector of the economy.

5. Conclusion: The Opportunities for Research

The economics of disarmament and conversion is an under-researched field and one which offers economists opportunities for applying both their theoretical and empirical tools and techniques. There are a variety of research questions:

- What are the effects of disarmament on labor markets as reflected in the employment and unemployment of redundant military personnel and Defense workers?
- What are the regional and local economic impacts of disarmament and which regions, towns and rural economies are vulnerable to reduced Defense spending?
- What is the experience of conversion of both Defense plants and military bases? Case studies are needed of successful and failed conversions and the reasons for success or failure.

- What are the lessons from previous disarmament efforts and from the experience of the civilian economy in adjusting to change?
- How successful is public policy in minimizing the adverse employment effects of disarmament and which policies are likely to be successful at the national, regional and local levels?

The economics profession has allocated substantial quantities of its human capital to addressing broad macro-economic issues such as inflation and unemployment, as well as more esoteric problems which give satisfaction to economists as producers. In contrast, the profession has allocated relatively few of its economists to study the theoretical, empirical and policy questions raised by Defense spending, disarmament, conversion and peace: issues which are important for the future of civilization. Perhaps the challenges of resource reallocation and conversion apply equally to the economics profession as well as to the military-industrial complex!

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MODELS OF CONVERSION

What Have We Learned?

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1. The Context

In 1984 a Quaker trust funded a doctoral research program on arms conversion and the UK Defense industry at the University of Bradford's Department of Peace Studies [1]. No such study of the UK Defense industry had been undertaken from a conversion perspective since that by the Economist Intelligence Unit in the early 1960s [2]. Yet, before Gorbachev's accession to power in the Soviet Union, nothing looked less likely than either an end to the Cold War or disarmament. That matters turned out as they did is a graphic illustration of the need for governments to prepare for peace just as thoroughly as they prepare for war.

The rationale is different in each case. Democratic governments make military preparations to deter war or, if that fails, to wage war. No-one doubts that such preparations can be left until hostilities break out for then it would be too late. Yet, if preparations for peace are neglected - of which conversion strategies are an important part - the results can be dire, too. Some may argue that such neglect is much less important because no-one dies and no civilization is destroyed in consequence whereas the failure to prepare for war may well have these effects. Elsewhere, though, this deduction has been disputed because it fails to take into account of the potentially very damaging long term consequences of a "bad peace" settlement after a major conflict. In these circumstances, as Professor Holsti aptly puts it, peace becomes the father of war' [3,4]. Thus, it may be argued, preparing for peace before a major conflict is over is vital to building peace afterwards.

Conversion needs to be placed in the wider context of international peace building to which this ASI program is a welcome and important contribution. The purpose of this chapter is, first, to examine the various models of conversion developed in the post-Second World War period. This will focus on the major Western states but may now be more relevant to Eastern Europe and the former Soviet Union. Secondly, the analytical models will be applied to the West, especially the United Kingdom and United States, in

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the period after 1989. Finally, and allowing for the limited time which has elapsed since the end of the Cold War, some lessons for the future will be suggested.

2. Models of Conversion

2.1 OBJECTIVES

The conversion of military resources to civilian purposes can have two main objectives. It can be part of NATO's stated purpose ... the establishment of a just and lasting peaceful order in Europe' [5]. It can also be part of the process of making the Defense industry more efficient and ensuring it provides the maximum contribution to the national technology base. In this latter case conversion may be no more than a mopping up operation of unwanted military bases and the bits of the Defense industry that do not fit into the new, increasingly competitive and global arms business. While both objectives are likely to feature in reality one or the other will predominate. Moreover, determining which aim is uppermost is a matter of analyzing the realities of conversion strategy.

2.2 THE MICRO-LEVEL

What had been discovered about conversion in the West before 1989? The starting point for answering this question will be the micro-level because the aim of government should be to create a policy framework which is supportive of industrial and community initiatives. Consequently this micro-level aspect will be dealt with first so that the kind of support which might be needed for conversion can be identified.

A review of the literature reveals a number of different ways of thinking about Defense conversion [6,7]. As regards supply side adjustments attention is focused on the level of the company, factory and community. Each will be considered in turn.

2.2.1. *The Company-Based Approach*

Much attention in the post-Second World War period has been paid to the Defense-industrial company. The separateness of most Defense and civil activities within large corporations, combined with the known difficulties in moving from military to civil work, had led to concern amongst researchers and trade unions that disarmament would lead to mass unemployment and engender resistance to further cuts in military spending.

As far as the company-based approach is concerned, it is important to distinguish between diversification and conversion. The former involves entry of a Defense firm into a civil market, either by internal development or through acquisition, without abandoning its original Defense market. The latter involves a once-for-all re-employment of a firm's Defense resources to civil use. The main interest here is on the extent to which either diversification through internal development or Defense conversion are achievable.

A firms' Defense work needs to be considered within the context of the management's overall strategic perspective [8] . Defense work impinges on a corporation's business portfolio in three main areas: technological capacities; corporate financial results and profitability; and global risk for the firm. Naturally all these factors vary with time and place in relation to civil work. It is important to note that governments can, if they wish, influence all these factors in order to discourage military activities and encourage civilian ones. Indeed, as Dussuage pointed out in 1987, without a central government
role in the conversion process Defense firms would not, in most cases, convert because they would have much to lose and little to gain.

Yet a few (mostly US) studies have been carried out to examine the lessons from Defense firms' own diversification and conversion programs [9,10]. The many factors which influence the prospects for successful diversification or conversion by a Defense firm are summarized in Table 1. Two of the most important are the technological synergy between its Defense and civil activities and its degree of Defense dependency. Clearly there are formidable barriers to exit for a large weapon systems producer like VSEL, the main UK warship builder, where technological synergy is low and Defense dependence is very high. At the other end of the spectrum, for some Defense electronics suppliers with high technological compatibility and low Defense dependence the prospects may be much better. What was clearly established long before the Cold War ended was that successful Defense diversification was usually dependent on a firm's military technology and that Defense conversion had few successes.

2.2.2 *The Factory-Based Approach*

In view of the amount of attention paid to factory or plant conversion over the last *20* years it is worth underlining the factors which made this approach so problematic. Success required a complete redefinition of the business idea of the Defense firm - an extremely difficult task in view of the historical conservatism and distinctive culture of Defense firms compared to civil ones. Factory-based conversion is also made more difficult if military activities provide the principal source of technology for civil work, since this then has to be replaced. The risks involved in making entirely new products, assuming that marketable alternatives can be found, and undertaking major new investment in plant and machinery have proved too great for most Defense firms. Moreover, the long time-span of 5 to 10 years for successful diversification or conversion requires sustained commitment.

While Japanese commercial ship-repairers have, according to Professor Todd [11], had outstanding successes in diversification and conversion by internal development to even technologically unconnected markets this is a skill which has largely eluded Western arms manufacturers.

TABLE 1. Defense industry diversification and conversion: the industrial firm

FACTORS IN ASSESSING THE PROSPECTS FOR SUCCESS
* Previous experience of diversification
* Degree of synergy between Defense and civil technologies
* Dependency on domestic and foreign Defense contracts
* Future profits in relation to investment/extent of risk
* Degree of existing diversification
* Availability of new civil markets (especially in the nonDefense public sector)
* Availability of managerial, technical and capital resources
* Time span to design and develop new civilian products
* Ownership/adaptability of Defense plant *and* equipment
* Avoidance of Defense industry pitfalls e.g. over-designing, concurrency, over-optimistic market expectations
* Similarity of production operations in Defense and civilian fields
* Adaptability to commercial cost controls
* Acquisition of personnel or firms with civilian production or marketing skills
* Similarity of pay and conditions to chosen civil industries
* Establishment of retraining and reorientation schemes
* Company culture/commitment of top management
* Worker involvement/union participation

2.2.3 *The Community-Based Approach*

Economic adjustment or community conversion provides a model which has been broadly successful. Pioneered in the USA, this approach emphasizes the role of local authorities and activist groups working together to promote strategies to reduce the vulnerability of local economies to Defense cuts.

More specifically, the Office of Economic Adjustment was established within the Pentagon in 1961 to alleviate the economic effects of a large number of planned military base closures. Then, in 1970, President Nixon created the Economic Adjustment Committee to coordinate assistance from *23* federal departments and agencies to affected communities. The OEA serves as the permanent staff for the Committee.

Assistance from the EAC/OEA is aimed at stimulating the local economy through finding alternative uses of the former military base, economic diversification and cutting red tape in obtaining federal assistance. The process involves all levels of government as well as the business community in the area affected. In the period 1961-1993 a total of 171,177 civilian jobs replaced the loss of 85,557 former US Department of Defense and contractor jobs at 97 former Defense facilities [12]. The transition period for civilian reuse is often 3 to 5 years and it may take up to *20* years for full redevelopment to occur. Despite the difficulties this can be said to be a tried and tested approach.

2.3 THE MACRO-LEVEL

So, even before the Berlin Wall unexpectedly came down, it was clear that if disarmament ever proved possible in the West serious problems confronted Defense dependent companies and communities. Micro-models of conversion revealed in detail the significant barriers to company-based Defense diversification while the factory-based

model was unlikely to work at all without substantial government aid. Even then it might not be successful in many cases and questions would certainly be raised about the social efficiency of this model for resolving the problem of resource allocation. Only the community model of conversion looked at all hopeful and even this was primarily a mopping up operation to deal with the effects of Defense cuts rather than part of a strategy for international peace building.

Hence the need to link the micro-models of conversion to a macro-model [6] in order to assess the prospects for Defense conversion in 1990 and how they had changed by 1995. This is especially important as the scope for independent initiative on Defense conversion at company, factory or community level is usually limited. Such programs have, therefore, to take account of the wider context and the support that public policy may or may not provide.

2.3.1 *Environmental Conditions*

The improved international environment in 1990 could scarcely have caught the main Western powers, or most prime Defense contractors, less prepared for substantial spending cuts. Moreover coming at a time of economic recession in the civil economy, too, the prospects for successful Defense conversion, within the time available, were poor.

As Table 2 shows at a high level of generalization, the West required as determined an effort to win the peace as was ever required to win a war. Even by 1995 only some countries had begun to rise to the challenge and then the international environment was no longer anything like as favorable as in 1990. Yet progress has been made in recognizing the significance of the economic aspects of security and the need for Defense conversion strategies. It is this which will be detailed in more detail in Section 3.

2.3.2 *Structural Conditions*

The permanent Defense industry, built up during the decades of the Cold War, could not just be reconverted as many US and UK civilian firms were at the end of the Second World War after temporary involvement in arms manufacture.

The main features of these Western Defense industries are well known and require consideration here only in terms of their impact on conversion prospects. Factors which militate against Defense conversion include: high regional and industrial concentration; integration in monopolistic arms markets; and greater reliance on Defense exports. A crucial consideration which may favor Defense conversion is the level of civil research and development spending by government and industry. Internationally, a country like (West) Germany whose government has spent more on civil R&D than the USA, UK or France was in a better position to exploit opportunities which arise. At the start of the decade there was initially some pressure for Defense contractors to consider diversification because of reduced Defense budgets. In fact, despite some modest efforts, often by acquisition rather than internal development, the top contractors mostly refocused on Defense work and major national and industrial restructuring efforts intensified.

TABLE 2. Defense industry diversification and conversion: the environmental context

	Factors affecting the prospects for success in the West	
	1990	1995
Economic conditions:	recession	some improvement
International relations:	relaxation of tensions; CFE Treaty	some deterioration
Security concept:	government emphasis on military factors	US/German emphasis On economic aspects Increases
Military expenditure:	modest cuts planned	deeper cuts but bottoming out
Political commitment:	non-intervention in the economy	US conversion policy implemented

2.3.3 Political Conditions

At this point it may be asked why any public assistance beyond that related to community conversion should be provided? If the main concern of government is to ensure the best possible return on its Defense investment then the focus is likely to be on technology transfer. This may be part of a wider debate about whether government should support a Defense industrial policy aimed at international competitiveness. In this case Defense conversion is mainly a mopping up operation requiring minimal public funding.

The contrary arguments were put by Inga Thorsson, the Swedish conversion expert [13]. She maintained that the Defense sector should receive special attention for three reasons. First, disarmament should not lead to unemployment for otherwise the promotion of peace and reductions in military expenditure would be hampered. Secondly, incentives for the transfer of resources from the Defense industry to civilian production were vital in order to develop the country's technological and industrial base and maintain employment. Thirdly, the Defense industry's main customer is the government on whose behalf human and technical resources devoted to weapons manufacture were constructed. So society has a responsibility to help return them to commonality with their civilian counterparts.

In order to assess the role of state policies in assisting the conversion process Table 3 highlights some key considerations to be applied in the next section. Another factor to be taken into account is the extent of public pressure for conversion or increased Defense spending.

TABLE *3.* Defense industry diversification and conversion: the political context

Factors affecting the prospects for success
*Link between conversion and disarmament or arms control
*Compensation for reduced military expenditure/extent of integration of Defense industry into economic strategy
* Link between conversion and regional economic policies
* Link between conversion and industrial policies

3. Defense Conversion in the 1990s

During the early 1990s the sheer scale of disarmament in Eastern Europe and the former Soviet Union, despite the eruption of nationalist and ethnic conflicts, finally helped persuade some Western governments to give the economic aspects of security a higher priority. Space does not permit the macro- and micro-models of conversion to be applied to all the countries affected [14]. However, the USA and UK should suffice to illustrate how far a supportive environment for Defense conversion was created and which approaches to conversion should benefit. In general terms, it is too soon to be sure whether the frameworks adopted will have the desired results. Nevertheless a number of tentative conclusions about the scope and potential for Defense conversion can be drawn from this analysis.

The main features of conversion strategies in the USA and UK, as developed by 1995, are summarized Table 4.

Under President Clinton the USA adopted a national conversion strategy in 1993 which assisted Defense companies and not, as before, only Defense dependent communities and redundant arms workers. This was an important development which came about, as the macro-model of conversion had suggested, by linking Defense conversion to the government's overall policy framework. For US statute law defining the policy objectives relating to Defense reinvestment, diversification and conversion makes clear that they are aimed at furthering US national security objectives and the national technology base [15]. Nevertheless, the scale of Defense cuts, though substantial, are primarily arms control measures compared to the massive disarmament undertaken in the former Soviet Union and Russia in particular. Moreover, there is considerable debate in the USA on whether the compensation for Defense cuts, insofar as it is directed at Defense companies and developing dual-use technologies, is really conversion at all. A heavy emphasis exists on exploiting the opportunities for spin-in of civil technologies to reduce the costs of weapons development and create a more efficient Defense industry. Even so there can be no dispute that some deLence companies, like the war shipbuilder Bath Iron Works, are making use of government assistance to diversify into commercial markets.

TABLE 4. Defense conversion strategies in the USA and UK, 1995

Features of Defense conversion strategies	USA	UK
National strategy	Yes	No
Defense conversion linked to:		
Security policies	Arms Control	Arms Control
Compensation for arms cuts	$21.6 billion	Little or none over 5 years
National economic strategy	Yes	No
Primacy of Defense industry	Yes?	-
Regional economic policies	Community conversion/retraining	EU programs/DTI Assisted Area extended
Industrial policies	Technology Reinvestment Program; Fed. High-Tec Investment	Dual-use technology centres; Regional seminars

In the UK, on the other hand, there is no national Defense conversion strategy as government policy is to leave economic readjustment to the market. There has been little or no attempt to compensate directly for reduced military expenditure, except through regional economic aid. This has been channeled through European Union programs, notably KONVER which allocated £15.6 million of matching funding in 1993, and the UK's Department of Trade and Industry which revised its Assisted Areas map to allow Defense dependent regions like Barrow-in-Furness to qualify. Local government has played a key role in promoting community conversion initiatives. At an industrial level very little support for Defense diversification exists although the establishment of Dual Use Technology Centres by the Defense Evaluation and Research Agency is a potentially important development.

Thus US Defense conversion strategies have been developed which are aimed at supporting company diversification, particularly of small and medium-sized enterprises, and also technology transfer between military and civil sectors. Local community and regional approaches to conversion have also benefitted substantially. In the UK, though, support is limited mainly to advice on company diversification, collaboration on technology transfer and very limited funds devoted to community conversion.

4. Conclusion

Historical experience both during and after the Cold War, especially in the USA, suggests that community and regional approaches to conversion are the most likely to be successful. Even this, though, requires public funding and a facilitating role by government departments. Yet company diversification, supported by mechanisms for technology transfer, have also had some successes in Western Europe and the USA and

merit more attention. The scope for worker and union involvement has also been demonstrated as at Bath Iron Works where previously industrial relations had been bad. The prospects for the micro-models of conversion do hinge, though, on the macro-model. It is here that we in the West have fallen down badly on three requirements in particular:

- *Preparation.* Being caught unprepared for significant cuts in military spending during the 1990s increased opposition from the Defense industry, workers and communities.
- *Timing.* Too often companies and Defense dependent communities were left with insufficient time to adjust to Defense contract cancellations or base closures.
- *Compensation for Defense cuts.* The whole notion of a 'peace dividend' came to be replaced by a 'peace penalty' wherever Defense workers or affected communities felt the impact of factory or base closures, but neither they nor the general public could see any compensating benefits.

This leads to the final question of the objectives which Defense conversion strategies seek to serve. Few would dispute the desirability of making Defense industries more efficient and less waste or of ensuring that they contribute as much as possible to the national technology base. This does seem to be the principal goal of most, if not all, Western governments with indigenous Defense industries. Yet for the goal of ... a just and lasting peaceful order in Europe to be more than just rhetoric the connections between conversion and other elements of international peace building will have to be made. This would require the same commitment to developing peace strategies that is currently given to developing military strategies. Until that happens the peace objectives remain subordinate.

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CONVERSION IN THE PERM REGION OF RUSSIA: EMPIRICAL STUDIES

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Abstract. *The regional conversion programs have an advantage - their implementation permits the comprehensive use of the capacities of defense entreprizes of various industries. A combination of the various productions (of both defense and civilian enterprises available in the region) makes it possible to organize complete cycle technology production; to rationally solve the problem of establishing the necessary cooperation ties; to produce the materials, spare parts and finished products at the lowest cost; and, in the long run, to most efficiently invest the state's money. If implemented, the programs will not only solve the region's employment problem, but will also saturate their markets with industrial products and consumer goods in particular"*[1]

"The adoption of regional focus for conversion opens up new possibilities. Within a region or city enterprises formally of different ministerial affiliations can begin to establish relations with one another on a market basis, opening up new production possibilities. Civilian activities previously not considered can be developed in this form to identify local demand. Some production facilities of "universal" defense industry enterprises may find new opportunities as specialized suppliers of semifabricates, possibly industry, components, or services, initially with an orientation to the regional market. Such units may be able to privatize as independent companies [1].

[1]Report by W.G. Kotov, deputy head of the Department, Russian Ministry of Economy, "The role of regions in the development of the conversion process", presented at the OECD seminar investing in conversion: Opportunities, Constraints and Policy requirements. Birmingham 25-26, May 1993, p. 1-2.

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1. Introduction

The advantages of conversion, the transformation of military production and know-how capabilities to civilian production on a regional level, are obvious. Local markets may be created, synergies between existing production capability established, and regional welfare increased. In addition to conversion on the enterprise level, international efforts to support Russian conversion have also focused on regional approaches [8]. Theoretical approaches such as national and regional innovation systems also focus on the spatial location of innovative activity [9,14]. Given the obvious advantages of regional approaches to conversion, it is astonishing that very few regional conversion results have been demonstrated, although regional conversion programs have been time and again drafted in all Russian regions.

This paper examines some of the experiences of regional conversion and related learning processes during the period of 1991-1995 in the Perm region, one of the highly defense-dependent regions of the former Soviet Union, but a region with great potentials due to its resource base. The paper explores some of the basic ideas around regional innovation systems in relation to the experiences of the Perm region. The case study is based on interviews carried out with defense enterprise managers and the regional administration during five study tours during November 1991 - February 1995.

2. The Perm Region

The oldest military industry in Perm is more than 250 years old. Peter the Great selected Ural as an industrial area due to its richness in minerals and due to its distance from the frontier regions. Since the Ural mountains were fabulously rich in gold, metals, and other minerals, Russian settlements were established in the 16th century as the first primitive mining efforts were launched. Perm was the gateway to Siberia where canons have been cast for 200 years for the army. During the Napoleonic wars in Russia in 1812, Ural played an important role for the military production. Since the First World War, the region has had the status of a military industrial area. During the Second World War a number of enterprises were moved from the European and Asian parts of the Soviet Union, some of them to Perm.

The region[2], the size of France, is inhabited by 3 million people of which 1 million live in the city if Perm. The total work force consisted in January, 1991 of 1,550,000 persons of which around 550-600,000 worked in industry. In 1985, 212,800 people worked in the military industry, which was at the time 38% of all industrial employees. From this follows that every fifth person in the region was affected by military industrial employment[3]. In 1988, less than half of those employed in the military industry, that is 90,000 persons, worked directly with military production. Before perestroika, military production, in the military enterprises of the region, ranged from 39 to 95 percent[4] of the total production. In the region,there are 23 military enterprises, of which 20 are located in the city of Perm. The economy of the region, and particularly of the city, was over-militarized as the ten largest defense enterprises accounted for 50% of the industrial employment of the city, 37% of the production funds, and 37% of the end products output of the city. The industrial enterprises of the region are often subdivided into a machine-building, metallurgical, chemical-mining, oil and natural gas-chemical, and a forestry complex.

Both the volume of military production and the number of persons employed in the defense industries has been reduced during the part years. In general, military production was reduced by one-third from 1988 to 1991. Since the collapse of the Soviet Union in 1992 defense orders were reduced to 32% of the level of 1991. The Perm enterprises experienced dramatic cuts, which, however, did not immediately result in corresponding cuts in production and employment.

The defense enterprise share of total regional employment in Russia is shown in Table 1 together with the absolute number of defense industry workers in respective localities.

The number of people working in the defense industry, 213,000, should be compared to the above figure of 90,000, which comprises the persons working directly with military production. The difference is due to the fact that defense industries have both civilian production and a number of service functions such as daycare centers, holiday resorts, and the like.

The size of the Perm military enterprises ranges from design bureaus with some hundred employees to large science-production associations in aviation and aerospace employing up to 70,000 workers. A special characteristic of the military enterprises in

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[2]The data on the region and Perm city is based on three sources:
-On the prosperity of conversion of the Perm's defense complex enterprises, a status note from the regional administration (Nov. 1992).
-Program of the Perm region defense enterprises from 1993, conducted from the regional administration.
-Passport to the Perm region, 1993 of the Dept. Of External Economic Relations of the Perm regional administration.

[3]The estimates for the total number of work force varies from 1.3-1.5 million, depending on source. The best source is the USSR State Committee for Statistic's unpublished data for 1985 analyzed in Horrigan, 1992.

[4]These figures indicate the company having the largest share of military production (71 percent) and the one having the lowest (19 percent).

TABLE 1. Defense industry employment in the regions of the former Soviet Union

Defense Industry Share of Total Oblast' Employment			**Absolute Number of Defense Industry Workers (by locality, in thousands)**	
1.	Udmurtiya	--57%	1.	Sverdlovsk--350
2.	Kaluga	--47%	2.	St. Petersburg--318
3.	Mari-El	--46%	3.	Moscow City--300
4.	Novosibirsk	--45%	4.	Nizhniy Novgorod--257
5.	Omsk	--43%	5.	Noscow Oblast'--225
6.	Magadan	--41%	6.	**Perm'--213**
7.	Voroezh	--40%	7.	Samara--212
8.	Novgorod	--39%	8.	Novosibirsk--172
9.	**Perm'**	**--38%**	9.	Tatarstan--172
10.	Vladimir	--37%	10.	Udmurtiya--168

Sources: Julian Cooper, The Soviet Defense Industry: Conversion and Economic Reform, (NY: Council on Foreign Relations Press, 1991); and Clifford Gaddy, unpublished Trip Notes, Summer, 1992.

the Perm region is their dependence on end-product producers. The major part of the enterprises design and produce aircraft engines, guidance systems for these, and the like. Only a few are end products, e.g., of tanks, heavy armored vehicles, rocket launchers, etc. The region's research institutes work mainly on advanced materials.

The military share of different branches is presented in Table 2.

The table shows the dramatic change of the number of workers employed in direct military production between 1991 and 1992. At the same time it shows the increased civilian production - one of the strategies the Perm enterprises used in order to cope with the reduction in defense orders [5]

Figure 1 shows the activities of enterprises under conversion during 1990-1994. Compared to 1990, production volume is only 11% of direct military production. The civilian production of these enterprises has increased around 34% while the production of consumer products has been fairly constant. The latter can be explained by several factors. One is the military enterprises' reluctance to undertake non-prestigious work with consumer products. Another are the difficulties they encounter in mass production and the lack of financing. A third factor is the competition from foreign products. For example, in 1994, large quantities of foodstuffs were imported to Perm.

During the five-year period the work force reduction has only been around 30%. This means that 70% of the work force still is formally employed. Many are, however, either on part-time or permanent leave. At the end of 1994 a number of Perm defense enterprises were only working 1 or 2 days a week. While some of the best, young, and entrepreneurial employees have left the defense enterprises, those not able to find other employment opportunities stay. Women seem to be the group which is most frequently dismissed, particularly young women with children [2].

TABLE 2. Military share of institute activities

23 defense enterprises (of which 20 in the city of Perm)
4% of the enterprises of the Russian military-industrial complex
16 % of the enterprises of the Ural military-industrial complex

Aviation industry (5 enterprises):

	Number of workers		
	1990	1991	1992
Military production	13,000	22,000	5,000
Civil production	19,000	18,000	23,000
Total	***32,000***	***29,000***	***28,000***

Mechanical industry (8 enterprises):

	Number of workers	
	1991	1992
Military production	15,000	7,000
Civil production	24,000	31,000
Total	***39,000***	***38,000***

Electronics and communications equipment industry:

Employment:	38,000
Share of military production in total output:	
	1992
	37%

Source: Osikov, Alexander, Conversion in Russia's Regions, published in The Soviet Establishment. Stockholm, October 20, 1993.

Official unemployment in the region was in 1990, 2,000 people (based on 9 enterprises of the defense complex). In 1991, it was estimated to have increased by 500 people. During the month of May 1992 the total number leaving state industrial jobs in the region was 13,331, the number of employees getting jobs was 12,869, i.e., a job loss of some 700 jobs. Our interviews document lay-offs of 0-20% during 1991-1992, depending on the enterprise. Most of the enterprises experienced a 10-20% loss of employment, including both those leaving voluntarily and those laid off.

In June 1994 there were 32,000 registered unemployed which had registered at the regional unemployment office. Of these 70% were women. The official estimate for hidden unemployment was calculated to be 130,000 people. In summary in June 1994 the official unemployment was 2% of the work force, and 8% unofficially. The unemployment was worst in small cities and villages, which often depended on only one working place. In the city of Perm the situation was easier, although there is great difference among the different neighborhoods in Perm.

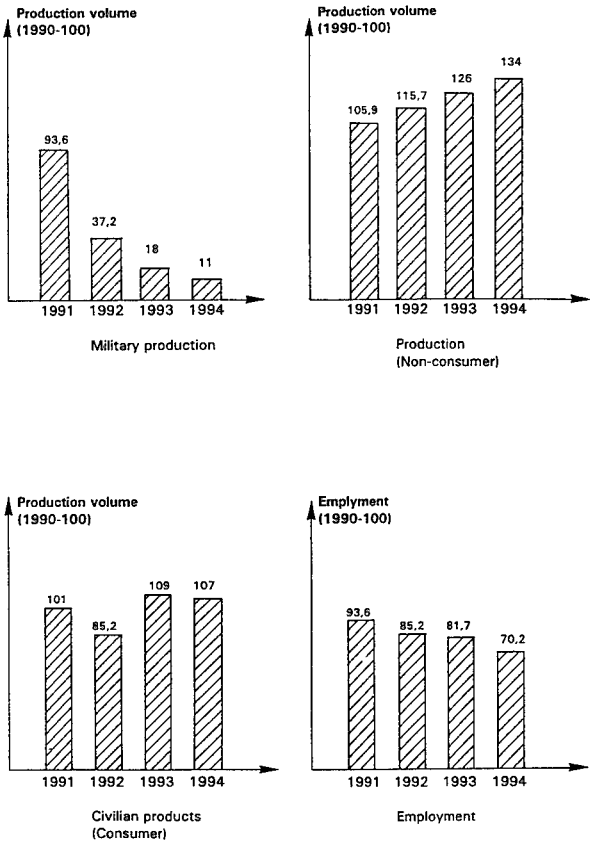


Figure 1. Activities of enterprises under conversion, 1990-1994

The region has an educational center, the Perm Polytechnic Institute (now Perm Technical University). This institute has trained 60,000 engineers with 44 different specialties. In 1992 the institute had 12,500 students in 80 departments and 10 facilities. Around 70 percent of the students come from the Perm region. The Institute's main task is to educate engineers for the region's military enterprises. This creates a structural problem today since the enterprises are not employing any newly educated engineers with military specialties. The Institute has specialized in six military disciplines, among them aircraft, rocket engines, and artillery.

3. Towards A Regional System Of Innovation?

An innovation system (the literature talks about national innovation systems [9]), defines the competitive advantage of a specific geographic area. The focus here is on institutions and relationships between them in a network perspective.

Mainstream innovation theories perceive innovation as a linear process, from research through development to diffusion and consumption, starting in the laboratories and ending with the consumers' consumption. The linear innovation approach has not only been challenged by recent developments within industrial organizations during the last two decades but also theoretically from a historical viewpoint (e.g., [11,13,6]), as well as from the proponents of evolutionary theories of economic and technological change (e.g., [6)]. Common among these contributions is that they highlight a non-linear pattern within industry and technology development.

"Systems of innovation" denotes a concept of innovation emphasizing that innovation is not a linear process but an interactive and heterogeneous learning process, entailing all players involved with a given activity including suppliers, customers, public support, regulatory institutions, etc. From this perception learning and hence innovation are socially embedded processes, which cannot be satisfactory understood without taking the cultural and institutional context into consideration.

Systems of innovation are thereby social systems. They are dynamic systems with interactive learning and feedback between the involved players [4]. The embeddedness of these systems also implies a spatial dimension to be added, whether it be the firm, region or nation. Recently, several contributions have within this framework discussed regional systems of innovation [14].

The systems of innovation approach applies to defense production in the sense that the involved innovation processes happen via intense interaction between producers (defense contractors), customers (typically defense ministries), suppliers (e.g., subcontractors), and users (armed forces). Furthermore, spatial clustering is outspoken within defense production [10]. Seen within the system of innovation perspectives the current situation presents serious problems. The links of the defense enterprises of the Perm region were not to each other, but to the branch ministries in Moscow. Since 60% of the military R&D capacity was located in Moscow and the Moscow region, and a very large part of the rest in St. Petersbourg, there were few links to the local production scene. Given the center/enterprise contacts, there are very few regional institutions providing regional links and innovative activities. The Perm Technical University and the Branch of Russian Academy of Sciences are the exceptions.

Some research and development capabilities are localized in Perm. There is a composite materials and a powder metallurgy research institute, and design bureaus for aircraft engines, steering systems, rocket engines and artillery systems. These research institutes and design bureaus are closely connected with large Perm enterprises such as the Perm Motors and Motobvihikly (formerly the Lenin Machine Building Plant). The core capabilities of these research and design institutes were, however, directly linked to the military production of the region.

An additional problem in creating regional links and providing regional synergies is the vertical integration of the defense enterprises. Large-scale scientific production associations are self-sufficient in terms of not only R&D capabilities, but mechanical workshops, quality control laboratories, and even raw material adaptation. In contrast to the defense production in the U.S., which is dominated by a few large-scale prime contractors with a manifold of subcontracting enterprises, subcontracting is practically non-existent in the area.

Finally, a problem particularly related to conversion is that there are few institutions related to civilian production. This is a result of the spacial concentration of defense enterprises, and the fact that civilian enterprises have been linked to ministries in Moscow and not to regional activities and production. Thus, there is a double problem in the creation of user-producer links between civilian and military areas.

4. Regional Conversion Plans

Already during the Gorbachev conversion program proposals were made for the regionalization and decentralization of conversion. Among others, the International Conversion Foundation in Moscow[5] worked for such regional initiatives. At the time of the collapse of the Soviet Union the State Committee for Conversion had worked out the regional model for enterprise conversion in Russia. This model was presented to the Perm regional authorities and to the military managers at a meeting in November 1991.[6] This plan for decentralization reflects the economic way of thinking to an extreme degree. It establishes a hierarchical structure of organizations and institutions for the regionalization of conversion with the individual enterprises at the very bottom. A regional conversion plan, in spite of this hierarchical structure, was assumed to emerge as an aggregate of all the individual enterprise plans. The model has never been applied, although it was officially presented as late as 1993.[7]

In November 1991 regional conversion was already an issue in Perm. The Perm managers were extremely critical towards the national plan adopted in 1991, and the lack of concrete support to enterprises in Perm, even if support had been promised (62 million rubles had been allocated to the enterprise "Sorbent", but never received). The regional

[5]A private non-governmental organization to promote conversion in the Soviet Union.
[6]In the context of the international UNEP/PRIO seminar on conversion and the environment in Perm November 1991, a special meeting among the enterprise managers was arranged to discuss conversion.
[7]At the OECD seminar "Inventing in Conversion, Opportunities, Constraints and Policy Requirements", Birmingham, May 1993.

government had conducted an inquiry among the military industrial firms exploring the interest for a regional conversion program. Until this time there had been no formal regional cooperation among the military industrial firms. A number of firms expressed their interest for partners and joint ventures. Subsequently, a regional program was drafted for the years 1991-1995 with the participation of 20 companies of the defense complex. The goals of this program were:

a. The compensation of economic losses in the region's defense complex enterprises due to drastic reductions in military production while simultaneously maintaining mobilization capacities.
b. The maintenance of the enterprises' scientific and productive potential and the exploitation of it in the interest of the region, in order to even out the structural imbalance of the region's economy (providing products and services for the consumer market at the expense of military production).

The plan, however, was never implemented.

In 1992-93 a new regional conversion plan was approved and sent to the central government. This program consisted of 180 proposals identified in four (military) industrial complexes. The financing required was estimated to be 38 million rubles (170 million $ US at the time).

5. The Conversion Plan

The plan issued by the Perm regional administration is called the Program of the Perm Region Defense Enterprises Conversion.[8] The main aim of the plan is to preserve the scientific, technological, production, and work-force potential of the defense enterprises, and retain their ability to manufacture competitive products. The role of the regional administration in this process was expected to be to:

a. facilitate demonopolization, privatization, and development of small and medium-sized businesses in the region;
b. help to adapt defense enterprises to market conditions, i.e., help in the development and functioning of market infrastructure - exchanges, banks, insurance companies, auctions, exhibitions, etc.;
c. facilitate technological modernization of MIC according to Russia's defense doctrine;
d. stimulate development of the region's production infrastructure; and

[8]The following is based on a summary of the report.

e. ensure qualitative improvement of the social sphere, growth of consumer goods and food production of the local consumer market.

According to the Perm regional administration[9], conversion (Circa 1992) was characterized by two strategies:

a. To preserve the existing technology and to transfer the high-level technology to civilian products.
b. The civilian production should be based on the same technology as the military to make it cheaper.

The plan talks about "big" and "small" conversion. The former takes place if high-level technologies are introduced to penetrate new markets to earn hard currency for the modernization of the technological base and the conversion of the region's infrastructure. Small conversion implies the utilization of free capacities for production of consumer goods and high-tech civilian items for domestic market.

The MIC plan of Perm divided into four complexes: engine-building, machine-building, chemical technology, and electronics. A range of diversification possibilities are listed ranging from repair of aircraft engines to household electronics and medical equipment. Of the total of 180 concrete proposals, two are of special interest. The enterprises in Perm produced 65% of the parts of a Moskovitch automobile. Consequently, there was a proposal to develop the Perm Car. Another example, already being implemented by the Perm aviation enterprises (Perm Motorworks, Aviadvigatel, PAPO named Kalina, PAKB, and the Perm Polytechnic Institute's Department of Aviation Engines), is the production and international certification of the jet engine PS-90A.

The program clearly demonstrated some of the problems, but also the possibilities, of regional conversion. First, there was the need for the regional administration to learn the potential of the enterprises in their region. Second, it was necessary for the enterprises to establish regional networks to replace the former ministerial networks. On the more negative side, the program goals reflect a "technology push" since there is little or no market assessment. The rhetoric of preserving the high-tech capabilities of the region are not accompanied by any demand assessments on the civilian side.

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[9]Interviewed in November 1992.

6. In Search For Financing

When the first regional conversion program was presented by the State Committee of Conversion in Perm in November 1991, financing was not seen as a problem. Conversion, in fact "conversion by command" [5], was at this time a new thought for many of the companies. The general attitude of the Perm enterprise managers was that conversion was possible, given that the mobilizing requirements[10] were expelled. However, in our interviews in March 1992, financing had become a problem. The shock treatment in December 1991 - January 1992, where defense orders were radically reduced, left most of the Perm military enterprises - and particularly the design bureaus and research institutes - with financial problems. At this time western technology and western financing of conversion projects and programs were seen as the solution.

Again the mood changed by November 1992 when no longer is western financing, but western marketing assistance, seen as the solution to conversion. A number of companies interviewed claimed they had financing to start a new production, but needed access to foreign markets and help in market assessments. By this time, no doubt, state credits for conversion were forthcoming also in Perm, although not in amounts to compensate for the reductions in military orders. Credits have also been forthcoming for the survival of the companies during 1993. The Perm enterprises, in fact, protested against the lack of sufficient subsidies - together - probably for the first time in history.[11]

On the regional level it was assumed in the early conversion phase (1991-1992) that regional conversion funds would be accumulated by the converting companies paying 3% of their turnover to a regional fund. While this fund was highly publicized in the local press, there is no indication that payments actually were made or that any activities were supported by this fund.

In the regional conversion program of Perm some new regional sources of financing were envisioned. It was proposed that 80% of the surplus derived from the privatization of enterprises under conversion should be channeled to the regional conversion program. Tax exemption could be another source of financing as would foreign investment (in the program it was proposed that 5-7% of local national resources be put aside as a guarantee of the foreign investor). Since taxation laws were in constant turmoil in 1991-1993, the regional administration was not able to make any stable predictions of the financial situation. In 1993, the regional budget received 20% of the value-added taxes, 19% of the corporate profit taxes, 50% of the excise duties on drinking spirits and vodka, and 100% of other federal excise duties, except on cars (Sinelnikov, 1993).

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[10]The enterprises of the MIC have to maintain large production capabilities (work pace, raw materials, facilities) to be mobilized in case of war. These requirements have been reduced considerably since 1992.
[11]Article in Cevodnja, August 3, 1993. 22 military enterprsies in the region stopped work on July 29.

Given the financial strain on the regional and local budgets and the urgent task of creating a social safety net, it is not astonishing that the regions in general, and Perm in particular, have not been eager to finance conversion. This is seen as a problem for the state. The instruments for state financing which were suggested in the Perm regional conversion program were:

a. The possibility of allocation of additional regional quotas for export of the regions' resources and products, especially to finance import of industrial equipment and repayment of foreign loans.
b. Establishing for a period of 5 years the Perm regional non-budget conversion fund, which would be formed by transforming during the 5-year period 80% of the federal surplus tax originating from the military enterprises of the region, and by transferring 70% of the hard currency gains from export of military products manufactured by the enterprises of the Perm region. In addition, it was proposed that a part of the region's budget allocations for supporting the mobilization capabilities be transferred to this fund.

Finally, the regional program proposed that the military enterprises would get access to their hard currency assets, withheld since 1991 in the USSR Vnesheconom Bank by the government of the Russian federation.

7. Regional Initiatives: Two Case Studies

Two regional initiatives may serve as examples on how conversion on the regional level has been tackled in Perm. The first is the example of establishment of a conversion fund; the second is a concrete project of Perm Auto.

7.1 CONVERSION FUND: PRIKAME

In July 1992, a conversion fund was established in the Perm region as an agent of regional conversion. The fund was established on a membership basis, including all the major military defense enterprises of the region. Among the members are also the Perm Technical University, the regional and city committees for management of property and innovation funds, and even a bank. The original intention was that the conversion fund would implement the regional conversion program with funds from both regional and state sources. This was at the time estimated to be 40 billion rubles.

Some of the most interesting conversion projects were selected for technical economic study in the first phase, such as the development of production for paints and plasticizers, development of water purification equipment, transformation of aircraft engines to generators, the development of extruders, and, in general, the development of oil and gas industrial equipment.

Expectations in 1991 to the beginning of 1993 were high due to the expected budget funding, through both regional funding and funding for privatization. All this turned out to be an illusion. After two years in 1995 no central budget funds had been forthcoming and the region had only been able to finance one project 300,000 rubles to develop the Perm car. Membership use and money directly from the companies has financed technical economic feasibility studies where the main task of the conversion funds has been to collect a group of experts in order to make the studies more qualified, particularly on the market assessment side. These studies have created business plans and tried to look for regional synergies. In one of the studies, three electronics enterprises were to cooperate with the other. The aircraft engine complex has also been involved in the creation of electrical aggregates on the basis of aircraft engine know-how.

In spite of the fact that the conversion fund today can show only a few concrete results, a number of the military defense enterprise managers interviewed underlined the importance of the fund. For the first time, the defense enterprises of the region have for a forum where they can meet each other, talk about common problems, and potentially find common projects. This is, however, not enough. According to the director of the fund, there will in the future be two main areas of work. First, to try to train and guarantee administrative personnel for the enterprises, and second, to automatize the production of the enterprises. These two problems, the lack of qualified administrative personnel and the inadequate automation of production, is considered to be two common problems for the defense enterprises. The question is, why limit the activities to defense enterprises?

7.2 THE PERM AUTO

Velta, formally the Perm October Revolution Machine Building Plant, which produces defense electronics, bicycles, motorcycles, household appliances, trailers, and other civilian products, has also produced (from 1965 through 1992-93) wheels and spare parts for the Moskovitch automobile. At this time, the Udmurtiya plant of Moskovitch decided to turn to other suppliers. As a consequence, Velta possessed a substantial component producing capacity, but no orders. At the same time an enterprise in Tatarstan was contemplating on starting to produce a Ranger car on license from the UK. The car would be assembled in Russia, which the parts would come from the UK. Since there were currency problems, the relationships and the plans were discontinued. The president of Velta and the Tatastan firm decided to develop a car which would be assembled at Velta.

In 1992, when the first regional conversion plan with a number of projects was compiled, the idea of producing a Perm car was included. The car production and Velta were supported by the regional conversion fund, which gave a credit of 300 million rubles from the regional administration. The car production was seen as a possibility for regional synergism since the Perm auto would have a glass-fibre frame and there was a fair amount of knowledge on composite materials in the region. The motor would be the same as the Moskovitch Orbita.

Velta organized a separate joint stock company with participation of Velta, the company from Tatastan, and other companies of the region. So far 20 cars have been

assembled. The car has been tested at a Moscow Institute and has not received bad test results, according to the chief of production. The plan is to produce 100 cars in 1995 although the problems are many. The car is aimed at workers who should be able to buy it cheaper than other cars on the market. However, the production costs are fairly high. The frame is coming from Tatastan, the motor from Ufa, and the seats from a third region. In fact, the Perm area is producing no more than 30% of the car. Velta has no previous experience in car production nor qualified workers to do the job. So far, assembly has been manual and there seems to be no clear idea where either the investment for series production or the know-how would be available.

Technically, the car is now rear-wheel driven, but is expected to be front-wheel driven in the future. The director of the factory is optimistic about solving the problems and is currently (1995) negotiating with a foundation for the handicapped in order to design and produce an invalid car.

While the car has not been distributed yet, the director is convinced that it can be bought for the price. The advantage is that the frame will not age in the same way as metal. There is a need for a four-wheel driven jeep, and there are no competitors. If the joint stock is able to company-produce a larger number of components in house it should be competitive.

In summary, the Perm car is a symbol of the problems in conversion. The military enterprises are in crisis and Perm auto represents for Velta a possible way out of this crisis. First of all there is a need for more end products (Velta's only end products today are bicycles), and certainly there is a need to do something. At the same time, the appropriate knowledge and investments are not available and the competition from foreign cars is extremely harsh. There are many people in the Perm area who are skeptical of the car, including a number of representatives of the administration and the city. Rumors say that the 300 million credit was granted for the Perm auto project only due to the lobby of the defense enterprises.

8. Regional Learning?

Given the need for regional conversion and looking at the situation with the eyes of a technology assessment researcher, there are few, if any, signs of successful regional conversion. On the positive side, military production has been reduced without social unrest in the Perm area. The scale of unemployment is limited, although increasing and, given the newness of the problem, difficult to cope with. Industrial restructuring is only beginning and the effects of privatization are not yet visible.

What has been achieved on the regional level is the creation of a platform, the regional conversion fund, for meetings and discussions. However, this is a new local institution without very much financial or other leverage. What seems to be needed is the opening up of the military industrial complex, first, to the other industrial complexes of the region. The modernization of the oil and gas complex could be one of the important

tasks to be undertaken by the military industries of Perm, as a few of the regions' enterprises have, individually, converted to gas equipment design and production.

Second, more user-producer networks are needed. A number of the enterprises have proposed new products for the medical/health care centers. No institutional contacts have been established between representatives of this sector and the enterprises/design bureaus.

Third, the environmental field has a great, even global, potential. The regional administration administers funds for environmental protection (paid by the companies as dues for pollution), which could be used in a double way by applying new solutions, developed by the converting enterprises, to environmental problems. A number of proposals exist in this field, but have not been tested in practice due to lack of funds. Instead of looking at the environmental and economic problems of the region as a whole, the current discourse on the environment promotes solving the economic problems first and the environmental ones later.

The way the Perm military enterprises have approached regional conversion is problematic. On the one hand, the regional conversion program has been praised for its content and therefore reflects the seriousness of the effort. On the other hand, it has resulted in the identification of 180 projects. These reflect new ideas, but are not founded in the core competencies of the military enterprises, as is clearly shown by the example of the Perm car.

What seems to be needed is the creation of new institutions which create a forum for a dialogue among regional administrators, the leaders of the military enterprises, and the leaders of other enterprises of the region in order to identify core competencies and the specific strengths of the Perm region. This should also be a first step in the formulation of regional systems on innovation whether emerging on the platform of the gas and oil complex, the chemical complex, the aviation complex, or a future program for forest and agricultural industries. In this context the contributions, based on the individual competencies of the enterprises, may be identified and appropriate networks for emerging industrial activities promoted.

In this process it may turn out to be necessary to select among the scientific and technical capabilities of the military enterprises to be preserved and maintained. So far, the objective of "general" preservation of the capabilities may have more hampered than helped regional conversion.

In summary, the most urgent task on the regional level is the creation of institutional structures which promote a dialogue among the main economic players of the region. The idea of Financial-Industrial groups[12] has so far not been implemented in the Perm region, at least not with implications for the conversion process. Within the need for a new institutional structure, focus should be on the creation of a tradition of entrepreneurship and creation of small enterprises, e.g., based on the separation of the already emerging small enterprises within the larger concerns and holding companies. The establishment of financial institutions for venture capital is a critical factor.

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[12]The first deputy defense minister, Andrej Kokoshin, is to establish a limited number of financial-industrial groups (FIGs) consisting of defense industries, commercial banks, industrial companies, trading houses, and other commercial structures. On the one hand, the FIGs would secure the survival of an advanced military production. On the other hand, they would promote the development of a competitive high technology sector in Russian industry. The plan is that the FIGs will become industrial locomotives concentrating on the greatest possible number of high technologies. By the end of 1994 some twenty FIGs had been announced and a government decree had been established as a legal platform. By early 1995, eight financial-industrial groups had been registered.

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MILITARY TECHNOLOGY AND ITS LINKAGE TO THE CIVILIAN ECONOMY

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1. Introduction

In modern European history, military science and manufacturing in support of the armed forces surged with the evolution of the nation state. The standing armies of the time enforced a revolutionary reorganization of the prevailing artisan mode of production. Serial standardized manufacture of uniforms, boots and increasingly other military items was organized in state arsenals well before the emerging capitalist mode of production revolutionized the existing forms of production and established industrial manufacturing as the dominant mode. During the second half of the nineteenth century the industrial mode of production matured rapidly and eventually became the main source of military supplies. The state arsenals had long since lost their role as spearheads of modernization and rationalization.

Instead, private entrepreneurs ventured to offer national governments military equipment which they had developed at their own risk. They had to parade their products in front of the procurement authorities, which often included the heads of state [1]. Alternatively they had to prove the quality of their products in distant wars. Military innovation was predominantly an entrepreneurial activity offering the *chance* of above average profits in an environment of rearmament which eventually turned into WW I. Export contracts were also part of the entrepreneurial risk calculation. As a consequence, it was not entirely unusual that the same manufacturer supplied the two sides of an on-going war.

As time moved closer to the beginning of WW I a more chauvinistic climate began to prevail and the formerly indiscriminate export of military equipment began to align along the emerging confrontational lines; though only very loosely. But more importantly, governments started to perceive achievements in applied sciences as a strategic asset. Given that important basic research was beyond the means, or rather the profit calculation imposed by the market, of even the largest private risk capital concentration at the time, the German government set up the Kaiser Wilhelm Gesellschaft (today: Max Planck Society) to fill the gap between the universities and

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private sector investments in innovation. The long arms race preceding WW I provided a big push for transforming the arms industry into spearheading innovation. It allowed the individual firms to proportionately speed up their investment in innovating the technology.

Fully within the logic of this strategic initiative of the government the Kaiser-Wilhelm Gesellschaft (today Max Planck Society) played a tragic role in chemical warfare only a few years after its foundation. More importantly with respect to the organization of military production after WW I the German economy was profoundly transformed as the war continued. The system of "Kriegswirtschaft" (war economy) was implemented. By setting elevated prices for strategically needed products without shifting to a straightforward command economy, government resources were channelled directly to speed the development of military innovation and replaced private risk capital in its function of optimizing procurement. In its extreme ideological configuration this formula to gear the economy toward meeting the ends of war, fighting was labelled the "totale Krieg" (total war) by Ludendorff who pictured the need for societies to organize along totalitarian lines while preparing for, and eventually fighting a war.

In WW II the role of the state as progenitor of national Defense and by implication of military equipment became firmly established, not least because the government sponsored laboratories set up to undertake strategic research to optimize national Defense ventured technologies whose development costs and uncertainties were beyond the horizon of private risk capital. Nuclear energy [2], of course, is the eminent example. But as a matter of fact, the governments had taken over the financial risk of military R & D in virtually all fields of military production. The military-industrial sector was turned into a regulated sector of the economy and did not cease to operate under government tutelage at the end of the war. To the contrary, the emerging Cold War and the efforts to rebuild arms industries on the European continent reinforced the role of government and converted this special relationship into a permanent feature [3]. The Keynesian doctrine of economic development prevailing at the time facilitated the entrenchment of the arms producing sector into government structures.

The nationally secluded procurement processes rapidly exhausted the possibilities of organizing competitive bids. The exponential growth of R&D costs led to the preselection of primary suppliers who advanced during the process to the position of a monopolist in the national context. Since military budgets did not follow the explosion of fixed costs which characterized the whole arms producing sector with few exceptions, a continuous "crowding out" of suppliers became inevitable. In the absence of a market, technological superiority became the dominant criteria for individual procurement decisions. The demand for technological sophistication was reinforced by the virtual reality of the predicted advances of the closed military-industrial complex in the Soviet Union. Measured by the resources the military R&D sector absorbed, it represented the spearhead among high tech-sectors and successfully displayed this image in the political sphere.

Without the extraordinary dynamic innovation processes in the civilian sector of the global economy during the last quarter of a century the subject to be discussed in this

article would be rapidly exhausted by identifying the cases where military technology was successfully transferred into the civilian sector. However, a consensus is building that the civilian sectors of industry have taken the lead in innovation. It is assumed that the flows of technological innovation have been reversed. This on-going process is having far-reaching consequences for the structure of the military-industrial sectors in different countries. The restructuring of the military industrial sector in reaction to this shift will be the subject of the sections to follow.

2. Political Illusions About The Peace Dividend

The hypothesis underlying the widely heralded peace dividend maintains that the valuable resources hitherto absorbed by the military sector can be directly converted into additional welfare. This concept appeared particularly appealing in reaction to the military spending spree resulting from the "Reagonomics" in the United States and its reactive imitation imposed onto the WTO and European NATO as well. It provoked a rather politicized scientific debate about the welfare which reduced military spending and disarmament would provide. This discussion insinuated to take successful conversion for granted. Thus, the ensuing disarmament discourse, particularly within the UN-system, resulted in a totally unrealistic projection of a 1.2 trillion US-$ peace dividend to be harvested in the present decade [4]. Today, however, as the steep global cycle of military procurement begins to bottom out, few, if any signs of additional welfare can be identified.

The western political debate about the harmful effects of the arms race [5] was matched by a similar discourse in the Soviet Union after Gorbachev had come to power. He was aware of the catastrophic paralysis of the Soviet economic system. And contrary to the traditional reading of the concept of military-industrial complex by the Soviet ideology which maintained that it described a systemic feature of the capitalist system not applicable to "socialist" economies, Gorbachev admitted that the arms race impeded the advance of the socialist system. He had come to the conclusion that the apparent economic havoc, which plagued the Soviet economic system, was being cemented by the political dominance of the Soviet VPK (=MIC). Gorbachev's understanding of the deficiencies plaguing the Soviet system was focusing further on discipline at the workplace. Aiming at improving the situation, he launched an anti-alcohol campaign [6] along the lines of traditional, rather harsh Soviet mobilization [7] campaigns. In order to win room for political manoeuvre vis-a-vis the VPK he concentrated on profound changes in foreign policy. On the basis of his initiatives to popularize the concept of peace dividend he hoped for new economic dynamics which were to save the Soviet system. Within this logic, he announced a large-scale program of converting the arms industry in 1988. A certain irony of destiny marked the political events following this courageous declaration of intent.

While Gorbachev tried desperately to save the Soviet system, the West took his manoeuvres as conscientious steps toward systemic change. With hindsight, however, his aborted strategy to safeguard the Soviet system prepared the path toward systemic change,

not least because his strategy was based on an equally flawed analysis of the economic issues involved. His conversion program came to nothing. He had fallen prey to the illusion of harvesting the peace dividend he himself had helped to promote.

But Gorbachev was not alone in underestimating the difficulties of transforming an economy dominated by military production. More generally, contrary to an international debate already active in distributing the "peace dividend", it turned out, East and West alike, discovered that the existing technological capabilities of the military-industrial complex could not be converted into civilian production without major investments [8], if at all.

3. Economic Realities And The Peace Dividend

The military-industrial sector was formed and reinforced in both systems behind a shield of political state-interventionist protection. Productivity was not controlled by a market mechanism. Competition in both systems was rather about political influence and convincing presentation of innovative technology, seemingly leading edge, almost irrespective of price. From this pattern emerged an intrinsic trend toward an ever growing share of R&D in procurement outlays. The system was to a large extent and probably is still shielded against any non-partisan evaluation. Additionally, the military paranoia about secrecy, however justified it may be, adds to the continuation of separating the manufacture of military supplies from the mainstream of civilian industry. The politically accepted imperative of secrecy even offers protection against too much parliamentary scrutiny.

The American B-2 stealth bomber is an obvious example of the splendid isolation of military procurement from established rules of parliamentary budget authority. It emerged from nowhere and will probably never face an evaluation of its costs and benefits in the context of potential alternatives, because none of the dominant actors is interested in reviewing this project. Resulting from a similar pattern the Russian Tu-160 variable geometry bomber was displayed at this years Le Bourget exhibition. While the harsh budgetary limits in Russia are likely to break the splendid isolation of the military high-tech networks at least if the critical discussion [9] in Russian media reflects the political tendency in decision making; then the competition in the United States is more about crowding out one or the other of the "kilobillion" systems, acclaiming American superiority rather than reviewing the underlying industrial structure and the suitability of the now uniquely elevated American military outlays. Nonetheless, procurement reductions have made a significant proportion of the military industrial sector redundant and forced these manufacturing capacities to seek alternative civilian markets. But contrary to the dictum of the political conversion rhetoric, was it not feasible to redirect the military production capacities - not needed any longer- towards civilian markets? In most cases the accumulated combination of specific factors of production was not competitive in civilian markets. And even where conversion seemed feasible both from a technical point of view and the cost structure of the respective unit of production, these

enterprises were not experienced in marketing, further impedive conversion and successful entry into civilian markets. As a consequence, the dominant strategy in western economies in response to dwindling military demand was diversification of production mostly through acquisitions and hardly ever through plant level conversion of production. Core industries responded with mergers and mega-mergers [10], in order to bring production capacity in line with shrinking demand.

In the former socialist countries the situation is much worse. The transformation of the entire economic system and the restructuring of thousands of plants, military and civilian alike, all burdened with many social functions not related to production, were to be achieved simultaneously. The capital stock of the civilian industry was particularly poor and worn out, while the capital stock of the military sector was generally superior including imported modern machine tools. The diseconomies caused by extremely elevated levels of vertical integration of production, reflecting decades of misgivings with the proper functioning of central economic planning, impeded rapid shifts towards alternative products. A logical step would have been to move toward the production of specialized components. A more economical specialization and division of labor is developing only very slowly as the transformation of the economy advances. At the same time, the military-industrial sector was not flexible enough to actively seek niches of subcontracting in export markets, not least because the culture of military secrecy was being maintained at the factory level.

Thus, in spite of basic systemic differences, there are also common features in the downsizing of the military-industrial sectors. The reallocation of factors of production released from state-tutored military activities requires large amounts of investment and implies the closing down of many production sites not suited to achieve dynamic efficiency, which is a necessary condition to survive in civilian markets. Thus, rather than being an immediate boon, as was expected by Gorbachev, disarmament and the accompanying restructuring of industrial production require considerable investment in order to avoid large scale unemployment. In the former socialist countries the volumes of investment needed are clearly beyond their means in the best of the cases. By implication this amounts to either slowing down the restructuring process or large scale, regionally concentrated unemployment. The widely heralded peace dividend is a medium term perspective at best.

It should be added that the military budgets of the boom years did not include provisions for the full life-cycle costs of the procured systems [11]. In some cases an environmentally safe completion of the life-cycle requires considerable capital outlays and this burden, yet unpaid, is not restricted to the decommissioning of nuclear devices only. Again, the production orientation of the exhausted Soviet economic system induced a reckless attitude toward the costs and dangers of environmental hazards created by production or even the product itself. The military mortgage against the future, left as a burden for the coming generation, is a common feature at both ends of the arms race. However, the accumulated burden seems to be much higher in Russia, Kasachstan and the Ukraine than elsewhere.

4. The Emerging Economic Environment Of Defense Production

The last twenty years are marked by profound change in manufacturing. Human skills and many mechanical devices were made redundant by the electronic revolution. Tons of mechanical gears were replaced by match box sized chips. The possibility of instant global communication and exchange of virtually unlimited volumes of information brings about a permanent revolution of the vertical integration of production processes. New forms of the division of labor (outsourcing) have emerged and continue to change the industrial landscape profoundly. The number of competitors with whom to reckon has increased as a consequence of globalization and the rapid progress in some late-coming industrializing nations in particular. The opening of Eastern Europe and the former Soviet Union further expands the realm of competitive sourcing.

But most important for the changing linkages of the military-industrial sector with the civilian economy is the fact that the rate of product and process innovation in the civilian sector of the economy has accelerated at an unprecedented scale during the last quarter of the century. This rapid pace of technological development is determined by the "pull of the global market" for civilian products.

Increasingly new technologies require the command of several fields of technology which combine into "super-technologies". They are not any longer within the reach of small and medium enterprises. Instead, an unprecedented concentration and internationalization emerges as a dynamic reaction to this trend. New products and process technologies have short life times as the global competition puts enormous pressure on every actor in the market, not only to speed technological development, but also to market any innovation instantly and globally. Large corporations operate globally and react to the challenge of the shrinking half- times of their innovation by broadening their technological base through diversification and the formation of strategic alliances allowing efficient vertical integration of production with the widest access to markets.

In this process the volume of private risk capital invested in R&DT has increased in scale, it generates R&DT investments within corporate networks and their alliances which dwarf the amounts that national Defense laboratories or traditional military high-tech contractors can hope to mobilize within their framework demarcated by the national Defense budget. Moreover, investment of private risk capital in R&DT is ultimately linked to the rigorous control of the market, providing for a more efficient organization of research and better targeting toward operational results than the closed military R&D networks avail themselves in the absence of efficient non-partisan outside control.

It is by now well documented [12] that globalization has reversed the post-WW II pattern, when the size of military R&D budgets, in the United States and the Soviet Union in particular, had no match in the civilian economy. It should be noted, however, that Russia and the Ukraine do not participate in the global networks dominated by large transnational corporations, because their participation in the world market during Soviet times was largely restricted to raw materials and arms. Several valid examples of military research and the ensuing application of new technology provide sound evidence that the

military investment in large scale R&D has imparted the evolutionary path of civilian technology [13]. This is not surprising as, at the time, no private risk capital would have invested sums in R&D comparable to what military budgets entitled the large research laboratories and a small group of established Defense contractors to spend. Though only nominal parameters of productivity control were applied and this R&D process reproduced itself in the seclusion of a virtual world of projecting perceived military threats.

The most conspicuous example of a militarily determined path of technological evolution is, of course, nuclear energy. But the economic development of industrial nations also shows that the benefits of the military exploration of new technological paths have not always been harvested by the civilian industries of the nations focusing on military research. The secretiveness of the military sector and its institutional pattern did not provide for a shrewd exploitation of the inherent civilian applications, and a broad diffusion of the technology, and thus left the successful application and creation of new civilian markets to .other nations, Japan in particular.

The former Soviet Union provides the extreme case of dissociating customized military R&D and generic industrial innovation. Among the observers of the high-tech sector in Russia seems to exist a consensus that laser technology was much more advanced than in the West. However, these achievements emerged because of their potential military applications and their large potential in civilian applications has not been exploited sufficiently to benefit the Russian civilian industry, even today for lack of organizational experience to download sophisticated scientific discoveries into applied process technology and product innovation. At the same time, the Russian Defense research establishment tends to overestimate the market value of the technological innovation it commands and is very hesitant to collaborate with transnational corporations in order to ready these technologies for commercial exploitation. Given the dynamics of industrial innovation the commercial potential of this potential wealth may convert into a mere historical footnote.

Before reviewing the consequences of the intrinsic changes in the driving forces behind R&D, it should also be discussed that the military technologies procured to match the requirements of toady's military operations display many commonalities with rapidly emerging civilian markets. While global observation from space using the whole spectrum of waves, communication, storage and instant availability of large volumes of data, remote control of operations etc. belong to the high priority areas of military procurement, these technologies are at the same time the most dynamic sectors of civilian high-tech markets. It is this demand pull which is one of the driving forces behind the allocation of corporate investment in R&D.

5. Towards A Civilianization Of Military Systems

New networks of innovation superior to state supported Defense innovation have emerged. The formation of globally operating corporations and mega-alliances among

these corporations pursuing mutual strategies of innovation and production allow to concentration of volumes of investment, hitherto unheard of, aiming at developing specific market-oriented technology.

This is one major reason why military research and product development has begun to lose track of available innovation. Civilian innovation cycles are surpassing the absorptive capacity of the present design arrangements applied to large sophisticated weapon systems which take several years to mature. The controversial Eurofighter provides an example of the inertia of military design. Its electronic architecture [14] was finalized when the 80386 chip was on the market and will thus carry this technological level into the next decade while hardly any civilian application is likely to continue to use this technology, outdated by several generations by the time the aircraft is supposed to become operational.

Another reason rests with the fact that many advanced modules and subcomponents can not be produced as customized items any longer. Leading edge innovation is only available on the basis of sophisticated process technology in "global factories" which may require an investment of not less than one billion US $ of investment, as is the case with chips. The design features of such technologies are generic by definition. Their production becomes economically feasible only on the basis of very large numbers produced, while they are likely to dominate the global market for only a certain period.

Hence, a military design can incorporate leading edge technology if and only if the design architecture displays levels of flexibility comparable to what has become an imperative for products to succeed in increasingly competitive civilian markets. The present generation of sophisticated weapon systems, however, has a long way to go, before developing the capability of assimilating successfully concurrent innovation generated in the civilian sector during the life-cycle of the system.

From this we may infer that the extraordinary speed of civilian innovation that global corporate networks generate will eventually impose new orientations and a profound reorganization of military R&DT. Future affordable production of military equipment requires basic change of its implicit design architecture, in order to provide for sufficient flexibility indispensable to absorb technological innovation which the civilian sector creates in ever shorter intervals. The on-going, though barely admitted trend of "civilianizing" military production in terms of the share of civilian components is to be further explored and systematically expanded, because military designs continue to be the result of innumerable stipulations rather than being efficiency driven and optimized to the task . Quality control and the organization of military production itself has to assimilate the methods prevailing in advanced civilian sectors. The present bureaucratic routines, even intervening in the production process at the plant level under the pretence of controlling quality, are not any longer warranted given the superior quality standards achieved in the civilian sector without governmental supervision. The opportunity costs of maintaining the present structures largely regulated at national levels are increasing.

Of course, institutional inertia and vested interests are likely to slow the necessary changes. But if rapid changes will be blocked by the entrenched lobbies of the national bureaucratic industrial networks presently controlling procurement, reasonable military

Defense will become unaffordable for democratic societies. But more importantly, scarce resources will be wasted for isolated military research with little, if any civilian spin-off and diminish the capacity of the respective nation to invest in the generic modernization of its economy; a necessary precondition for nation states to maintain a sufficient Defense posture.

It will not be denied that a few very specific military requirements may still call for separate technological development. But most, and definitely far more than the present procurement procedures permit to be identified, "demands of the military market could be met by using civilian driven technological developments..." [15]. Rather than constituting a separate R&D sector the military "market pull" should be translated into an input in the programming of civilian technological development. In order to manage such a new strategy, the civilian industry would have to be in the driving seat of organizing the required research rather than public research laboratories.

If the above description of trends reflects the present path of high-tech sectors in the global economy, it is safe to conclude that the preservation of national Defense sectors for the sake of sovereignty will not only be costly, but it will also lead to production of more and more "second-rate" military equipment. For example safe, wireless satellite-supported communication around the globe is already a "first-rate" market-driven technology whose quality and price can not be matched by traditional efforts to customize military communication systems at the national level. While some non-state parties in civil wars seem already to exploit private sector networks, it is still a routine exercise of major armed forces to invest huge sums in the development of their own communication networks instead of buying "off the shelf" advanced civilian systems.

The same argument applies to air traffic control and many other fields where dubious military specifications protect the maintenance of a bifurcated market [16]. This product philosophy is almost the opposite of the way civilian products are designed, which are oriented towards flexibility, versatility and strategic provisions for the addition of innovative technology as it becomes available. The gap between the development periods which military systems traditionally take, not to mention their life-cycles, and the stunning rate of innovation which the civilian market generates at lower cost than the customized military components require, continues to grow. In order to change this, and to provide for a timely assimilation of new technologies emanating from the civilian sector, radical changes are required which go beyond the product architecture and effect the industrial organization of military production as well. The "civilianization" of military systems must become the point of departure of the design work, and replace the implicit "civilianization". Such a step would allow us to reintegrate large proportions of hitherto separated military R&D investments into national strategies attempting to enhance the competitiveness of the economy rather than continuing to be a drain.

The difficulty of overcoming the continued stalemate of the procurement processes in individual countries is related to the existence of a number of established military manufacturers who are so imbedded in the close non-market government relationship that they cannot successfully diversify and enter into civilian markets as the military demand

is shrinking. Jointly with a large cluster of government bodies they form corporate interests to defend the status quo, i.e., a separation of military and civilian sectors.

There are, however, significant differences among the major industrial countries with respect to the specific forms and the degree of entrenchment or rather the dependency on the status quo. In some cases, like Germany for example, the present status of the Defense industrial sector seems to facilitate a merger of civilian and military sectors whereas in other countries, Great Britain being an example, the restructuring moves in the opposite direction. At the same time, a circle of military-industrial interests, while favoring a continued separation of the military, hopes to consolidate its position through the creation of a regulated EC or European NATO procurement market.

Only a non-partisan bottom-up review of how the state can best procure the hardware for its military security would provide the chance that decision makers will finally recognize that the change of the dominant technological paradigm is to have profound implications not only for the future structure of the Defense industry but also for the type of equipment modern armed forces use to fulfil their missions with acceptable levels of efficiency.

6. The MEKO-frigates: A Market Driven Design

Naval yards in western Europe were particularly hard hit by a combination of financial and technological factors. Many yards were closed. Constantly increasing unit costs were not matched by equally growing procurement budgets. In the case of France and Great Britain a large share of the naval budget is absorbed by the costly and specialized construction of nuclear warships. More importantly still, at most 25 % of the total value added in naval construction fall today within the traditional work of the yards. The rest is mostly taken by the electronic industry and specialized builders of engines and turbines as well as the missile, torpedo and gun manufacturers. As a consequence, export markets became the battlefield for survival. Quite often, supportive national governments even created the export markets by extending subsidized credits to foreign customers. But the structural crisis of the sector could not be stopped and renowned naval yards now stand idle.

The multiple efforts to unite procurement at a European level came to very little. One multi-nation project after another faltered, generally after years of jointly elaborating the specifications and negotiations over workshares and "juste retour". The elaboration of specifications in the naval sector is a particularly traditional and interventionist exercise. The variety of technologies to be integrated into the design of a modem warship is steadily increasing, which prolongs the gestation period of any new class of ships [17].

Aiming to survive in the contest among European naval yards the German yard Blohm & Voss opted for an alternative strategy. The yard developed the so-called Meko-frigate at its own expense and absolutely independent from traditional government sponsored contracting. The design followed construction principles that were applied in the field of special cargo ships. The frigate is basically composed of standardized modules

and components. Their installation assimilates the loading of containers which then are functionally connected. This procedure provides for a maximum of variability of the design. By changing the design Blohm & Voss escaped from the established upstream supply links prevailing in naval construction.

The yard was able to provide customized frigates to the respective clients on the basis of worldwide sourcing and gained the flexibility to consider suppliers favored by the customer without the need of major, costly design changes. This product architecture also allowed for a significant reduction of construction times because the modules of complex subsystems can be manufactured simultaneously before being integrated as units at the last stage of construction. Another attractive feature of this modularized design is the possibility to add-on innovation as it becomes available during the whole life-cycle by exchanging entire modules. Ships of this design are not arrested in the yard while the integration of new systems is taking place because modules can be integrated outside the ship. Another commercial advantage seems to reinforce the market position: a customer may start buying a lean version, however retaining the option to rapidly add-on technology as additional finances become available or new contingencies emerge.

The Meko-frigate design may have some drawbacks from the perspective of traditionally designed, though rather expensive frigates, but it convinced many navies and the yard won a large share of the international market in this class of naval ships [18]. And from the perspective "value for money" the tax payers in Germany are wondering as to why the German navy does not procure ships based on this principle.

7. Transnational Corporations As Emerging Monopolist Component Suppliers

The commonality of a number of basic components in civilian and military systems severely limit the chance to maintain specialized military suppliers in the market on the basis of spurious military specifications. The pull of global markets speeds the technological improvement of the civilian variants and regularly leads to a concentration of very few suppliers who dominate the market internationally. Their market driven investment to improve product quality can not be matched by a supplier developing customized military components. As a result, there is increasing pressure on nationally designed weapon systems [19] in light of qualitative concerns on components produced by the civilian market leaders. The number and relative size of such components increases steadily. This trend structurally destroys the paradigm of maintaining a national Defense industrial base. Certain electronic equipment, diesel engines and heavy gears used in army and naval equipment are cases in point where single or perhaps two suppliers dominate a specific product range internationally.

A recent study of Japan's security policy [20] argues that Japan based its strategy to secure national security on a consistent industrial policy aimed at securing the necessary technological competence by taking the global lead in key civilian sectors. In a sense this logic of Japan's industrial policy resembles the underlying trend of the present advance of

globally leading civilian corporations toward growing shares of value added Defense production.

8. The Russian dilemma

For Russian decision makers the present situation poses a dilemma. The Russian economy is far from becoming fully part of the thriving corporate networks dominating the civilian sector of the global economy. But without gaining full access to this dynamic economic sphere, Russia's military production is also bound to lag behind in many crucial fields. A return to the old splendid isolation of the arms industry - much favored by a powerful lobby - would reduce this sector to continued production of customized systems, unable to spin-in the innovation which the civilian sector pushes relentlessly. Thus, the present plan to consolidate a core of military industries under state control as centers of technological excellence - launched by the deputy Defense minister Kokoshin - seems to be based on a flawed analysis of the ways innovation is presently generated and proliferated at global levels [21]. If carried out, however, we are likely to witness a secluded Defense sector trying to exploit cheap, which may include nuclear, highly destructive technology to make up for the gap in technological sophistication, not unlike the logic of the old Soviet military doctrine.

If one adds to the puzzle which Russia's government has to solve, the necessity to develop a sound economic base in order to be able to finance a politically sustainable Defense posture, it becomes clear that the future Defense-industrial strategy will be a major road-block before the country will smoothly integrate into an enlarged European commonwealth.

From an enlightened western European perspective, a rational security policy, which takes into account the new post Cold War political geography of Europe, would seek to assimilate Russia's economy as fast as possible into economic community of advanced countries, not least in order to forestall a political backlash. While the national Defense industrial bases in different western European countries are not any longer sustainable, not least because of the dramatic consolidation of the sector in the United States, new structures are bound to emerge. There is little valid political argument for not taking Russia aboard when it comes to radically restructuring the European Defense industrial base. Creating cumulatively mutual interdependence in Defense production would be the best insurance against renewed antagonism and would further relieve the Defense industrial burden of Europe as a whole. But unfortunately the political arena is still occupied with yesterdays uncompleted projects.

9. Defending The Status Quo: The Dual-Use Campaign

Somewhat late in a paper discussing the linkages between military and civilian technology the widely publicized concept of dual-use technology will now be addressed. When Defense budgets began to come under pressure the dual-use discussion moved onto the center stage. Earlier it was simply taken for granted that there were large spin-offs. However, in the contemporary political climate of the Cold War the cardinal aspect of the opportunity costs involved in the military deviation towards innovation at the product and process levels was hardly discussed. This was reflected in a serious discussion at various levels in western Europe about the implications of the American Defense investment escalation under Reagan. It was argued that the American policy was a sinister design to win ultimate technological superiority in world markets by means of extraordinarily elevated military R&D outlays. Of course, the European Defense lobby demanded a vigorous response to this challenge.

Once on the defensive, the bureaucratic-industrial alliance forming the core of the Defense sector started to devise institutional arrangements which would allow the opening secluded sphere of military R&D in an attempt to improve the competitiveness of the civilian industry in the respective countries. In a second step the dual-use potential was integrated into the criteria of Defense investment decisions. Politically these efforts were directed at enhancing the fading legitimacy of elevated Defense budgets.

The measurable success of this policy, accompanied by high level panels and political rhetoric, is extremely limited. The systematic British arrangement to offer military technological achievements for application in the civilian sector was not particularly successful and did not help stop the prevailing trend of de-industrialization. To the contrary, this trend is counterbalanced by foreign civilian investment. The competitiveness of the American industry at large did not improve in world markets. One might argue that the very sectors where the United States were leading have reinforced their position on the basis of civilian market dynamics. This observation is not contradicted by the fact that the leading edge was originally won on the basis of military technology, like the conversion of long distance bombers into successful modern commercial aircraft like the Boeing 707, the British Comet and some Soviet designs as well.

The argument which this paper attempts to support qualifies the dual-use discussion in its present form as a mere sales argument of Defense-industrial interests in western countries as well as in Russia. The proposed dual-use technology remains technology driven rather than market driven. From past experience there is little reason to assume that the two criteria are likely to match very often, while this would be a precondition for the viability of the present attempts of implementing a dual-use policy.

If using the term at all, it would be more appropriate to apply it to the emerging numbers of civilian components which are assimilated by advanced military technologies. This definition does not exclude successful innovation generated in the course of customized military research, but it denies the likelihood of this to develop into a

systematic pattern in the context of the dynamism of global corporate alliances to advance their position through innovation at all levels.

10. Differences In Corporate Responses

Globally operating corporations are not particularly attracted by nationally protected "markets" of military procurement, though they are in a structurally unique position to take increasing shares of value added in military production simultaneously in several nationally protected markets. The increasing commonality of civilian an military applications provides global market leaders with a leading edge with which traditional military supply networks can no longer compete.

National Defense industrial champions who represent the consolidated remains of the Defense industrial bases, on the contrary, attempt to complete the consolidation by acquiring additional Defense business. Sometimes they even venture to expand the base of their core business abroad. Where they emerge in this form they do so with implicit support of the respective national governments and expect active export promotion on their behalf.

In a few cases the national champions are at the same time globally operating corporations. In Japan and Germany the government abstains from direct regulation of the national Defense industrial base, at least relative to other major industrial nations. Hence for Defense manufacturers the government forms an element of the market and is less of a regulator of the market. As a result Defense manufacturers have generally anticipated shrinking markets and defended themselves by vigorous diversification [22] into civilian markets.

In order to better understand the parameters of the anticipated restructuring of the (western) European Defense industrial base, we shall graphically illustrate what the present moves of the major players are along the two axis focus on Defense versus diversification and nationally protected and regulated versus global investment and strategic alliances for innovation and marketing. The positioning of companies produces a static picture of what in reality is a dynamic process. It emerges from the annual reports consulted that companies which have already expanded abroad are pursuing this expansion further, while companies with high shares of Defense production are seeking a consolidation of their Defense industrial position. Joint ventures across Europe are presently a favored element of this strategy. Comparing Britain, France and Germany it emerges that the French military industry is not yet connected with the global networks of (civilian) innovation whereas in Germany military production is predominantly embedded in civilian networks most of which have expanded internationally. In Britain the situation appears to be somewhat bifurcated, while British Aerospace and some smaller companies not included in the graph focus on excellence in military manufacture as their exclusive domaine, other, formerly predominantly military-industrial companies like the formerly embattled Lucas company have managed to slice their share in the globalized civilian economy. The scheme is rather tentative and should be read as an

outline for an empirical research project in the process of being started. The ultimate aim would be to determine important parameters of diverging industrial strategies to be taken into consideration in the political discussion about the shape a unified European Defense procurement market.

11. Positioning Of The Leading National Military Producers [23]

No conclusion will be attempted because the situation appears to be rather diffuse. Except that the lessons of the heydays of military R&D during earlier post-war decades are no longer applicable. Not least because a single global corporate alliance may invest much more in R&D in trying to bring a supposedly promising technology to profitable markets than the Defense budgets of all European nations together. This technology may have such generic properties as to penetrate the military sphere immediately. The political decisions have not been taken to reconcile military procurement practices and mostly "European" political declarations with the economic imperatives of deregulating the national economies or have the post-Cold War security doctrines matured sufficiently to predict the composition and volume of procurement in Europe.

However, the scattered observations presented herein should help to assess the realism of different political proposals. Hopefully, they will encourage additional, probably contradictory observations in order to enrich a somewhat barren political discourse with empirically supported arguments.

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17. The French project to build a nuclear powered aircraft carrier drawn out over almost two decades highlights the dilemma of traditional naval construction in an environment of rapid technological innovation.
18. Space does not allow to discuss the entrepreneurial, rather than state-tutored naval designs of another rather successful private German yard, the Luerssen Werft. But it seems that a straightforward entrepreneurial approach to naval design was the key to Luerrsen' s extraordinary export performance.
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23. The table is based on the European companies listed in Chapter 13 'Arms Production' in the 1994 SIPRI-Yearbook.

CONVERSION IN HUNGARY

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Before examining the state of military industry in Hungary, it is useful to survey the state of technical development which has undergone a significant change since 1990. Over 50% of the previously nationalized industry has been privatized. At present there are about 800,000 private enterprises in Hungary, including small family enterprises and medium-sized ones. This led to a transformation of the structure of industry, starting in 1990, and now small and medium-sized enterprises constitute about 70% of industry, i.e. the transformation in industry, into the direction which is exhibited by prosperous economies, has progressed significantly.

Hungary, as one of the former Comecon countries, exported a high proportion of its products to socialist countries. After the collapse of the so called socialist market, starting in 1990, part of the Hungarian industry had to close down, production was reduced by about 30%, as the products were not convertible on the world market. However, since the second half of 1993, production has increased considerably, the increase in percent attaining a two-figure number in 1994. The new industry was capable of putting convertible products on the market. An analysis of the mental sources of this remarkable development revealed (Fig. 1) that in some fields the people involved in research and development have undergone a remarkable cultural change. For example, in agriculture and economy, the number of those working in research and development, was reduced by 20 to 30%, of whom a great percentage were employed in small and medium-sized enterprises. Among the technical intelligentsia, this change was even greater, about 70% left their former jobs at universities and research institutes, and most of them found employment in private enterprises.

In the new fields of development this group of people became very active in promoting industrial development. During the past 4 years the National Committee for Technical Development financed application and development research by about $120M, with participation of various institutions in the proportions shown in Fig. 2. More than 60% of the money went to small and medium-sized enterprises which indicates that outstanding researchers leaving research institutions for enterprises made good use of their knowledge in this field.

R.F. Dundervill, Jr. et al. (eds.), Defense Conversion Strategies, 141–149.
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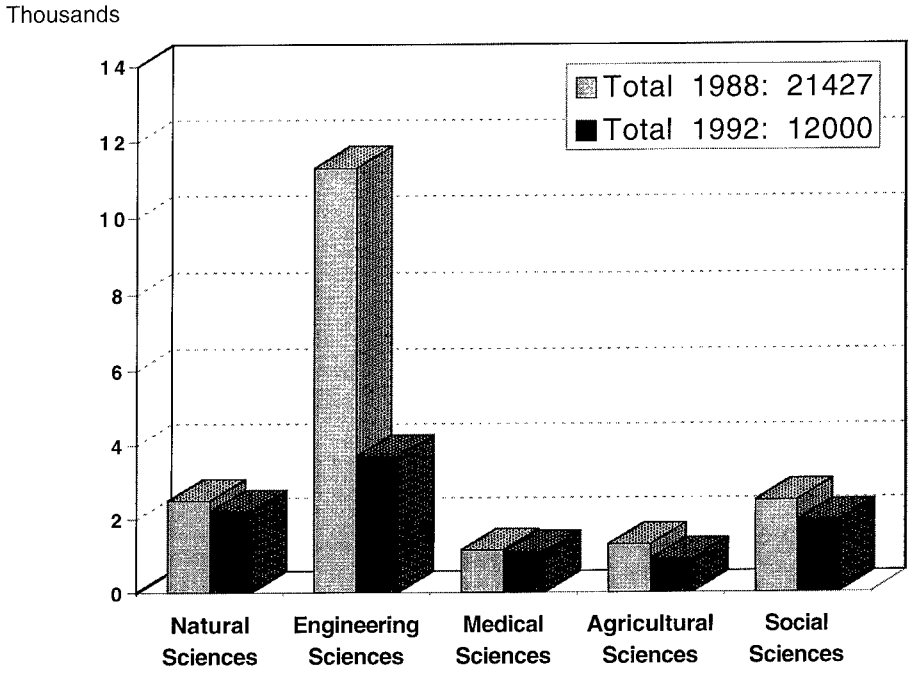


Figure 1. Number of R&D Personnel by Fields 1988 - 1992

The rapid development of the infra-structure was inevitable to the cultural transformation. In 1990 the technical infra-structure was in a bad shape; on the one hand, good quality roads were missing, and other means of communication (e.g., the telephone network) were not well developed. In research and development, provision with computers was at a low level in spite of the fact that Hungary produced computers. From 1990 on, the National Committee for Technical Development contributed to the improvement of the infrastructure by $140M in the field of research and development, in addition to the funds provided by state institutions for this purpose. Figure 3 gives a survey of the distribution of the support among the various topics of the infrastructural help. This also indicates that we have attached great importance to primary information exchange, and helped our experts' participation in international meetings. We have put emphasis on the development of computer networks, with special regard to our universities, and at present the infrastructure is mostly available to enable an unimpeded flow of information. I wish to point out that the National Committee for Technical Development, the Hungarian Academy of Sciences and the Ministry of Education and Culture started a program in 1985 for infrastructural development by which several thousand research sites have been connected to the international computer network since 1990.

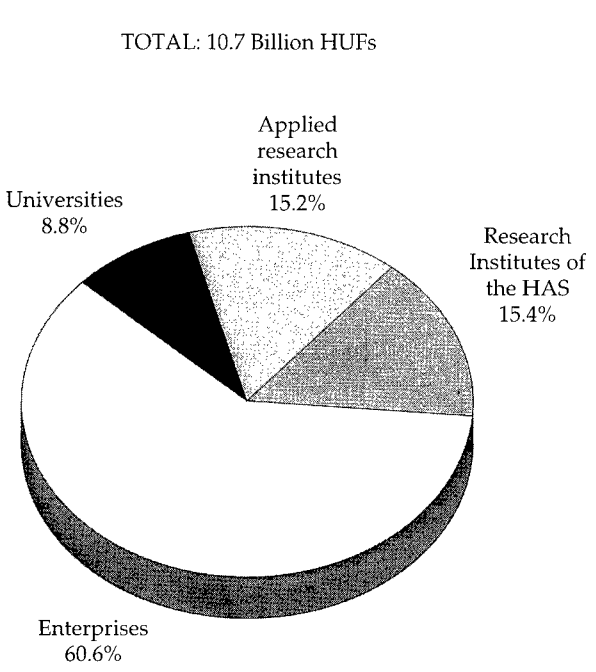


Figure 2. Applied R&D Applications Approved 1991 - 1993 (By the Type of Applicants)

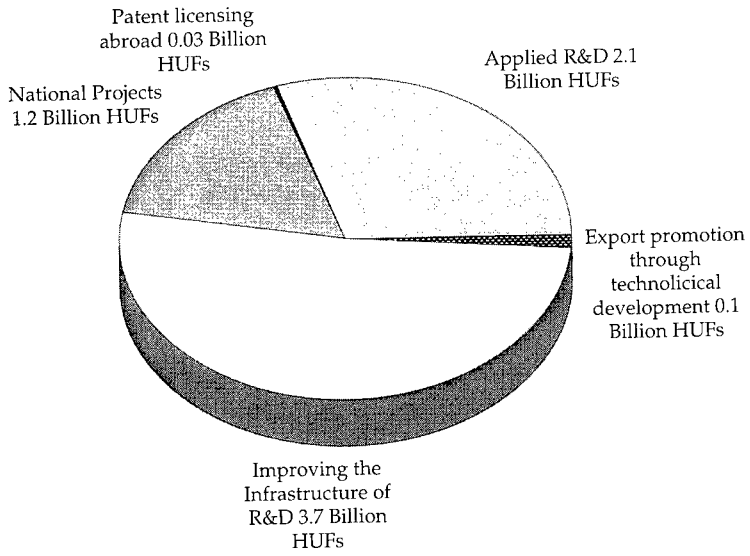


Figure 3. Financial Support Schemes in OMFB 1993

It is very interesting to survey the areas where development funds were invested during the past 4 years. Figure 4 shows that the fields selected for development were the ones which are of elementary importance for a small country. It is worth noting that heavy industry is practically missing. Development in steel industry was not funded from central resources but from the resources of the companies.

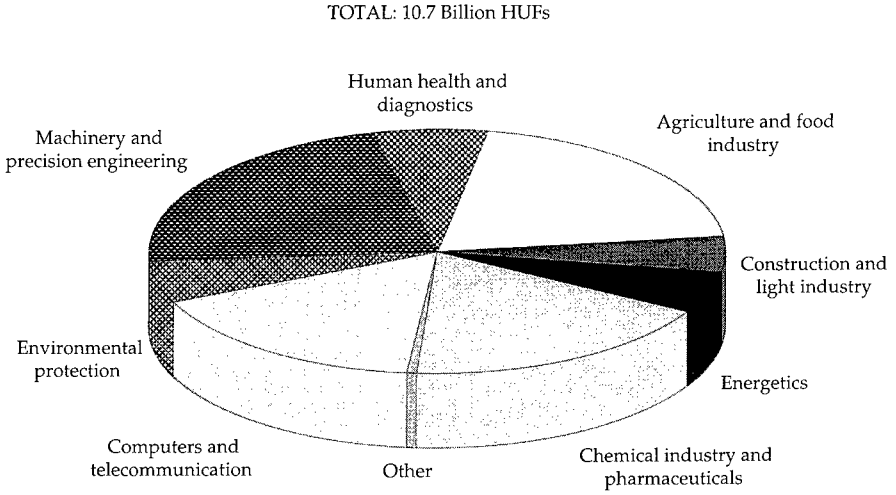


Figure 4. Financial Support of Applied R&D Applications 1991 - 1993 By Fields (Million HUFs)

The roots of today's Hungarian military industry are in the extensive national Defense base created between the two world wars. Production of military industry has undergone a remarkable development following World War II, mostly through restoration of industrial bases founded earlier. Due to the polarization of the world systems, after the establishment of the Warsaw Treaty, development was determined by the compulsory influence of the Soviet technique. This constraint distorted the structure of our military industry and the development of special areas of industry in consequence of the compulsory specialization. Production was restricted to some special fields with large-scale production which allowed little chance for developing Hungarian technical research.

The conversion of military industry to civilian production, which started in the 1970s, resulted in a remarkable change in the structure of production (Fig. 5.).

In 1989 Hungary exported 85% of the production of its military industry to Warsaw Treaty countries.

The international political rearrangement after 1989, the collapse of cooperation in the framework of the Comecon and Warsaw Treaty and the increasing pressure due to the introduction of market economy required reconsideration of the operation of the industry and within it the military industry. Successful establishment of a new industrial strategy

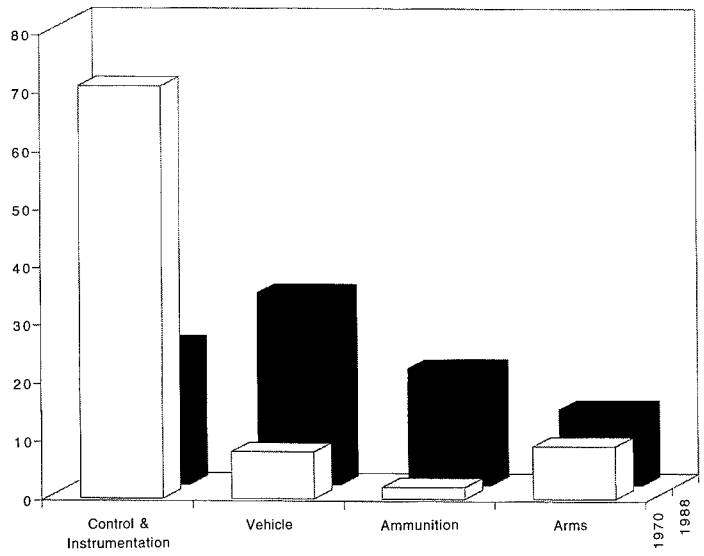


Figure 5. Change In The Structure of Production
(Military Industry; Hungary 1970 - 1988)

was rendered difficult by the recession in the world economy and the pressing lack of functioning capital. Conversion of military industry was made more difficult by the fact that because of the specialization in 1989, Hungarian military industry could only supply about 30% of the requirements of the Hungarian army. 80% of these products were manufactured using technologies taken over earlier from the Soviet Union. 70% of the requirements were imported from earlier socialist countries.

These proportions are no longer valid due to market and internal economic reasons. The changes modified production in the years 1988-1993 (Fig. 6). For companies which have the technical level and flexibility to survive,

- short - term survival may be assisted by switching military-industrial capacities over to civilian production, and
- in the long term, the double diversification (for military and civilian use) of
- military-industrial capacities, the strategy of production flexibility may bring results in quality assurance and in extension of professional civilization which may improve the prospects of our joining NATO and the European Union.

The conversion of factories manufacturing four different groups of military products, which went through success and failure in the years 1990-1994, is described in the following sections.

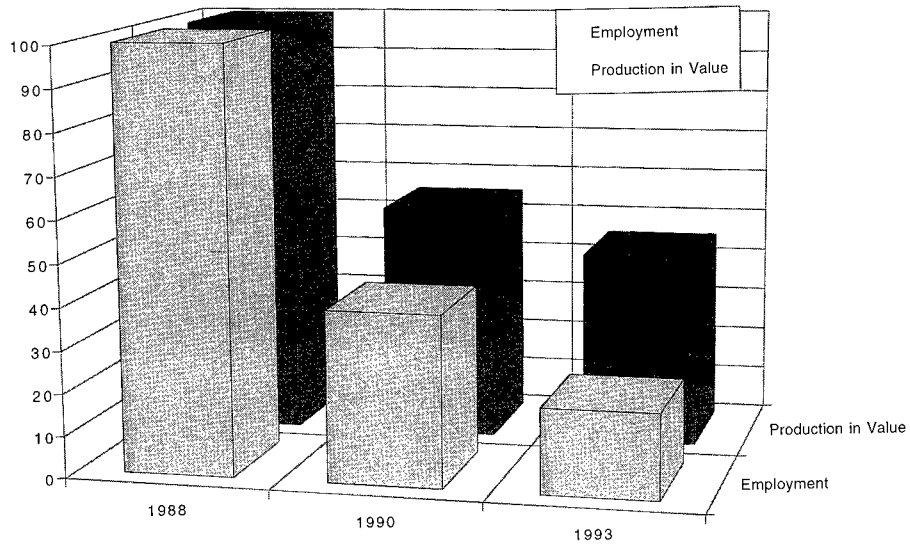


Figure 6. Change In Production
(Military Industry; Hungary 1988 - 1993)

The company representing armament production was forced, as a consequence of the complete freezing of domestic military industrial orders since 1987, to restructure its production and sale The limited liability company founded on in January 1990 by state-owned factories producing partly civilian products is one of the few companies which was capable of carrying out the conversion and increasing its sales to more than three fold in the period 1991 - 1994. In the course of restructuring, about 70% of the capacities available in 1987 were converted for manufacturing sports and self-Defense weapons demanded on the market in a way that they remained suited for producing weapons for the armed forces if needed. Exports increased continuously, now amounting to 90% of the production. The key to successful conversion is flexible technology, good marketing policy, continuous product development according to the demands of the market and also long production traditions. The number of staff, 226 at the time of foundation, was increased to 661, since the company is able to satisfy the demands for the entire range of its products by extension.

The factory with 50% Hungarian share, producing gas masks and other chemical protective tools prepared for conversion to civilian production, as orders from the army decreased in the years 1990-1992, to manufacture sanitary containers, laboratory tools, stretchers and equipment for transport of wounded people. Thus, in spite of the drastic reduction in the demand for military technical tools between 1993 and 1994, the company was able to stabilize its sales in 1994 at 70% of those in 1992, by nearly doubling the production for the civil sphere in 4 years. However, as a consequence of the reduction in the sales of military-technical equipment from 71% in 1990 to 9% in 1994, the company was forced to reduce the staff by 50%.

The company which manufactured instruments for measuring radioactive radiation and for chemical protection for the army and civil Defense, and for export into Warsaw Pact countries in the 1980s, lived through a severe crisis, starting in 1988, in consequence of the collapse of its domestic and foreign market both in the civil and military sphere. By 1994 the sales dropped to 35%, the staff to 12% of those in 1990. In 1993 the domestic and foreign sales of military products practically froze. In 1991 the company went bankrupt, and then following liquidation, on January 1, 1994 was transformed into a share company with 31% foreign and 69% Hungarian private funds, in order to preserve production capacities important in the national economy and to employ 220-250 people.

The company converted about 60% of the earlier military industrial capacities to manufacture mainly nuclear, medical diagnostic and environmental analytical instruments and process control systems. The sales in 1994 exceeded those in 1992 by 20%, with exports amounting to 20% of total sales. The future strategy of the new company includes the retrieval of its earlier market both in the civilian and military sphere.

Partial conversion of the share company owned by the Hungarian Ministry of Defense specialized to produce radiotechnical, radiolocation and telecommunication devices is impeded by technological, ownership and management limitations. As the sales of non-military products increased only to 19% of the total in 1994 from 13% in 1992, the total sales dropped to 80% because of the reduction in the demand for military appliances. From 1993 the orders from the state decreased, and conversion to producing instruments for the civil sphere is sluggish, for the following reasons:

- The machines available are suited primarily for military production.
- There are no traditions of civilian production.
- There was a global and significant decrease in the demand for products of mechanical industry, in general.
- Lack of capital also hindered conversion of capacities.

In view of the still considerable state orders, progress may be expected from privatization involving partners from abroad, with increasing capital requirements for development. Analysis of the situation allows the conclusion that military-industrial capacities should be converted in Hungary, and most probably also in earlier Warsaw Pact countries in two ways:

- to production for the civil sphere
- to develop military-technical products and equipment to ensure a higher standard of Defense of the country.

Some basic prerequisites of a successful conversion are as follows:

- Management with a new concept to find new markets, to conduct aggressive marketing policy, to utilize new technical, economical and marketing ideas;

- Appropriate product development for different markets (civilian and military), with external financial help;
- State contribution to the funding of investments directly based on research and development, at least in the starting 1 or 2 years;
- Best utilization of the opportunities provided by international cooperation.

The first and foremost task to be performed in a further conversion, in order to maintain functionability of companies whose production has been reduced significantly, and to utilize the opportunities provided by the domestic and foreign market, is to raise the general technical standard, in other words, to carry out technological conversion. This can be expected only from the utilization of advanced forms of international integration, which may be established on the basis of cooperation in research and development, production, service, maintenance and sale, and resting on mutual economic interests.

On the foundations of foreign licence, technology, functioning capital and existing domestic production and research and development, modern military-industrial technologies matching demands may be developed. These, in turn should be capable of manufacturing modern and marketable products for military and civilian use, for the domestic market, the foreign partner or countries of the third world. In addition, they may have a promoting effect on civilian background industries. In other words, technological conversion is the fundamental prerequisite of the conversion of our military industry for manufacturing products for the civilian sphere.

Following the democratic transformation of Hungary, breakdown of corporate structures greatly accelerated. Decentralized privatization has occurred along lines which are relatively homogeneous in respect to the technology and market. In military industry this process will temporarily increase the proportion of member companies with exclusively military industrial profile. In view of the experiences, success and failure in the conversion process in advanced industrial countries, a diversification of the activity of these companies is expected if functionability is to be maintained. Military-industrial profiles also suitable for civilian production provide good chances of this, at a much higher technological level.

Realization of these schemes is, however impeded by the reduced budget in these countries, the additional burden imposed by disarmament and liquidation of armaments, and the very expensive, or sometimes unrealizable conversion in the case of heavy arms production.

The way out - to the production of certain preferred strategic appliances in harmonized international cooperation - for Hungary too, may be the opening of domestic markets and long-term financing of programs and thus state-guaranteed demand.

The branches of military industry, or nowadays defense industry, in which the Hungarian industry may establish sound cooperation with foreign investors and other partners during the conversion process in the near future are as follows:

- fire control systems where we have experience both in production and development,

- radar systems (based on service and maintenance experience),
- strategic and tactical radio-telecommunication, for which we have manufacturers, component manufacturers and system technologists,
- cable telecommunication; manufacturing experience in analog and digital techniques,
- manufacturing small arms, with technological bases and expert staff for production/ development,
- aero-technical mechanical, assembly, operating and service base, assembly and service base for tanks and armored cars,
- manufacture of gunpowder, based on domestic production and development results manufacture of exploding pressed bodies,
- manufacture of ammunition, with long traditions,
- manufacture of special delivery vans, with assembly and service premises available, and
- defense appliances and logistic tools, premises and staff available, technology needed.

To achieve the aims, harmonized state and company activities and extensive international cooperation with NATO assistance are inevitable.

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THE CIVILIZATION OF MILITARY-INDUSTRIAL COMPLEX IN POST-COLD WAR WORLD OR: MILITARY-INDUSTRIAL COMPLEX AS THE SOCIALIST INSTITUTION

"The guns do not shoot. People do." US NRA

IGOR GRAZIN [1]
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1. Introduction and Acknowledgements

You are not going to find many figures in this paper. And, nevertheless, it has been based upon an empirical study. It was a study that covered all the former Soviet military industry left behind on the territory of the Republic of Estonia. With the help of my colleagues, I counted 19 individual plants and corporations there that could be considered as formerly belonging to the Soviet military industrial complex (MIC). From these 19, eight were studied on-site (through interviews and documentary analyses), and the rest of them through statistical data. More specific findings are going to be published later. Here I intend to present the main conceptual conclusions of the empirical study that evidently deviate from some of the commonly accepted truisms accepted in this area.

As to the choice of the sampling, it has to be noted that in its "purity," Estonia presents almost a lab-test-case, with the following remarkable features:

a. Estonia is an independent state politically untied to Russia and thus to the former Soviet MIC. More than that: being opposed to the still existing Russian political pressures in the Baltics, Estonians own industrial policies have been aimed at cutting off any economic links and possible influences from the Russian MIC.
b. Estonia is currently undergoing radical military-doctrinal change from the non-existent doctrine (a republic in the USSR other than Russia could not have any political, less geo-political interests of their own) towards the gradual recognition of the geopolitical conditions of her survival next to the enormous, militarily strong, unstable, economically misdeveloped, poor and unpredictable neighbor like Russia. That change leaves the leftovers of the former MIC uncovered by the political doctrines or the willingness to keep them alive through any system of governmental support. In other words: the former Soviet

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MIC appears here (i.e., in Estonia) in its "purest" way like an economic-political entity.

c. The former Soviet MIC has to act (and react) within Estonia as in a relatively established economic entity with the relatively unified rules of market behavior and within a relatively small and thus very visible and graspable economic space.

d. The nature of MIC entities in Estonia has been the one that presumably should facilitate the natural tendency towards conversion. In none of the cases I found a plant or company involved in the production of the completely finished product having clear military purpose. (The closest to that was, by the way, filters to the gas masks.) In all cases, what I had at hand there were smaller or larger workshops producing something of the high quality that might have had some civilian application as well. In three cases I dealt with the highly skilled workshops that handled those military orders that could not be placed elsewhere, so these companies were the producers of custom-made parts demanding a certain level of mechanical and engineering capabilities. In other words: what made them a part of MIC was not the product they produced, but something else—outside from themselves and their technologies.

e. And, last but not least in Estonia we have a successfully developing economy, one of the few in the post-Communist world. To quote the figures form "The Economist": in 1994 the increase of GDP was 6% (in Russia, it was 16% of the decrease), budget surplus 2.2 (in Russia, deficit 9.8), consumer price increase 39% (versus Russia's 209) and interest rate 16% (versus Russia's 242) [2]. So if we keep hoping that all post-Communist transformation, the Russian ones included, will end up in the overcoming of current deep structural crisis, it may be said that Estonian economy being many steps ahead of that in, for instance, Russia, demonstrates the problems Russia is going to face during coming years. (Although estimations vary, it is more or less safe to say that the advantage in reforms in Estonia as compared to Russia is about 25 years.) That means that certain knowledge of Estonian developments might add something to our ability to predict at least some tendencies and challenges the conversion of MIC may face in other economies.

This work was done in the College of Business Administration at the University of Notre Dame (U.S.A.). The crucial support for it was provided by M & T Trust and Dr. Frank Potenziani whom I am deeply indebted for his continuous help, wisdom, encouragement and inspiration during many years. The idea of the project and additional support came from Professor Anthony Hyder and the Graduate School Administration of the same University and during the final stage from its Law School.

I am happy to express my most sincere gratitude to the people without whom the empirical part of this work could have never been carried out: Vice-Chancellor of the Ministry of Economics of Estonia, Mr. Tarmo Ruben; CEOs, financial and engineering officers of the companies surveyed, Victor Borovik, Villu Ehrlich, Vladimir Galkin,

Anatoli Kononov, Einar Kuuse, Vladimir Nazarenko, Kalju Niidusaar, Toomas Noorem, Vladimir Nosov, Mart Perli, Vladimir Rudnev and Walter-August Terav. And all the assembly-line men and women who gave me many most valuable insights into what was and is going on in their companies. I wish them all the best luck in overcoming these not the easiest days in their lives! And, of course, Lena and Anton: thank you for everything and for all your welcomes after all the trips that were and will be made...

2. What is the MIC?

Although military-industrial complex (MIC) is in and by itself a fragment of society, history and a culture *an sich*, this is not the aspect I am going to deal with in this paper. By "civilization" I mean this time a derivative from the adjective "civil", so what we are going to talk about is the making of the parts (sub-branches, enterprises, corporations, administrative structures) of the MIC civilian. Giving up the academic tradition of composing articles of a little bit of theory plus a little bit of cases, we are going to concentrate now almost exclusively on the theoretical aspects of this "civilization" and try even to avoid the statistical data available elsewhere. We tend to believe that at least sometimes theory is able to reveal realities yet unseen in the reality itself and in a predictive way to fill in the gaps left after the empirical being itself.

Without much hesitation initially, it may be said that MIC consists (by definition) of something military and something industrial and that these two components are somehow related to each other (i.e., form a *complex*). With a little bit of elaboration, this composition may be said to consist of:

(a) armed forces themselves (combat units and logistical ones).
(b) military bases and infrastructure (communication lines, recruiting offices, schools, etc.)
(c) productive and maintenance structures (arms', uniforms' etc. producers).

In spite of this seeming simplicity, the grey area around these unequivocally military-industrial phenomena is significant. To put aside the directly armed-forces related phenomena and to remain exclusively in the realm of production and economic performance, we still may ask questions like: does the company producing so called "double-orientated" output (i.e., both tanks and baby beds) belong to the MIC or it is only the civilian assistance to the defense efforts of the country (or vice-versa)? Does the clearly civilian enterprise, producing the devices that almost do not have any civilian use belong to it [3]? Or another case: the enterprise that was directly subordinated to some military industrial department of the USSR but produced exclusively the tubing and coolers for dairy farms—was that also a part of MIC [4]? And then—what about the products that have the double (i.e., civilian and military as well) use anyway: trucks, computers, socks...

Without specifying the details of the cases, we may state that although the nature of the product is an important component of the general quality of being part of the MIC, that is not all. We tend to believe that not all war-related things' producers are part of MIC and that some quite civilian producers, on the contrary, are.

And one other problem as well: the word "complex" itself imposes upon us the idea that certain parts of national economic life (related to arms, armed forces, military ideologies, etc.) are somehow closer related to each other (contribute to each other, complement each other, lobby together, etc.) than to the rest of the parts of national economy. In other words, there is something that makes them a "complex". But MIC is nothing unique or extraordinary in this sense. Supplies and deliveries, purchases and sales, commercial contracts and their violations and many other "complex-forming" things happen in other spheres of the economic being as well. But what is unique—and here we refer to the expertise of the late U.S. President Dwight D. Eisenhower—is the stronger than usual ability to influence and to be interwoven with the political superstructure of the given country. MIC is, then, more than a set of interlinked companies that has normal internal relations of cooperation and competition, but a piece of national economy related to the rest of society as a relatively solid whole, able to influence (in the totalitarian cases—even to determine) the rest of the social life and political course.

It is important to notice that this relation between the state and MIC is in no way accidental or irrelevant. Most of the areas of economy may be theoretically ran both ways—by the state and by private entities. (We ignore here the fact of the different level of efficiency by state and private administration). Health care may be private, but, it may be socialized as well. So do firefighting, hockey-playing (NHL versus the State Sports Committee in the former USSR), shoemaking, etc. The role of the state and private entrepreneurship in these areas is not determined either by the nature of the product, nor that of technology, nor consumption or some other techno-economical factor: a state run post office may be worse than the FedEx, but it still provides the service. This is not the case with MIC. MIC has to be directly state-related to remain what it actually is. These relations themselves may vary: from ownership to contracting, from preferential subsidation to protective tarification plus millions of more specific forms. But in any case: MIC must be "part of" the state and, in the worst case, the state may become "part of" the MIC. And there is one very plain and simple reason for that: the state is the only legitimate heavily armed institution in the society. To put other factors aside, what makes the difference between the police patrol and the street gang is that the former represents the state, while the latter does not. Armed people that are not affiliated (hired, employed, enlisted) with the state are not the Army or armed forces. The enterprises that make them guns, bombs, even missiles, may be sort of businesses (often illegal ones), but they will not be considered as part of the MIC [5].

So what makes MIC a MIC is not the product, technology, and relation to the armed groupings, but the special relation to the state and government. This relation itself falls into three basic types of channels of influence and command: (a) political; (b) administrative; (c) economic, with different combinations between them. Each of them,

in their turn, face us also with certain problems of theoretical-conceptual nature. The existence of a sort of a political unity and influence over state and government by MIC leaves it to the grey area the cases, where the components of the MIC (individual companies, corporations, their subdivisions, technological units) do not constitute any sort of a complete, finished, self-sufficient structure under the sovereignty of the given political structure (state government, autonomous self-management etc.). Or when the components of MIC had been networked to the larger systems that by now have ceased to exist as it happened in the case of the disintegration of the USSR, CIS, or the whole system of military and military-industrial organization of the Warsaw Treaty [6]. What makes us doubt the "complexity" (= being a "complex") in this case is the lack of a "horizontal" networking between these components of a MIC on a higher level. In the Estonian case, the enterprises of MIC that were integrated into the all-Soviet MIC were not very much related to each other—neither technologically, nor economically, nor even administratively—as they were subordinated to 5-6 different MIC ministries on the federal level [7]. So what is very clear is that they belonged to the Soviet MIC, but what is not clear (at first sight, at least) is whether they belong to or whether there is such a phenomenon as the Estonian MIC at all?

Our positive answer to that question is derived from a more general observation grasped not only from the (former) Soviet, but also current Russian and U.S. realities. Even without further detail, it may be said that whatever is considered to be MIC in a given society, it is always put into a very specific economic regime that is aimed at a certain degree of elimination of stress producing factors of the free market. Features like relatively stable and generous financing, protective barriers (from the regime of secrecy [8] to tariffs), preferential supplies and almost guaranteed sales of earlier ordered products, bonuses for personnel, research support, etc., may characterize almost any MIC whether in the Stalinist USSR or in the Clintonite U.S. [9]. The difference here is not in the basic features of the economic environment of the MIC, but that in the rest of the economy: the MIC in the USSR under Stalin was the model for the rest of the society, in the U.S. it is a rather shy effort to provide MIC with sort of a most-favored, preferential treatment.

All this does not mean that competition (and even marketization) is excluded from MIC internally. (The internal competition within the MIC was known even in the totalitarian Soviet Union!) [10] But, what it means is that MIC itself as a whole is protected and defended from the severe winds of the market. The Russian economy did let its consumer electronic industry and textile industry become destroyed by 1993, but this has not been allowed (and will not be) to happen to any crucial component of MIC.

The special economic political status of MIC did manifest itself in a different way in different economic systems and structures, but the very existence of this "special treatment" itself seems to be a constituent feature of MIC regardless of the economic system that forms its environment. For the capitalist society this "specialness" may express itself as a principle of cost-maximization ("thou shalt maximize cost") specifically characteristic for MIC in U.S.A. (naturally within the limits of constraint imposed by the size of the overall military budget approved by the Congress) [11].

So part of the agony of corporations excluded from the MIC results from that evident fact that originally they have been designed (created, expanded, merged, differentiated, etc.) to function under the circumstances different from those of the free market and macroeconomic competition or, at least (in the case of socialist regimes)—on the same terms of state support with non-MIC sector. Conversion thus means not only (or even not so much) the change of products, suppliers, and customers but also (or primarily) that of the basic economic and administrative rules of their operation.

The similarity in this unique economic status ("preferential treatment") may be even so important complex-formatting factor that it may create a quasi-complex interrelatedness in the cases where the official and direct links to the state are missing. I mentioned earlier that in the former USSR, MIC components in the territory of Estonia were related to the MIC of the whole Soviet federation and did not form any official complex-forming links with the (Communist) government of the Estonian S.S.R. But, nevertheless, under critical revolutionary circumstances of the gradual succession of Estonia from the USSR, these components of the former MIC (relatively isolated from each other earlier) suddenly recognized the commonness of their interests and formed their own semiofficial "horizontal" political and economic structures to fight back against the pro-independence movements and thus it was not surprising that this political movement (that remains in history under the name "The Plot of Directors") [12] was led by the CEOs of the two most significant military corporations on Estonian soil (Vladimir Yarovoi—CEO of "Dvigatel"; Igor Shepelevitch—CEO of Popov Radio-Electronic Plant). In the circumstance of the lack of a state provided economic shelter for the MIC, it was their similar economic and political status that forced these managers to act (unsuccessfully though, thank God!) jointly to preserve the "specialness" of their enterprises' economic regime that constitutes the backbone of their existence as such.

This spontaneous search for the (normally state-provided) "complexity" serves to me as an additional proof that just this not any other factor constitutes the *sine qua non* for MIC. MIC was ready to swallow the "humiliation" of producing the door knobs and toilet seats, but not the loosing of state-provided shelter against the market forces and free networking outside its own "gentlemen's club".

3. Two Faces of MIC

In the title of this paper, I used the term "civilization," that in spite of its ambiguity, helps us to avoid much greater ambiguity associated with the world "conversion [13]"

But even if we assume that at least something about MIC's conversion is intuitively understandable, (it is somehow related to the changing of MIC into something else) several more principal questions still remain.

Keeping in mind the inter-relatedness of MIC and the state and its doctrine—together with the well-known NRA's celebrated battle-cry: "The guns do not shoot, people do!"—it is not very hard to point at the very wide grey area between MIC and its civilian counterpart. The already mentioned products objectively usable for double purposes fall

in this area: trucks, excavators, etc., and even the ordinary infantry man's field fatigue without epaulets, is simply very comfortable parktroopers' work clothing. The grey area becomes even "greyer" when we switch our attention from the products of MIC to its technology. Most probably there are not too many areas of technology (i.e., know-how and hardware) that has only and exclusively military use and, on the contrary, the goal-related "ambivalence" of technology or its components lies at the very core of the whole idea of "conversion" itself. There are so many samples of "successful conversion" reported by the media that I am not going to increase their numbers, more so because these samples, as it seems, represent rather the realm of exceptions than some rule: the fact seems to stay—in most of the cases, the civilization of MIC has either not occurred yet or has failed economically, at least till today, i.e., A.D. 1995.

Part of the technological "ambivalence" (particularly in the state-dominated, state-controlled and even more in the state-controlled totalitarian societies) of MIC has been intentional and has been taken beyond the simple fact that the screwdriver may be used to assemble a microwave oven and the "Stealth" as well. I am talking about the "duality" of the product itself. And again not in the sense that the bus may take children to school and soldiers to the training field, but in the sense that a product itself is in a way an archetypical specimen with two (or more) modifications—the military and the civilian one. That means that the switch from one to another is made very easy and sometimes even the very existence of the military twin of a visible civilian one may stay hidden. Although it is not the case, for instance, with the Soviet TU series airplanes that all (with the partial exception of super-sonic TU-144) had both—civilian and military modifications. It still was the case with the Soviet tank industry. Harkov Malyshev plant was known as the producer of powerful diesel locomotives [14], but largely through the same lines from the back door came the tanks. When one of the (relatively unsuccessful) products of Malyshev factory—tank T-64 was mentioned in the West for the first time as the "newest and experimental" one, 10 years had already passed from the beginning of its mass production and, after awhile, it was even completed and replaced by a next one - T-72 [15]. Although this "marriage"—locomotive and tank—seems to be quite unusual (more common ones in this area were between tank and heavy tractor like in Kirov Plant, Leningrad), it is able to prove even more strongly the case of the very existence of quite deep "duality" of technology of MIC.

Keeping in mind the ideological constraints (particularly of the block "D" in the scheme on p. 37), it may be reasoned that the just described "duality" was the price paid by the MIC for its own expansion. It is easier to explain to the taxpayer (and to the world community, foreign intelligence services, and other interested institutions) that the country needs some more tractors than hundreds of new tanks.

The official military budget from "good ol' Soviet days" was about 20 billion U.S. dollars annually (according to the then existing official and state-guaranteed exchange rate) but the strategic parity with the U.S. was then nevertheless achieved. It is even further beyond the limits of the wildest imagination if we consider that the productivity of Soviet industry was about 50% of that in the U.S. Nevertheless, to some extent, just as one among many others, this figure (of 20 billion something) was taken seriously

because it remained an open secret that the real MIC is hidden behind the other covers—those with not-so-very-military titles. Kurchatov's nuclear weapon program was started in the Laboratory of Measuring Instruments [16]; Ministry of Medium Machine Building was in charge of nuclear reactors; defense radar systems (and particularly their components) came from under the Ministry of Radio-Technical Industry and even the uniforms—from under the Ministry of Light and Textile Industry. The deceit is only a partial explanation (for CIA and the Soviets themselves) for that. Rather it actually reflected the situation of "duality" of MIC that was actually built into the Soviet industrial system; the "duality" that included the civilian component or angle as well. Besides other things, the locomotive plants produced locomotives and radio-plants, stereos, as well [17].

So if the military-civilian "duality" of production was the price MIC tended to be ready to pay for the sake of its own expansion or at least preservation, there was another price it was forced to pay as well—although unwillingly: and it was the decrease in quality. Any infantry field-officer knows that although amphibious APCs may move on ground and water, on the ground they are bad cars and on the water—poor boats. And this is just the case we are going to discuss in some later paragraphs.

4. Technology-Political Flexibility of Modern MIC

In other words, this is the question of "policy-elasticity" of the technology currently employed in the MIC; of its adaptability to such a radical economic-doctrinal and circumstantial change as the swift from the state-protected to free market performance.

The extremely high level of the specialization and capitalization [18] makes that type of a change quite complicated.

The first factor here is that the very end of the production line has to be tooled with something that makes a military final product final—i.e., something of purely military use. Although this last portion of the line might be efficient, productive, cost saving, etc., itself, the use-value of its product is something that is to be changed or eliminated. This use-value by itself need not be reduced to the capability to kill or destroy; it may be also designed to resist the man-made means of killing and destruction and, in both cases, not have any reasonable civilian application whatsoever. For instance, the main strategic advantage of a Stealth Bomber, its undetectability, is without any civilian use (on the contrary, the better the civilian plane is seen on the radar screen, the better) [19]. Another case brought by Anthony Di Fillippo [20] is related to the nuclear power support to ignite the x-ray gun used in the potential Star War program. Although there seems to be the opportunity for the civil applications, in reality, that is not the case: the analogous technology in Japan, orientated towards the civilian use from the beginning has outperformed (in civilian sector), the corresponding developments in the U.S. I may continue along the same lines: among the companies in Estonia studied by us was the one that produced powerful nuclear-mini-stations potentially usable exactly for the Star War programs. After the change of situation, the active marketing of the product proved

that it does not have civilian market value and it has the market value only for the countries to whom it cannot be sold for political and international legal reasons. The only parallel application (actually used by the Cartographic Service of the former Soviet Navy) was to use these stations (after the sharp reduction of their power!) to power the inconveniently located lighthouses. Even without specific figures, it is visible that the substitution is not equivalent.

The sample of these power stations illustrates another point indicating the limits of elasticity of MIC technologies: the military products in their comparison with the civilian ones are in many cases, so to say, over-technologized, i.e., too sophisticated (and thus also too expensive) for the ordinary civilian use. That reminds me of a case from my own political past when I, as the member of the Supreme Soviet of the USSR, was participating in committee hearings (in 1989) on the Conversion of MIC: CEO of one MIC company that produces computer-controlled systems of automatic navigation of super-heavy radar systems proudly presented his main civilian achievement: a washing machine that included more than 40 computer-controlled washing regimes! Even on the photo I looked at the machine that looked like something extracted from the Star Trek technology and actually was the achievement of an engineering talent. But no one had asked one question: how many programs do we need to have 10 pairs of socks, shirts and underpants washed? And how that machine is going to work in a tiny Russian provincial city with a well sewage system? And what might be the market share of such a product priced at the level of two (then very expensive latest "Moskvich" model) cars?

All this suggests the idea that the cost of conversion includes in its price also a certain loss of technological level not needed (yet?) by a civilian economy. I am not aware of any overall comparative studies able to estimate the magnitude of such a loss, although there is some very approximate and indirect indicator, that of the amount of labor spent to produce a unit of value. Based on some American studies combined with the Russian statistical data, the military production (due to its high level of intellectualization and capitalization) includes 2.5 times less labor than similar civilian production [21]. If we keep in mind that the terms of productive employment of labor in the civilian sector are determined by the market forces and on the level that economy itself can freely afford, we may conclude that overall de-technologization (i.e., the reduction of cost) of the MIC must macro-economically lead to the cutting for half of the amount and level of the existing technology.

So the "over-technologization [22]" of MIC makes its technologies, in many cases, "commercially irrelevant" as stemming from the different design strategies. For military products: "high performance regardless of costs" [23]; for civilian ones—"high performance and quality at the lowest possible costs." What is important to mention also is that the cost does not include only the costs of production, but also those of maintenance and actual exploitation. Although denied by military and MIC authorities, the cost of exploitation of military equipment includes into the calculation the misperformance or the failure to perform by some units of military equipment as well; like the ones specified in the classical work of Melman—"communication systems that block communication," "weapons that either don't work or work the wrong way (like

killing their own men)," "control systems that cannot conceivably control [24]." The only reasonable explanation for the stockpiling of Soviet and American nuclear arsenals able to destroy each other a hundred times over is the underlying assumption that most of the missiles are not going to be able to leave their silos or are going to destroy the subs carrying them. There is a difference: if from the strategic point of view, it may not matter for the overall picture if this particular tank's engine will never start, it matters for me that my car does.

So the problem of flexibility of MIC technology is also embedded in the problem of flexibility of technological thinking of those in MIC [25]. To that sense the maker of socks (sorry, in the Russian case—foot cloths) for soldiers may still be "technologically inflexible" in the sense of its inability to adapt to the non-MIC environment. It is thus clear that the "duality" of the production of an MIC corporation may contribute to its ability to succeed through conversion, but that is not necessarily so. Even if from the purely technological point of view the conversion could be possible (for instance, through the increase of the civilian share at the expense of the military one in the case of the twin products), even the already existing civilian product is not an indicator of the right direction of the conversion. The Star Trek-level washing machine may be well-produced due to the civilian technological potential and due to the adaptability of the military-technological potential of its state-subsidized producer, but most likely it will not become a marketable product after the MIC shelter or crutch is taken away from it. It goes well about Russia, I think, if it has been said about America that "U.S. defense companies may not make good partners [for Russian MIC companies] because they do not understand the consumer market well [26]."

5. The Myth of Technological Superiority

I have said already that one of the most important classics on the field—Seymour Melman—has pointed at several samples of wrong performance of MIC produced things. Another classic—the discoverer of the Murphy's Law—has brought many others. But whatever they are, they deal with super-high technologies and thus with the inevitability/inescapability of the geometric progression of entropic failure: the higher the level of organization, the less is needed to undermine its proper functioning. It is much easier to spoil a computer than an ax. So the consumers of MIC who are anxious to receive the top-of-the-line product, have to swallow this fact and they actually do it through the lobbying for larger budgets that would enable them to increase the number of the products manufactured: one of 100 missiles may well hit the target, why not. But this is the cost the civilian economy and consumer may not want (or will not be able) to pay. One result of such a situation was mentioned already in the course of "successful" civilization of MIC: some of its technological "surplus" may be lost. But there is another, most probably much larger and socially more significant portion of the MIC that produces things with more or less average quality on a more or less average technological level. (I do not have the exact figures, but the estimation, after having put

the U.S. and Russian MIC together, is that the supersonic fighter producers are outnumbered by machine guns, marine boats and soldiers' dry food, etc., producers by ratio 1:10).

During our empirical research, we were told over and over again that the top quality of all MIC products is a legend, a myth. Not being an expert in engineering or battlefield tactics, it was a temptation to find an explanation to that fact. One was mentioned already—the "duality" of technologies aimed at two incompatible targets: military efficiency and civilian utility. It was just the Estonian soil whose destruction by heavy (K-series) tractors proved that the tractors produced in tank factories are bad for fields and the Chechenyan War proved that the tanks produced in tractor factories are not good tanks either.

But, that is not a full explanation. (There will be none in this paper.) Besides other things, it does not cover the case where only some "core technology" is common to the civilian and military output whereas the end part of it may be fairly far apart. Graphically, there may be two cases:

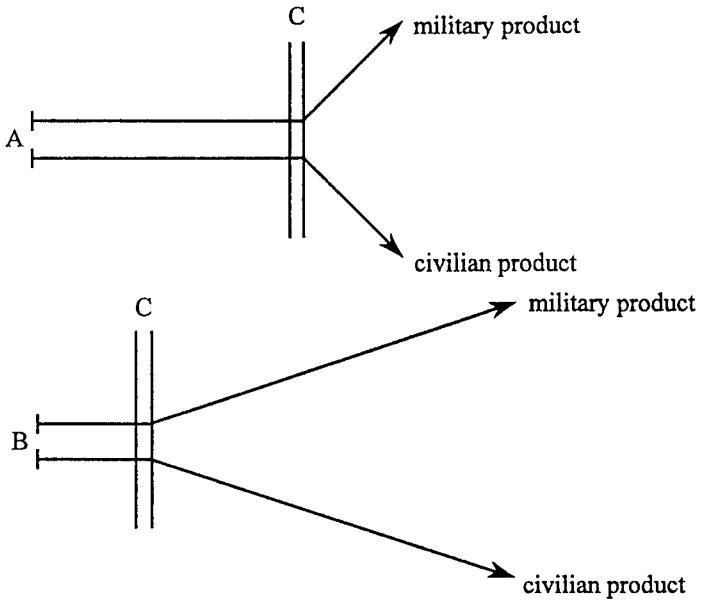


Figure 1. Commonality of Core Techniques

The "averagization" of the final military product may occur due to the necessity to keep one eye on the civilian consumption in Case A, but significantly less in Case B, where the autonomous military part of technology is significantly more responsible for the quality of the output than in Case A. Case B is the one that is not covered by the "duality-explanation."

So let me add some others. Among them should be:

1. Military production is not brought into the economy from outside and thus has to reflect the general situation on the overall industrial and economic landscape. The former "socialist" countries of the Eastern Europe have a good proof for that: except the existence of some very efficient systems of armament (like the nuclear weaponry), the rest of the military hardware was of an average, "reasonable" quality. The dual between SCUD and "Patriot" missiles, in the skies of the Gulf War, did not prove outstanding superiority of the formers. Without further elaboration, we would like to point out a case study by J. Krause and Ch. Mallory on the history of the development of chemical weaponry in the USSR— particularly the parallel analyses of the creation of Soviet chemical industry and the elaboration of the doctrine and methods of the chemical warfare in the 30s proves this point [27]. The facts demonstrate that although certain levels of obtained social control may make it possible to concentrate the resources on some critical points of technical development, it cannot be achieved on the overall to the point far beyond the technical capacity of the given economy. Soviet militarization (accelerated hyperindustrialization) was achieved at the price of rapid deterioration of other sectors the current Russian economy suffers from till today [28].
2. The recognition of this discussed fact has resulted in the compositions of the military doctrines concentrating upon achievement of rather limited, but at the same time, crucial strategic goals. In other words, facing the inevitability of the limits of MIC, the strategists have put their efforts to determine that top priority goals in military missions (and corresponding arms' systems) that fall short of the complete destruction of the adversary but would nevertheless reach the predetermined geostrategic goals. A sample of such a search may be found in the painstaking Soviet dilemma between the necessity to go whether in the direction of the creation of strategic bomber aviation or ICBMs [29]. The decision in favor of the second option created the modern nuclear strength of Russia without strategic air forces able to match those in the U.S. (B-52, "Stealth").

   Having concentrated the resources on those directions, the USSR, in other areas, relied solely upon the massiveness of conventional weaponry of relatively low quality. For instance, as Y. Yarymenko and V. Rassadin said... "in machine engineering, [in Russia] the machines, machine tools and equipment meeting world standards have never gone higher than 16 percent, but at least 60 percent of the defense enterprise equipment is the best that this country has [30]." Not a long time ago, the threat to NATO was not so much the nuclear potential of WTO, but its massive deployment of armored and tank forces equipped with relatively low quality arms in DDR [31]. In September, 1994 the analysts of the Baltic News Service had to admit that up to 90% of the metal produced in Russia does not meet the standards of international market [32].

These two moments thus predetermine each other: the inevitably restricted areas of high technology need the military doctrines that take advantage of these technologically advanced niches and the military doctrines necessarily created within the framework of inevitable limits of economic potential of the MIC concentrate upon finding most vulnerable and the most crucial targets of potential adversary.

All this leads us to the conclusion that, technologically and techno-politically, there are at least following limit-setting circumstances on the conversion of the MIC:

1. The existence of the MIC's super-high technology, that due to its costs and "surplus" quality, may not fit into the structure of the free market demand.
2. The lack of the existence of unexpectedly high quality of mass production of ordinary MIC's output that might more or less easily be converted into products able to compete and survive in the civilian sector.

6. Theoretically Possible Types of Conversion

The definition of conversion discussed above, i.e., that conversion may be related only to the MIC and that MIC itself (as I tried to prove earlier), is constituted by its managerial and economic ties, makes it possible to predesign on the abstract level some theoretically possible versions of managerial and structural changes that may happen within the MIC. Graphically, they may be presented in the following form:

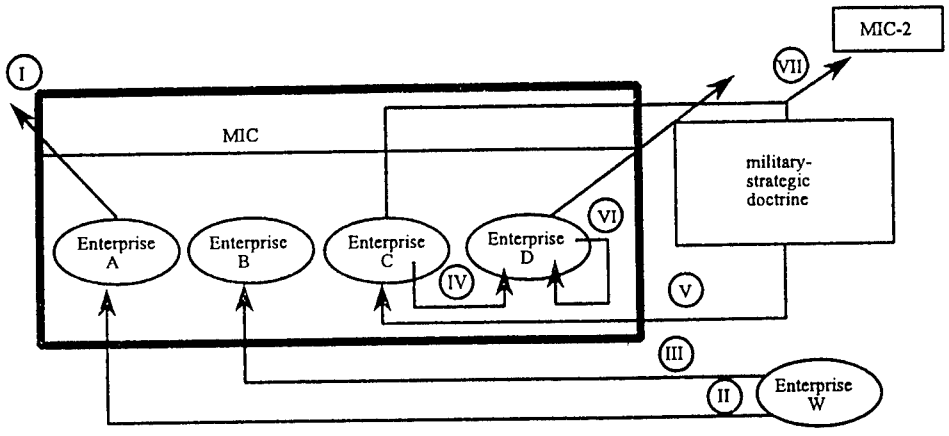


Figure 2. Types of Conversion

The types of the activities presented above may be briefly described in the following way.

Version I. "Pure," "clean" and "straightforward" conversion *per se* : the former MIC enterprise leaves it completely and ceases to be part of it. The result here is a liquidation of it, whether complete or, at least, in its old sense: the enterprise becomes whether a civilian one or simply ceases to exist. Organizationally and structurally, this might mean (or, perhaps, must always mean!) sort of an integration into non-military industrial infra- and superstructure. I had one extremely impressive case here at hand: company (once in radioactive materials now mainly in rare-earth metals that also may have certain military-industrial applications)--*Silmet*, Estonia--is going to survive through the combination of two interests: those of the loparite producers in Russia and Finland (*Sevredmet*, *Tenex*, etc.) and of the producers of the final product (*Rhone Poulenc* of France, *Nissho Iwai* of Japan, *Neomet* of USA) on the global market [33].

Version II. Conversion "upside down," i.e., the case when a formerly civilian enterprise becomes a military one. It is still conversion (in the sense of a radical change), but might not be the case of "civilization" in the sense of replacement of military-orientated potential towards the peaceful one. As the increase and growth of MIC (if it still happens to occur), goes beyond the scope of this survey, we are not going to touch upon this problem. But there is another option as well: the involvement of the new (formerly purely civilian) enterprises into military production due to the changed (presumably less-aggressive and more self-defense orientated) military doctrine. Whether such a change, combined with the "humanization" of the military ammunition (like "smart bombs" versus "dumb bombs" and "carpet bombing") is conversion of MIC is a question that remains to be answered. For me, the answer is there: everything depends upon the economic regime around the newly "reverse-converted" enterprise.

Version III. Modification of the "Version II" with one principal difference: here the "reverse-conversion" is of temporary character and may not be derived from the military, but from political and economic doctrine. I am not able to think of any option of putting of a formerly civilian enterprise into military business without extending to it at least some crucial "privileges" of MIC (and thus making it part of the latter). But this might easily be the case if we look at the "enterprise W" not as a sort of a "heavy-metal-factory" but as a managerial structure (like: commercial entity, privatization agency, bankruptcy commission, venture capital fund, etc.) that comes into the MIC with solely one goal: to get out of it and not alone, but with some other MIC enterprise with it. All the involvements into liquidation sales of MIC plants, their products; retraining programs of their employees, etc. belong to this group of temporary "conversion upside-down."

Version IV. Plain and simple reorganization and restructuring within the MIC and its components themselves. Although internally it might seem a conversion (if the changes are radical enough), actually, from a general economic point of view, it is not. Even less it would be the "civilization" of MIC in my sense although such types of restructuring, in the long run, may lead to the real changes towards the peace oriented developments as well.

Version V. The changes within the MIC that are related to the modification and changes in the military doctrine, but are basically equivalent to the former status within the MIC. Hyperbolically: today the light tanks are doing on the battlefield the same what the cavalry did in WWI—they are able to penetrate behind the front line of the entrenched infantry and to chase the tactically retreating adversary. Does that mean that the enterprise changing its production from stirrups to tread is going through the process of a (reverse-?) conversion [34]?

Version VI. Partial conversion. The case where part of activities go to the civilian and others to the military needs. Two options exist here: a) adding civilian products through the expansion of already existing manufacturing potential or through the reduction of military-orientated products and the re-employment of freed capacities for civilian purposes ("zero-sum" option); b) changing (hopefully increasing) of the civilian part of the already existing double-orientated production capacities in the cases where both of the productions have been in place already.

Version VII. Conversion in the sense of reduced military confrontation and threat through integration with the formerly or potentially adversary MIC. Technically, the company's technology and product are not changed and the "cumulative" potential of the global MIC also remains the same, but the "polarization" within the latter is reduced. Two examples may clarify this point. In April, 1995, Russia made the decision to start selling to the U.S. anti-missile and anti-aircraft system C-300 designed to fight "invisible" airborne targets (like "Stealth" and its potential analogues) [35]. In another deal, Russian "Dvigateli NK Inc" sold to the U.S. company "Aerojet" the NK-33 engines for the potential use in the "Atlas"-boosters by "Martin Marietta" [36] In these cases, the remaining within the MIC by Russian companies means new markets for them and, at the same time, has a "conversional" value due to the reduced level of confrontation between Russia and the U.S. (We were reminded about that confrontation by Moscow TV, Channel I News on April 25, 1995, through the report on maneuvers in the Baltic Coast of Russia training personnel for the case of "NATO expansion.").

Moving some industries from one MIC to another may have different "conversional" implications that depend upon the nature and the political doctrine of that other so to say--recipient-MIC. It is evident that military supplies (arms or the means of their production) to militant regimes make the world a more dangerous place to live in. It goes without saying--in principle. But the problem is that the detailization of that principle may actually oppose the goal of conversion itself due to the competitive commercial interests of other MICs.

The case here is the Russian nuclear energy plant deal with Iran. The reactors Russia wants to provide to Iran (light water reactors VVER-1000) are able to produce weapon-fuel (plutonium) only theoretically, and only in combination with an enormous additional infrastructure even much more developed countries than Iran are not able to build. More than that--according to the deal, even the existing theoretical possibility will be reduced to zero because the microscopic amounts of remaining uranium and plutonium will be extracted from the Iranian waste by Russia. So what really lies behind the U.S. concerns in that deal is its economic content--a billion dollars for the construction of the

plant, plus eight billion dollars worth of nuclear equipment [37]. The content of this case may be summed up in the following way: the actual conversion (peaceful sale of nuclear technology) is politicized by economic competitor (USA) and presented as arms proliferation, i.e., militarization. From what we may conclude, not all conversions of this type are recognized as such [38].

Hopefully, we have covered all most important options of structural changes within MIC in their "pure" and abstract form. That, of course, does not mean that all of them are of the equal significance or occur with the same frequency or are otherwise equally represented in reality. The radical process of industrial restructuring as it happens today in Russia also demonstrates that in reality the versions just described occur not in their "pure" but rather in a mixed and combined way. So my point here is elsewhere. Namely: of the seven described options, only two (I and VI) are the ones that meet the criteria of stable, long-term conversion and only one—that of a method aimed at it (III). Other activities still remain scraping within MIC itself that may lead to the conversion but also may not [39].

Keeping in mind the crucial economic-structural and political component of MIC, it may be said that all types of conversion and civilization of MIC presuppose the change of the military doctrine and not vice-versa. But they presuppose also the existence (if not change) of the economic doctrine, as well.

7. Conversion Itself. What's That?

So one option for the conversion or civilization of MIC is the one described just now: changing the ideological superstructure of MIC and correspondingly cutting off of the military part of the MIC's technology. But even this task and evidently—the simplest of all the possible cases may turn out to be not so easy to accomplish at all. Even if to assume the absolute simplicity of the case and the complete success of the "conversion" even on the level of theory, there remain problems.

"Imaginary Case A": Two parallel, a little bit interrelated assembly lines to put together locomotives and tanks correspondingly. We may close down the second one, but it will result, at least, in the layoffs and technology changes (also—marketing efforts, retraining of workforce, design development and millions of others relatively expensive things) for the former "tank-line" even if it somehow happens that the "loco-line" products' market still has some niche for a newcomer. (That doesn't need to be the case, by the way!) And, if we imagine that there is enough of "free money" and managerial skills to do all that or at the worst case—to sell all the idle equipment, we may say that our fairy-tale is complete.

"Imaginary Case B": The same case as "A" with one difference: the same line produces both of them—the military and the civilian product as well. It is the case that occurs more often in radio, radio-electronic, chemical industry where the technical relation between the tools' superstructure and the actual product is more flexible. Conversion here would be the abandonment of the military product. Here only some of the "Case

A's" problems go away—those that are related to the necessity to do something to the second, military line. But exactly like in the Case A, the problem of the "excessive" workforce, of the marketing of "excessive" product etc. still remains.

It has also to be mentioned that although we assumed the two parties in the "duality" of MIC as equals, actually they were not—civilian party was in rather a Cinderella than a full member of the family. As the manager of the Khrunichev (M.V)/Energy Machine-Building Plant (that produces MIR orbital station components and Proton rocket, equivalent to U.S. Titan) said: Although high-level policy makers "charged us not to forget about the needs of the people, still everyone secretly understood that they are not the main thing for defense industry interests." [40]

Nothing to say about (for both cases) the changing of the whole set of rules of the "economic play" that by our former definitive description is one of the constituents of the MIC. As Michael Checinski put it: "Without a centrally organized supply of machines, raw materials, and other production factors, the managers of the [former Soviet] military industry are unable to produce products even for the domestic market." [41]

In other words—the real or ultimate "conversion" of MIC is a procedure of breaking up the constituent formative linkage of it to the state and to the state's doctrinal component. If that is the case then several technical aspects of "conversion" often focused upon cease to be of the major significance. On the contrary—the conversion now turns out to be rather an economic-structural than engineering-technical and simply finance-supporting problem.

Before we elaborate on that theoretical assumption, let us point at the facts that a) there are already two generally different approaches to the definition of "conversion"—the "narrow" and the "broad" one [42]; and b) there are still certain "grey" areas that, at least—intuitively— belong somewhere "very close" to the conversion-related issues, but are covered by none of the definitions mentioned above.

> One personal remark is needed here: although a lawyer by education, I have never been of very high opinion of "theoretical" studies devoted to the discussions of how to define this or that. In this sense, I have to admit my commitment to operationalist and instrumentalist tradition in American epistemology: except (sometimes decent) salary for the participants of such discussions (who call themselves—"theoreticians") usually they are not of great gnostic value. But this seems not to be the case at this particular point. Keeping in mind the extraordinary significance of if not even of the demilitarization of the world at large, but of significant reduction of the MIC share in it, of the risks of new military confrontations, purely power-based policies, etc., the world itself—through its truly peace-orientated institutions—from NATO to the World Bank—has found and is looking for funds to achieve these goals. The access to these funds by the governments and companies, their adequate and proper utilization, mutual control and international cooperation, last but not least—the diplomacy of "conversion"—all they are dependent upon the existence of relatively clear and

widely acceptable understanding (definition) of "conversion." To put it simply: if you happen to think that your company is eligible to receive support from some conversion-funds, it is quite important to know what that "conversion" means.

Of two approaches mentioned above, the core-elements of each of them have to be clarified [43]:

(a) conversion in the narrow sense—"retooling of plant and equipment from military to civilian production using the same work force";
(b) conversion in a broader sense—"cuts in production of military weapons and related expansion in civilian production." [44]

The problem of the definition "a" is at least twofold: in reality, it rarely happens (after having studied all the MIC cases in Estonia, I could not find a single one that comes under this definition) and, then, after all—they are exactly the same heavy-load trucks that carry mobile ICBMs and the large diameter pipes in, for instance, Samotlor oil fields in Northwestern Siberia. Even the "broader" sense of the conversion turns out to be logically pretty narrow—it clearly excludes infamous Krasnoyarsk early warning radar station whose military purpose was clear to U.S. generals although not to conversion theorists—the radar station of that type was evidently not a weapon, not even a part of a weapons' system, but clearly something of direct impact upon the strategic balance between the U.S. and USSR.

The common fault of both of these definitions is in the word—"production." The problem is derived from the very general, common and visible economic-historical fact that the "production" (as a process and as the result) has a tendency to become better and better; i.e., forgive me the truism—more productive. Who knows how many sword, saddle and stirrup manufacturing businesses (and people—i.e., workforce!) were "converted" to the civilian sector after the cavalry was replaced by tanks, but the result of this process was clearly not something like the decrease of an overall killing power of the armed forces in general. So it means that the result of the conversion in both the above-mentioned senses might easily be the further militarization of the economy through the continued rise of the efficiency of both of them: MIC itself and its products as well.

And two questions more. What is to be said about the cases of more "positive," more "peace-orientated" developments of MIC? For instance, the replacement of more deadly/or: more torturous, more inhumane, more indiscriminate weapons with the less deadly ones? ("Smart bombs," for instance) [45]. Is this conversion?

Or is this also a case of conversion when the MIC is adjusted to some new—say, less-aggressive, but still military—doctrine, like it happened in new Russia? In all these cases, there is a sort of reduction of the military component of MIC and there may be the "related increase" in civilian spending. But if the cases were actually covered by the above-mentioned definitions of "conversion" combined with the preservation of the special economic regime of MIC I talked about earlier, any additional funding (earmarked

for the "conversion"), would turn out to be not only a subsidy (so disliked by GATT), but even worse—international subsidy to the government and even much, much worse—the international militarization of some particular state.

Due to the natural professional and political inclinations the insiders of the MIC try to define the "conversion" in a pretty narrow way, as for instance, "a set of means used for converting military industry to the output of products for the non-military customer with a concurrent change in proportions of allocation of resources between military and civilian spheres in favor of the latter [46]." As Michael Checinski has pointed out absolutely correctly, such an approach "ignores crucial problems of reforming the entire system of managing the arms industry and the national economy as a whole [47]."

In other words: MIC is too serious of a thing to let the MIC's leaders to handle it. When we are talking about the conversion as a large scale problem, two economies are to be considered to be most involved: those of the U.S.A. and the former USSR where the role and significance of MIC has been, by far, the most outstanding and most influential as internally as internationally. And what is crucial, both nations (now the U.S.A. and correspondingly, Russia) have taken into consideration these broader horizons.

8. MIC and the Military Doctrine

The difference between the producer of AK-47 and that of the sporting guns is not the killing power of each of these products [48], but the fact that they fit into the different network of their regular, ordinary and pre-scheduled use. MIC is constituted by and related (in an above-mentioned special economic sense) to the state through the fact that its technologies, work force, equipment, etc. and, most of all, its products are intended to be used in a certain way and in coordination with each other.

Every production is coordination and, I believe, that is not a big news to anybody. It does not make much sense to produce 17 car engines for 14 car bodies and this is a type of coordination that normally occurs through the means of management (within some productive unit) or market regulations (the extra engines that really are not needed by anybody will not find their market). So this type of coordination is nothing special. On the contrary—market-driven coordination that finalizes its effect always *ex post facto* actually always corrects that uncoordinatedness that always happens in reality. Car-producing is not perfectly coordinated with road construction, IBM software developments with those of the "Apple," old condos with new zoning rules, etc. Of course, it is the market that does not let this uncoordinatedness go too far, but it is the phenomenon that still exists. Thousands of products are thrown out of the warehouses, destroyed, or recycled for something else every day.

And—again—this is not the case for the MIC or, at least, is not the case to the same extent. The platoon that sits on the heights without proper ammunition, the heavy artillery without the infantry-provided shelter, strategic bombers without support from fighter-planes—all these cases serve one and the same result: defeat. This type of coordination between different things is also nothing very special: every housewife will

tell you that the curtains have to match the color of the sofa, to say the least. But the difference with the MIC comes in when we take into consideration the fact that all components of MIC (primarily its products) have to be coordinated to each other differently under different doctrines.

The general terms "war," "national interests," "public defense," "balance of powers" and the like do not explain much in real terms of the MIC-life. The questions here are on a more specific level of the kind or type of a warfare: offensive or defensive?; capturing the territory or its destruction?; maritime or ground operations?; rapid tactical strikes or slow strategic offensive? These and hundreds of other (by far more professional) questions determine the different ratios between the components of MIC. To pose at least one macro-level example: as the former GRU officer and military historian, Viktor Suvorov, has proved the severe losses by the Red Army during 1941-1942 against Germany were not caused by overall unpreparedness of the USSR for a global war, but by the unpreparedness for the defensive war on its own territory [49]. Almost all the Soviet MIC produced—artillery for border troops, super-fast tanks, light unarmored attack planes—were made for the offense. Other military steps—the creation of airborne armies, destruction of strategic defense lines, relocating of marine corps to the western steppes, etc., prove the same. In other ways the structure of MIC, its internal coordination, is determined by the doctrine of (prospective) warfare and it seems that besides the creation of a certain political-economic setting, the state provides the MIC also with its coordinating idea—the military doctrine.

That being the case, the result must be that the change of the doctrine causes the change of MIC. Different levels, aspects, angles of doctrinal change, may have significantly different economic impact upon the *status quo* of the MIC. The factors surrounding the MIC may be structured in the following way:

objective and material factors	economic potential social potential [50]			
subjective and ideal factors	ideological doctrine A	political doctrine B	military doctrine C	economic doctrine D

To clarify some points, let me hint at examples from two opposite sides—the doctrines of the adversaries during the period of the "Cold War."

1. Ideological doctrine—basic goals and values of the society like worldwide victory of communism for USSR (with expansionistic tendencies derived from it), and the strengthening of democratic institutions and human rights (for the USA). Somewhere here, on this very general level, we may find the basic assessments upon who might be or become the most probable military adversary of the given country.

2. Political doctrine—the actual assessment of the vulnerability in the given time. Compare the period of the Caribbean crisis to that of the "Detente" of the early 70s. Although these types of assessments have been mutually generated, there may be also certain differences at the same point of time: after the successful testing of its own nuclear bomb, the late Stalinist USSR felt (and behaved) itself more calmly than Joe McCarthy-influenced USA.
3. Military doctrine—in the strict sense of the word, i.e.,—what kind of a warfare the armed forces and MIC behind them are going to face. By itself, this set of political considerations includes at least two aspects directly affecting the MIC:

   (a) The kind of weaponry and logistics directly needed for all types of combat operations and their logistical support. What the main operations will be—offensive or defensive? Ground or sea-to-ground? Sea-to-ground or ground-to-sea? With the nuclear strikes or without? With battlefield "nukes" or with the strategic ones? How long a "normal and average" battle will last? These and hundreds of similar questions belong to this group.
   (b) Technical and military viability of MIC itself. This is a question of its geographical location and of its combat-level ability to survive the opponent's offensive activities (starting from air strikes and ending with the infiltration of hostile military and industrial intelligence agents). When predicting a nuclear warfare, the military plant must have (at least) a disactivation team and anti-nuclear shelter. When Russia expected the ground war with China (in the late 60's) it tried to relocate significant new components of MIC to the "classical" places in the Southern Urals and even to the Baltic Europe. Just the opposite case cost Stalin millions of lives and thousands of lost productive capacities in 1941-1943 during his war with the Nazi Germany. [51]

4. Economic doctrine—In a way it is not some independent component of the scheme drawn above, but rather an angle of the aspects "1" and "2" and simply points at the very evident fact: nothing is free in this world and there is no such thing as a free lunch. Basically, then, this is a question about how much the rest of the society (i.e., non-MIC-society) is ready to sacrifice for its cause: whether real (the Soviet threat to the US in 1950 was very real) or imaginary (the current defense buildup in the Kaliningrad oblast of Russia is rather a medical-psychiatric than ultimately rational fact). Assuming the goal of maximization of its share in the national economy by MIC, it still may be said that there are limits to its expansion: even in the completely militarized Soviet Union and Nazi Germany not all was MIC (although often managed like it was) and—nevertheless—the result was military, military-economic and—in the case of the USSR—purely economic collapse with all political consequences that hence followed.

So the doctrinal elements of MIC may correspond to the actual social, political and economic realities more or less (for instance—more in Sweden, less in the US), but they may also deviate completely from each other. The result will be whether the economic collapse or (if the society manages to carry on its militarily overburdened economy) sort of real decrease in military capability of the country to support its (does not matter here; good or bad, real or not) political goals. To the merit of the Soviet Union, it has to be said that it tried them both. Starting with the Afghanistan War (that actually did not have even any doctrinal foundation) and ending with the current situation in the Russian Army inherited from the Soviet past.

In his analytical article (November, 1994), infamous general-lieutenant Alexander Lebed [52], in a way, summed up most important MIC-armed forces-political doctrine relations [53]. He wrote (this long quotation is inevitable here):

> "Is the society aware of those enormous problems our armed forces are facing and of the gigantic efforts needed to overcome them? No.
>
> Do both branches of power—the legislative and the executive one—have the adequate information about the situation in the armed forces? No.
>
> Does Russia have today superiority in military hardware or personnel with any of the members of a triad: NATO—China—Islamic World? No.
>
> Has Russia as a still "great power" somehow designated its foreign-political priorities, its really vital interests is she ready to defend by all means? No."

Our empirical study included an academically beautiful, but economically and socially painful case where the industrial degradation of a corporation resulted from the lack of military doctrine whatsoever. The company—one of the best in the former MIC of the USSR—even currently able to produce such important components for conventional land warfare as anti-tank and anti-helicopter missiles, anti-radar equipment, night screening devices, etc.—did not produce any of it: because by the time of the study, the military and military-economic doctrine of Estonia was not developed to the extent of its relations to her own (potential) MIC. It can easily happen that even after the establishment of the need for such products in Estonia, the cost of their local production may well exceed the economic rationale of doing so. But even in such a case, these calculations presuppose the existence of a sort of military doctrine and its financial appendices. From a purely theoretical point of view, it proved one clear point: almost nothing may be changed in the hardware technology or technological components of the MIC; once the doctrine is gone—the MIC is gone as well.

9. Doctrinal-Political Elements of the Civilization of the MIC. The Actual History

Two radical doctrinal changes in political (i.e., non-economic and non-military) philosophy may influence the path, level and the readiness to undergo the conversion in MIC:

a. the idea on the nature of the potential future warfare;
b. the geographic arena (i.e., the theater) of the potential future warfare.

As to point (a), the two basic options are available: the offensive and defensive warfare with the different combinations of them and their goals. Although the end of the Cold War has naturally changed the military strategic challenges the U.S. policy has to face today (for instance, the need for a possible pre-emptive stance against another nuclear power is not there anymore—fortunately), much more radical (and, from a scholarly point of view, more revealing) changes have occurred in the former USSR/Russia.

It has been analyzed deeply by many scholars (and it was never camouflaged very well by the Soviets themselves) that the ideologically motivated strategic-political goal of the communist regimes under Marxism was a worldwide communist revolution of the workers. From the Manifesto of the Communist Party to the latest efforts by Mikhail Gorbachev to make the communist system more attractive and viable, the goal remained the same: the socialization of the world and its economy. These basic features of dogmatic Marxism pre-determined the nature of the Soviet military doctrine and of the MIC buildup as well [54].

The most outstanding works by V. Suvorov, "The Icebreaker" and "The Day M," have proved that all the Soviet industrialization started in the mid-'20s and the whole MIC buildup (after the evident failure of the unfounded Marxist-Leninist belief in the "worldwide appraisal of the probtarians of the world") was subordinated to the preparation of the military takeover of Central and Western Europe by the USSR, the endeavor that partially succeeded (the Soviets did not succeed in the taking over of the whole Europe, but of only half of it). Analyzing the pre-WWII military industrial situation in the USSR and the Soviet MIC, V. Suvorov proves that all the Soviet military industrial output served the purpose of the massive strategic land offensive against Germany and France via Poland and Romania.

I want to mention only some from the hundreds of facts carefully studied by Suvorov. In the years of 1938-1939, the USSR started to produce the massive numbers of howitzers unsuitable for defense and actually all the Red Army's artillery became based on this type of a gun [55]. Then by 1941, Stalin had equipped airborne troops of more than a million trained paratroopers [56]. In the late 30s, the Soviet plane's designer, Oleg Antonov (his bureau has designed all the most capable transport planes—ANs—for the Soviet Army since WWII) started to work on a project of making an ordinary tank fly (by adding a complicated wing construction to it) and by 1942, it actually flew! [57]

Earlier I mentioned the case of a locomotive building factory in Kharkov. In 1933, its "parallel" assembly line, as witnessed by (then) Colonel Heinz Guderian, produced 22 tanks per day. In 1939, Hitler started his war having 3,195 tanks, i.e., with less than that one Soviet factory was able to produce in less than half a year of work during the peacetime [58]. As to the quality of the tanks, Suvorov (a tank-officer himself) claims that the Soviets were the only ones able to appreciate the work of the American "tank-genius" Y.W. Christie—his tank was bought by the Soviets in the U.S. and sent to Russia under false documents (as "agricultural equipment") and then copied. Its main feature developed further by Soviets was the speed—70 mph—that was so important that it was even included in the Soviet brand name—BT (stands for the fast tank). It had only one significant fault though—BT could not be used on the Soviet roadless territory. The conclusion is clear. It was prepared to work for the Soviet offensive in Europe with its well-developed road system...[59]

On the more practical level, the 1929 Field Service Regulations and their subsequent modifications until the very end of the USSR "were particularly strongly oriented towards the offensive [60]." It was mere luck of the Western countries (and even that of Nazi Germany) that the main theoretician of the mobile offensive land war based upon the superiority in tanks (the idea later developed by Heinz Guderian) and faithfully adopted by the WT RO [61]—Commander Tukhachevski fell as a victim of Stalin's purge in the Red Army in the late 30s.

The principal reorientation of the doctrine having significant economic implications was undertaken in 1987 when the WTO adopted more defense-orientated vision of the possible future war [62]. Enormous offensive buildup turned out to be useless and put the Soviet MIC in the situation of the need of almost immediate conversion of most of its labor and material consuming parts (steel and armored metal producing, and tank and artillery building industries primarily). So what Russia inherited was the enormous amount of metal and men unfit to carry out the mission other than designed by the Marxist idea of forceful expansion of communism.

Another severe change, already mentioned, was the change in the geographical situation of Russia and the corresponding operational challenges for her armed forces. Russian domestic ambitions in its relations to its own parts-turned-neighbors (on the borders with the Afghanistan-led unstructured Moslemic world and in Trans-Caucasus) created new military realities and the collapse of the USSR—the buildup of a new handicapped MIC. I've said elsewhere many times over that almost nothing in the Russian MIC and her army, from military hardware to the training of field officers, from the morale of the conscripts to the supplies of rounds for the AKs and the international agreements, fits into the framework of the war in Chechnya.

Another factor was the fact that once so carefully unified MIC that took into consideration different scenarios of potential war (like moving industries to the East in the case of the successful NATO offensive and to the West for the case of the military confrontation with China, etc.), the single economic space of the former USSR fell apart according to the "wrong," i.e., unpredicted lines. What was natural politically (falling apart into the former constituencies and occupied countries) turned out to be unnatural

economically. Whereas the "loss" of the Baltic States, never completely trusted by the Soviets, was rather a geostrategic change (due to the reduction of the military access to the Baltic Seas that, strangely enough, is still considered to be of some strategic importance by Russian admirals) than a technological one [63]. The falling away of many other parts bore more significant changes: the "loss" of the main launch pad in Kazakhstan (Baikonur) is the best known, but not the single example. Although not completely, but at least partially the militarily disastrous campaign in Chechnya may be reduced to a problem related to the collapse of the former Soviet MIC's geo-economic space: Chechnya stands exactly in the way between the oil fields of the Kaspian Sea and their consumer, the Black Sea and its Russian (or is it Ukrainian?) fleet.

So what was the result of such a type of collapse was a group of MIC players with only parts of the puzzle in hand [64]. In a certain way, it is also a conversion if we mean by that only one part of the whole more complicated process: coming to an end of the military production. A plant in Estonia produced a mini-power-station, another—gas filters, the third—"black boxes," etc., but it did not and will not produce neither laser guns, nor gas masks, nor strategic bombers that might need them. So the potentially military-orientated contribution of these companies to the MIC, in general, is now reduced to zero. Whether it becomes something more again remains to be seen and will be dependent on the doctrinal components of the (former? forthcoming?) MIC. With the Baltic States, the case is plain, simple and clear: unless they are going to be reoccupied by Russia once again, their industry with its former-MIC parts will never become a contributor to the Russian MIC in the foreseeable future. What about the countries of CIS; it will depend on the future development of their confederate ties and on their general perception of their role and lawful interests in the new, post-Cold War world.

10. The Dangers of Reconversion

The mafia-style stability of MIC—it is hard to get in and even harder to get out of it (as a boss of GRU put it to a newly-recruited agent: our law is simple, the entrance fee is rouble, the exit one—two—seems to bear at least one positive news, namely that economic and technological inflexibility of MIC makes impossible its unexpected, untractable expansion of significant magnitude and during a short period of time. The buildup of modern Russian military strength from point zero has taken about 70 and even to a significantly lower level of the late 30s it took about 10 years under the most severe regime of forced labor in GULAG camps. Even in the case of a highly industrialized nation, it took Hitler not less than five to six years to militarize it (it needed very strong and consistent efforts from the Western democracies not to pay attention to it even after Munich) to a "sufficient" level and the intended full-scale militarization was not completed even by the last "successful" year of Nazi Germany—that of 1942.

This circumstance is important from another aspect; from the point of view of an ever-present topic on all international forums of arms-control and reduction and conversion: the possibility and opportunity of reconversion. That is, to turn the "civilized" parts of former MIC back on the tracks of military production.

Before going further, we have to make a clarification of the issue. As I said earlier, the MIC is created and grows from the soil and on the grounds of a general economic and industrial landscape. That means that within the natural limits of the achieved economic and technological development, any civilian factory may be turned into a military one or any of them may simply be created anew. So there are no conversion-related problems here. The problem is elsewhere, specifically, whether the fact that this given plant or corporation has been part of a MIC earlier makes it easier to convert it back into the military sector and can it be made faster and cheaper than in other, "ordinary" cases?

In certain cases, the answer must be "yes." For the beginning, I mean the ones that result from the intentional policies of the governments to make the conversion into military production possible. That has been the case in the U.S.A., in the USSR, in Sweden, in many other countries. For instance, when building up the foundations of the modern U.S. military-industrial potential in the 30s, the government took care of the preservation of capital and labor reserves and the idle equipment in the civilian sector in a shape that would make it mobilizable in the case of military or military-doctrinal necessity [65].

Being guided, to some extent, by the previous experience, the late Soviet (and early Russian?) leadership built the "duality" of MIC production into the general doctrine of its industrial policies as well [66]. This has resulted in the extremely narrow and castrated interpretation of the idea of conversion itself (nothing to say about a wider context of its civilization), namely that of a mere change in the ratio of military and civilian output without any significant changes neither in the "core technology" or R&D support that leaves the actual technological potential for reconversion actually intact.

One type of reconversion that might exist is really easy and thus may be of justified concern to politicians. It is the case when military product is produced on the final stages of the technological chain of otherwise civilian or non-military character. The sample here might be the Soviet TU and AN-type airplanes that, besides their well-known civilian modifications, have their military-purposed "twin-brothers." Much more cases of the same sort may be found in the area of production of the means of chemical warfare [67]. The following example is well-known: "Hydrogen cyanide is an intermediate product of the civilian chemical industry. Identifying Soviet factories producing this chemical is, therefore, quite easy; determining whether or not they were actually supplying this chemical to the military is not."

But this is a typical Case "A" from Figure 2. Another option of relatively easy reconversion might be in the areas where the technical development of military hardware has been or remains relatively slow. Again, this may be seen in the area of chemical warfare: for instance, such relatively "modern" and "efficient" battlefield chemicals as already mentioned hydrogen cyanide, also chlorpicrin, phosgene and chloraceton were used by the Russian army during the First World War already [68]. Or take another area, that

of some ammunition of handguns (the Russian army still uses for some guns the "'36-type rounds"), military dressing or even the infamous AK-47 itself originally designed in the late 40s. In these cases of relatively simple, well-established and not fast-moving technological development, the fact of having been a part of MIC may, to my mind, facilitate the relatively fast and cheap reconversion.

But, most likely, that is not the general rule. Because when it comes closer to the really developing areas of the modern means of warfare, it has to be taken into consideration that the reconversion is a symmetrical process in an asymmetrical time. It means that the direct reconversion brings us back to the spot where the actual conversion occurred in the first place whereas the actual time has rushed forward. What was possible during the period of WWII (where top-of-the-line technology was in some types of early radar systems, "Katyushas" and T-34s) is hardly possible in the era of super computer-controlled cruise missiles, laser guns, nuclear submarines and "smart" bombs. The samples of wrongly timed, i.e., delayed, (semi-) military technological developments may be brought from the late USSR. The Russian space shuttle "Buran" (very much alike the U.S. analogues) was designed and produced so late that it never became anything significant in the Soviet space history and we may assume that the corresponding military applications of shuttle-technology came too late as well. The initial failures and the whole mismanagement of the Soviet project of manned space flight to the moon finished it completely: the time of the relative advantage of it was let to pass by.

These are just samples that time becomes an important factor in the technological development that may eliminate or sharply decrease the possible advantages of the "savings" obtainable, in principle, through the process of reconversion into something that has existed earlier. In other words, the perfect reconversion brings us back to the point in time passed whereas time actually is new.

The real technical and techno-political advantage (and, thus the really dangerous development for the adversaries) may be taken in the technological niche, or in the areas of some radical technical or engineering breakthrough prepared by the former R&D that, as a rule, is very tractable [69]. After having abandoned the manned-flight-to-the-moon program (as it lost its political significance and did not gain any scientific, technological or political value), the Soviets moved into another direction and achieved the significant superiority in automatized exploration of the moon's surface by the means of the tele-directed robotical instruments. What about the predictability of technological breakthroughs based on fundamental R&D: the history of the A-bomb itself shows how secure that is; once it was proved that the problem is technically solvable, it was just a matter of time for Russians to repeat and then to supersede the American success. (Even if the spy story of the Rosenbergs has more than a belletristic value, the spies could have accelerated the Soviet program for a year or two, a moment in time that did not play any role in the Soviet military superiority since the late 60s) [70].

11. Legal Aspects

As we have been discussing military-doctrinal impacts on the conversion to some extent already, we have to mention briefly one important international legal matter, as well: the breakup of the USSR if not invalidated, then at least put an extreme strain upon the system of security in Europe that had been created through the years of the Cold War [71].

Two moments are here of principal significance. Firstly, the Conventional Forces in Europe Treaty (of November 19, 1990) based on the idea of the balance of non-nuclear weaponry between NATO and WTO. Currently the results of the breakup of the USSR and WTO have been incorporated into the implementation of the Treaty by the Tashkent Agreement of 1992 [72] that divided the quotas granted to the USSR proportionally between its successor states. It goes without saying that this did not only legalize the significant concentration of conventional weapons in the militarily tense areas (like Caucasus)— unpleasantness is not a legal argument!—but it ignores completely not only Russian actual ideological, but even more legitimate security concerns [73]. The military structure that faces constant challenges from all over its Caucasian and Tadjik border in a mountainous area, and in a form of a semi-guerilla-type combat system, has to be different from the one that was built up to (counter-) attack NATO on the plain fields of Central Europe. And the role of conventional arms here may be of higher significance than initially expected.

Secondly, to put aside the legitimacy of such concerns—to my mind none of that exists—it still remains the fact, as Prof. A. Konovalov writes [74] that the Russian leadership is seeking for an answer to the problem of the "threat" from the eastward expansion of NATO. The answer that would be militarily efficient, "adequate" and, keeping in mind the current stage of Russian economy, very cheap. And that answer to the Western challenge for Russia actually exists: tactical nuclear weapons (SS-20, SS-23 type missiles), actually—modernized version of them: SS-24s and 25s combined with strategic TU-160 bomber [75]. And that puts the pressure on another treaty; that of the STARTs as well [76].

From these two main samples, let me conclude that the international legal framework for the MIC conversion today is far from granted.

This level of international legal regulation of the doctrinal environment of MIC corresponds economically to the levels and problems of economic macro-management. It is indicative, for instance, that the core document in this area—the Joint Russian-U.S. Declaration on Defense Conversion (signed by Presidents Bush and Yeltsin, June 17, 1992) [77]—does not define conversion itself at all, although puts forward the macroeconomic and political means facilitating it: convertibility of the rouble, establishing favorable climate for investments, privatization, etc. Organizational methods include primarily the matching of the already existing infrastructural systems with the Russian economic and MIC's realities: the U.S. supported systems joint ventures, Ex Imp Bank, OPIC and alike.

Keeping in mind that the Declaration just mentioned was signed only some months after Russia had passed its most fundamental law on the subject, it may be assumed that the U.S. at least implicitly accepted its basic concept and its legal interpretation of the nature of conversion [78].

Paragraph 1.1. of the Law defines the conversion as "the partial or complete reorientation from military to civilian needs...of the freed production capacities, scientific and technical potential and manpower resources of defense and associated enterprises, associations, and organizations." Such sort of a definition leaves it in a grey area of ambiguity what the conversion means in real and pragmatic terms ("reorientation" may be interpreted in whatever way). In this sense, the specification of Article 2.1. seems to be of the great importance: conversion must be the "reduction or cessation of production activity for military needs at the defense enterprise." (As to the activities, then not only production *per se* is meant. Article 2.1. includes also R&D activities like "development, research, testing.")

Briefly then the legal interpretation of the conversion includes the following aspects:

(a) reduction or cessation of producing for military needs (i.e., the nature of a product by itself is irrelevant; the purpose of the use is what matters).
(b) the subject to conversion (in this specific sense) should be a "defense enterprise," i.e., an economic unit that, due to its economic status (the regime of management providing with supplies, financing, etc.), is that of a unit within the MIC.

12. Economic-Doctrinal Influences

As the civilization of MIC is, last but not least, an economic endeavor, there must be something in the economic thinking and ideas that makes such an undertaking possible. (The desirability of a conversion is rather a political, than economic although not absolutely non-economic issue. I'll talk about that a bit later). It means that the dominant and influential economic thinking holds that the conversion of MIC is: a) economically possible; and b) economically unharmful, at least. These two ideas are embedded in the three currently wider-spread economic ideas equally circulating in the Western, as well as in the Post-Communist Russian world.

"Number one" among them is the "balance wheel" theory of MIC. The idea of it is that by virtue of its immense absorption power (that creates huge demand for labor, supplies, materials, finances, etc.), and being protected "from the supply-demand economy," the MIC is able to keep national economy going even under the most depressing circumstances on the market [79]. Although not mentioned (for understandable reasons) in this specific report, there are some economically convincing (although politically horrifying as well) pieces of evidence for that out there: for instance, the militarization of German industry by the Nazis pulled its economy out of recession. And some elementary statistics demonstrate that the true success of the New

Deal in the U.S.A. came only after the country was forced into WWII by Japan [80]. More than that, the experience of WWII for the U.S.A. seemed to prove that the increase of military production may (or even must) result in the increase of the output of consumer goods as well [81]. Although this second point can be rejected on the basis of the incorrectness of the assumption of infinity of the capital available at any given moment for any given economy, the first one—"balance wheel theory"—may still hold as a means for the realization of the goals of the social engineering à la Keynes [82]. It is worthwhile to mention though that this type of Keynesianism, as it was pointed out by (at that time, the Minister of Foreign Affairs of the USSR) E. Shevardnadze, inevitably led to the apology of socialism or socialization of the economy (Stalinist communism in the USSR and the New Deal of FDR in the U.S.A.) [83].

Another perception (argument "Number Two") favorable to the MIC and to its natural instincts of self-preservation is that the development of MIC is able not only to increase the net output of consumer goods (as it happened in the U.S.; by the way, the case was just opposite in the USSR), but also to reduce the costs of their production. It might really be the case if we'd think according to the following patterns: MIC output (particularly in the modern times) is based on the very expensive and extensive R&D. This R&D is absolutely vital for the MIC for its existence and has to be carried out at any costs and these costs are covered by the government anyway. Thus, if the MIC becomes now involved in the civilian production, its R&D spendings (and also, R&D component in tools, equipment and capital stock) totally go on the balance sheet of military production and are obtained by the civilian assembly lines of MIC "for free." The civilian output, in a way, seems to become a free by-product of the costs that are born by the MIC anyway.

But this is a book-keeping illusion as well: mere change in the accounting systems will change the whole picture here and that is not the point. The point is that the civilian by-product produced under the rules of the privileges of the MIC is actually produced in the planned, government-paid or government-controlled sector of economy. In this sense, there is a basic difference in the economic essence between the similar pairs of boots produced in the "normal" and MIC factory. So what we have here at hand (even if we deal with, for instance, MIC of the U.S.A.) is the planned economy. In other words, it must be clear once and forever: MIC, even in the most democratic society with the most free market, is an element of socialism and communism and the question for the U.S. is—how much socialism its economy may want or can afford. That is, any expansion of MIC is a tribute to socialist economy and vice-versa. [84]

At the same time, it has been proved over and over again that the actual mechanism of planning (with its constant swinging between the adjusting of target figures and the reports from producers) presupposes two opposite strategies of behavior by the participants of this process: the producer has to ask for as much supplies as he can and the planner (supplier) has to provide him with as little as he can [85]. So the result is that the MIC producer becomes constantly underfunded vis-a-vis its production targets.

What is crucial here is that this underfundedness is not an objective phenomenon (on a macroeconomic level, the gross product inevitably matches the actual—not

imaginary!—inputs into it), but is a subjective perception by the MIC. And that being the case, there is not only the temptation, but the actual tendency to pass on the "underfundedness" of the principal (i.e., military) production to its civilian opposite number. What I have said here are more than mere theoretical speculations. The story of the intensified conversion in the late USSR (that forced the MIC to increase radically its civilian output) demonstrated that the MIC actually added parts of its military production costs to the civilian products (not—NB!—vice-versa).

"Although the required figures of the civilian goods output were not met, the growth rate in 1989-1991, at least in terms of costs, was high. On the other hand, the actual number of produced items was far behind." [86] It should not come as a surprise that under the circumstances of the drastic cuts of the MIC budgets, they primarily reduced their civilian production trying to keep the military-orientated side of their work intact [87]. These phenomena were the result of a more general military-industrial economic truth: "Typically, in military production overhead and labor costs per worker are higher, the variable costs curve rises more steeply than in civilian production. This means that a half way approach to conversion [88]...is doomed to high cost, low output and a difficult outlook in terms of product quality improvement." [89]

Another economic-doctrinal aspect (or obstacle) to the conversion is its own cost. We need to admit at least one elementary truism here: conversion does not come for free neither politically nor economically either. Far from that. For instance, "According to estimates of Russian experts, we need to invest 1.5 to 1.8 roubles in conversion for each rouble cut form the defense procurement order." [90] This is a ratio that might be more or less universal for the MIC developed to the levels of those in the U.S.A. and the former USSR. What about the specifically Russian magnitude of the problem the following has to be said. "One of the biggest obstacles to defense conversion is the unavailability of transitional financing. It is estimated that conversion will initially affect 800 to 1,000 defense enterprises and about one million to five million people in Russia...State Counselor on Conversion...declared at a NATO Cooperation Seminar in May, 1992 that Russian conversion will take 15 years and cost $150 billion." [91]

One aspect of these expenses is evident from the first sight: closing down of the production line, creating (designing, marketing, etc.) of a new product , relocation and retraining of the workforce, etc. presupposes the costs, sometimes with returns in a distant future or with no returns at all (or: with the prospective of further increase of costs like in the case of the laid-off workers unable to enter the active workforce again). Another, less visible expense is the expensiveness of the military products themselves, their price that exceeds extensive social and civilian projects by tens or hundreds of times. To give the idea of the problem, just a couple of samples from the classical work by Seymour Melman [92]:

I am not aware of the social or economic value of these or other projects used by Seymour Melman as tools of illustration. But even these imaginary cases of the real comparison of costs demonstrate one important feature: the purely organizational complexity of the consumption of the resources freed from under MIC. None of the projects in the right column can be started overnight or without a relatively long period

of preparation and establishment with no economic or socio-economic gains (like the reduction of unemployment, for instance) whatsoever.

Besides that, I am ready to admit that the U.S. needed the extension of their ability to handle 150,000-ton cargo vessels much less than 10 B-1 bombers. And, even if that happens not to be the case, the problem still approaches us from another angle: it may be said with a certain degree of approximation that "more capital" are the goods, the more time it takes to start, introduce and produce them [93]. That being the case means that

a) 2 nuclear-powered aircraft carriers	=	$5.8 billion	=	the cost of converting 77 oil-using power plants to coal, saving 350,000 barrels of oil per day
b) the cost overrun to 1981, on the Navy's F-18 aircraft program	=	$26.4 billion	=	the cost of electrifying 55,000 miles of mainline railroads, and the cost of locomotives
c) 10 B-1 bombers	=	$2 billion	=	the cost of dredging six Gulf Coast and Atlantic Coast harbors to handle 150,000-ton cargo vessels

the opposite (finishing of the production) must hold to some extent as well. In our case, the company that produced "black boxes" for the Soviet bombers, a relatively unsophisticated but still high-tech product, had introduced and engineered it for more than six years and two years was a period too short to "undo" it.

Russian proverb goes: to destroy is not (as difficult as) to create. But even without having the ratio of the costs between starting of the production and its liquidation, it seems to be clear that the latter is also resource-consuming and also the process extended in time; the process that does not produce any visible, tangible returns—at least the immediate ones. That process becomes even more extended if the more distant goal of the rational reinvestment into the civilian sector is kept in mind as well.

13. How Far to Go and How?

Now I am afraid that there may be the impression that I belong to those people who want to eliminate the MIC from the economy as fast and as soon as possible and almost once and forever. On the contrary, from the fact that MIC is a burden on the society and freedom one cannot conclude that the other burdens to be borne without MIC (like the danger of being destroyed, conquered, suppressed, etc.) would have been lighter. Whether we like it or not—the world is not a place safe enough to have it disarmed at once—from any side or angle. But, let us have the politicians and strategists decide how much of military buildup is enough and how much may be reduced. Not because I want to avoid the question but, because the answers to it will vary from country to country and from one geo-strategic position to the other. (Evidently—how much and what type of MIC is needed is different for the U.S., Russia, Somalia, and Estonia, isn't it? It is not impossible to see that the U.S. and Russia will not pose any danger to each other; but,

for instance, for the three tiny Baltic states, Russia will be a considerable and permanent threat for the forseeable future.)

But, the problem is that I am not able to give even a political-economic answer [94]. Even if we assume that the final long-term goal of an economy (let us take an almost lab test case of Estonia) is the complete elimination of MIC, even then the path and criteria of success of conversion/civilization remain vague. Estonia is the case where the more traditional understanding of the efficiency of the transition from military to civilian production may not hold. The piece in "The Economist" mentioned earlier [95] suggests that even the generally already positive picture of her economic development may include underestimation (the real growth in GDP might be as high as 10%) and thus—the economy of the country—may turn out to be "overheated." If that happens to be the case, then the individual company's success in conversion—including the complete absorption of the work force, technological potential, etc. may only add to this temperature with all the following consequences: decrease in quality and productivity, inflation (due to the unmotivated rise in the price of work force), etc. In other words, what is the point where the pendulum of conversion might stop? And whether it is really macro-economically desirable to keep all the productive potential of MIC intact *vis-a-vis* overheatedness of the rest of economy?

People loosing their jobs through conversion must find new ones—it is natural. They need some retraining, perhaps—it is natural as well. The same goes unquestionably about the technologies. But the question is—whether these productive capacities have to be given the competitive advantages due to their former belonging to MIC. By competitive advantage here I mean that firstly, the MIC had enjoyed competitive advantage as a state-subsidized system in the first place any way and now, secondly, it becomes "subsidized" for the second the time when turning this former state-given capitalization into a private asset in the civilian sector [96]. So what we have as a result is—subsidation in square.

The alternative is not a pleasant one: unemployment, the destruction of social structures of small industrial communities, sell-offs of equipment by its weight...what is the middle of the road here? The radical restructuring, whatever this vague word might mean, because it designates the grey area never studied by anybody. The grey between the black of the complete destruction of the MIC and the white of its complete conversion. But, there is a positive moment as well—the "greyness" of the area corresponds to the fact of "middle-of-the road": there is not enough money in the world to carry out the complete conversion, but there is still significantly more than nothing earmarked just for this purpose.

So the problem is the choice. The strategy of conversion. The targeting of the existing (and actually not so scarce!) resources. Whatever are the differences between the actual goals of conversion, there seems to be at least one common denominator: the conversion must result in the acceptable (pre-determined, internationally agreed upon, etc.) level of demilitarization of the political structure (state or the alliance of states), i.e., the risk of military confrontation or of any potential military conflict should be reduced. And, as to that goal something significantly less than the direct subsidation of the

conversion of the whole complex might work: the financial assistance to the demilitarization of some elements of MIC or of some economies of the international military-economic superstructure. For instance—the land offensive power of Russia was sharply reduced not through any concerted set of efforts, but due to the disintegration of the USSR and WTO. To "demilitarize" a nuclear missile it is enough to take off only its warhead!

Although, I find it extremely hard to accept the ideological premises of the article, its author—Oleg Antonov is perfectly right in one thing: the real conversion (in the sense of reducing of military risks and thus defreezing the economic assets from under part of the MIC) is not only the "weakening" or "strengthening" of your own MIC (that is always expensive) but also the not-strengthening (or—converting) of your potential opponents [97].

The political (now not only economic) sensitivity of foreign assistance to any sort of R&D (the defense conversion related ones included) in Russia was demonstrated by the so-called Soros-Russia scandal earlier this year [98]. The content of it was the accusations issued by the Russian Counter-Intelligence Service (actually—the former Soviet KGB) against the different foundations by George Soros operating in Russia. The report said that the main goal of these foundations and others alike is to serve as coverups for the intelligence and subversive (!) activities by the Western strategic institutions against Russia. Although, the Russian parliament later tried to distance itself from such an official position, actually it was done in the most passive and non-persuasive way.

To put aside the actual content of these allegations some suggestions tend to result from this extremely instructive episode. Firstly: the conversion aid need not go mainly and exclusively to Russia that officially is not extremely interested in it. Whatever withdrawal of such a targeted aid (that is, interpreted as the Western money employed to destroy the Russian military might) might avoid the future tensions with the official Russia and thus keep more perspectives open for more fruitful and understanding dialogues in the future.

Second, whatever conversion aid is coming to Russia, it has to come strictly, directly, and openly through governmental channels that cannot be accused of being the coverups for something else. The third moment—the aid thus freed may be retargeted towards the achievement of the same goals in other (former WTO) countries unequivocally desiring to obtain it and economically more able to make the most out of it—I mean the countries of Central Europe and the Baltic states.

As mentioned earlier, that makes these countries diplomatically less vulnerable against any sort of Russian expansion plus reduces (at least to some extent) her military potential by the part that depended upon her MIC's cooperation with the former satellite states.

Everything that was said here against direct private not-for-profit donations to the Russian conversion of MIC does not have anything to do with the *pros* of capital flow to Russia: in the form of capital investments based on profitability and the joint partnership with new Russian business.

A dollar invested in private business converting the MIC of Russia is a dollar invested against socialist revival and chauvinistic extremism of President Yeltsin's administration. It is the dollar invested into the rise of new Russian middle-class and into really new Russia. I mean the new Russia that will never be neither the junior partner nor carbon copy of any Western society, but still a proud member of democratic and free world. Russian capitalism does not need charitable aid (Yeltsin does—but it is another issue!), but fair partnership. Because Russian capital has, in its turn, so much to contribute to the rest of the world as well.

Besides other things—some neat profits, too [99].

14. Some Concluding Remarks

Through the observance of many instances of its functioning and existence—the systems of supplies and "sales," of technological and financial support, the unmarketability (or difficult marketability) of its civilian production, etc.—we have been confirmed in our initial principal thesis:

The MIC is constituted by a system of state-given economic privileges and state-provided barriers against the influences and pressures of the free market.

In other words: MIC is not a technological but an economic, socio-economic, politico-economic phenomenon and thus its conversion (or better: civilization) is rather a political-doctrinal then engineering-technical act by its nature.

All these features: state subsidation, economic isolation from the market, artificial pricing policies, outside planning of output and of its main parameters (from production quotas to quality controls) are the features of socialist economy. So like any army is built up on the principles of socialism (that is why the sample of perfect socialism for Hajek was barracks and all socialist societies tended to be organized like armies) so any MIC is based on the principles of socialist economy. This is inevitable and that does not matter whether that military defends a socialist or democratic ideas and whether the MIC functions in a wider context of socialist or market economy. The problem for the latter simply is: how much of socialist economic system it can afford within itself to remain what it is: the free market economy.

Now, if the MIC is a socialist phenomenon by its very nature, it is absolutely natural that not only its very existence but also its actual functioning starts to be controlled by political and ideological agenda and not by economic factors. Because one of the features of socialist economy is that it operates according to the political priorities and not due to the economic rationalities [100].

So if, theoretically, the rest of economy may function without any political indoctrination, the MIC can't. That is why a closer look at these doctrinal factors of the MIC are of significant importance when we try to determine and predict its future. Hopefully, I managed to point at least at some of them and not only the most visible, but also more significant ones.

Besides the more general conclusions implied by the previous text, I'd like here to repeat some points that although are a bit more specific, but still seem to me quite important.

1. Once the conversion is undertaken on the given plant, company, corporation, it has to be done as fast and radically as possible. If it is done only half way, the result is that costs of the non-productive military part of the company will go into its civilian part and make it even less competitive.
2. One way of acceleration of conversion is radical separation of the civilian and military parts of MIC with subsequent structural changes in the latter and to the extent desired. (I believe that it is too early to start even to think of the elimination or even some too significant reduction of the MIC whatsoever because the world is still too dangerous a place to live in).
3. The adaptability of MIC to the civilian conditions is lower than expected by politicians and promised by MIC's CEOs. This type of mutual fooling might be justified from the PR's point of view, but it cannot cover up one very plain and simple fact: the conversion of MIC is something very, very expensive—not only purely economically, but also politically and socially [101].

So the problem is—what will be the bill and who is ready to pick it up?

References

1. Currently at the University of Notre Dame.
2. Look at the "Beauty and the Beast" in "The Economist," Nov. 19-25, 1994, p. 60.
3. In our empirical study, there was a completely non-classified civilian enterprise to produce gas-analyzers that was also the producer of analyzers to monitor the hydrogen concentration in the battery rooms and oxygen mixtures in the living compartments of submarines. At the same time it is more or less evident that the number of civilian uses of submarines is more than limited.
4. Parnu Machine Building Corporation was resubordinated to the Ministry of General Machine Building of the USSR (i.e., the administrator of Soviet military space program) in 1988. But the production remained the same.
5. Although this link itself with the state is what makes the MIC what it actually is, its actual forms and appearances on the political surface may vary significantly: the MIC-Pentagon lobbying combination in the US (Peter Almquist. Red Forge; N.Y., Columbia Univ. Press, 1990, p. 13) is absolutely different from the former Soviet State Commission on Military Industry but they have one thing in common: they create the MIC that otherwise could not exist.
6. In practical terms this problem may be formulated this way: do less than 20 enterprises in the territory of Estonia that formerly were part of MIC of the USSR constitute the new Estonian MIC or not? It has to be kept in mind that none of them directly produced weapons and only in some cases (like "black boxes" for bomber planes, nuclear-powered mini-power stations for intelligence satellites, etc.)—sort of a "finalized" product.
7. It has been noted correctly that the breaking of production into very small pieces ("enterprise produced a deliberately limited range of products that it was not required to understand") was part of organizational strategy of the Soviet MIC. ("Doing Business in Russia" by ALM Consulting, Frere Cholmeley Bischoff and KPMG Peat Marwick, NTC Business Books, 1994, p. 147).

8. September 24, 1994 Russian TV news (evening program) reported very typically that military nuclear and chemical plants in Krasnoyarsk-N would not allow medical and sanitary inspection by civilian authorities due to the "danger" that they may be closed down or forced to comply with general safety regulations. On the other side, in the U.S. such a type of "special treatment" made it possible for more than one third of military installations that were supposed to close in 1988 stay open and will cost more than $15 billion in the next five years. (Eric Schmitt in the "New York Times," Oct. 10, 1994, p. A8).
9. We may quote here the "economic trinity" of any socialist system after Vaclav Klaus: subsidized prices, otherwise nonexistent demands and sheltered markets. (In: Leading Economic Controversies of 1995; E. Mansfield, ed., W.W. Norton, 1995, p. 211).
10. Besides very many other interesting things the outstanding scientist of our days, Acad. Roald Sagdeev has described, for instance, the battle, he calls rightfully — "titanic" between the two extremely powerful schools and structures in the Soviet military space technology — namely between those of Sergei Korolev and Vladimir Chelomey (the significantly less-known "father" of Soviet cruise missiles). — Roald Z. Sagdeev, The Making of a Soviet Scientist, John Wiley & Sons, 1994, pp. 201-211).
11. Seymour Melman, Profits Without Production, N.Y., A.A. Knoff, 1983, p. 90. There are no reasons to doubt that this principle worked in the USSR as well, and to a significantly larger extent. The costs of the Soviet MIC was more than just a straw that broke the backbone of the whole country. Also the same author's introduction to "Towards a Peace Economy in the United States," G.A. Bischak (ed), N.Y., St. Martin's Press, 1991, pp. XVI-XVII.
12. I made a bit more detailed note on that in my "A New Old Constitution for Estonia," in: "Legal Reform in Post-Communist Europe," S. Frankowski and P. B. Shephan III, eds., Martinus Nijhoff, 1995, p. 86.
13. Among them one is misleading up to the extreme—commercialization of MIC gives "MIC conversion" the meaning of (a) conversion of MIC itself and (b) the conversion of the fiscal assets of MIC. Even Russian neologisms "conversia" and "convertatsya" do not save much.
14. Viktor Suvorov. Osvoboditel; St. Pb., 1993, p. 74. Unfortunately, the English translator of the book ("The Liberators," W.W. Norton, 1981) has omitted this interesting detail.
15. V. Suvorov. The Liberators..., p. 61.
16. Sagdeev, op cit., p. 55.
17. The defense industry of Russia traditionally produces the main part (up to 90 and more percent) of TV sets, refrigerators, tape recorders and other complicated domestic apparatus and practically is the monopolist in the field of R&D in this sector." The Role of Military Sector in the Economics of Russia and Ukraine; Charles Wolf, Jr., ed., RAND-Hoover Symposium, Nov. 1992, p. 67. Whatever are the current jokes about the quality of such seemingly primitive efforts to hide the real magnitude of MIC behind the shelters of double-bookkeeping, the fact remains, that they were pretty successful and the confusion is still out there. Even to well-informed agencies like SIPPRI, CIA, Gorbachev and Rand Corporation give estimates of ± 8% of GNP! (Soviet Conversion 1991, J.T. Marlin, P. Grenier, eds., CEP, 1991, p. 15; The Soviet Military and the Future; S. F. Blank, J.W. Kipp, eds.; Greenwood Press, 1992, p. 16)
18. Look also at our footnote 6.
19. Towards a Peace Economy...p. 16.
20. ibid., p. 17.
21. Commersant (Russian weekly edition), Jan. 17, 1995, p. 61. This analyses by "Commersant" takes into account also: The Political Economy of Arms Reduction, L.F. Dumal, ed; AAAS, Washington, 1982.
22. This "over-technòlogization" as a significant cost-increasing and structural problem on the company level shows up macroeconomically as over-industrialization well known from the Soviet economic history (Economic Developments in Cooperation, Partner Countries from a Sectoral Perspective; R. Weichhardt, NATO, 1993, p. 137)
23. Towards a Peace Economy...p. 173.
24. Melman, p. 208.
25. And not just that: economic-technological thinking as well. One of our respondents--CFO of the former MIC plant told me, "After I told the workers that our goal will not be to produce 'black boxes' for airplanes, but money, they almost went on strike."
Although the change of mentality of the MIC's workforce is another very special topic, I'd like to agree with Oleg Antonov (in "NG", Oct 13, 1994) that the key to the saving of the potential of the former USSR's MIC is in the "emancipation" of the middle-level managers of unique skills able and motivated to make a new start in their lives and careers.
26. After the Cold War. Russian-American Defense Conversion for Economic Renewal, M. P. Clandon, K. Wittneben, eds., N.Y. University Press, 1992, p. 89.
27. J. Krause, Ch. K. Mallory. Chemical Weapons in the Soviet Military Doctrine, Westview Press, 1992, pp. 36-72.
28. Michael Checinski has pointed out one very significant point: although the socialist (or any other totalitarian or militarized society, from Sparta to Nazi Germany and the USSR) may "outperform" the market forces in the short run, on longer terms it will be a loser. The collapse of the USSR is a christomatic sample here indeed. ("The Soviet Military "...p. 93).
29. Chr. Bluth, Soviet Strategic Arms Policy Before SALT, Cambridge Univ. Press, 1992, pp. 176-181.

30. The Role of Military...p. 100.
31. There might be one psychological moment here as well. To quote my own corporal from "good old Soviet days" — A Russian soldier feels himself well and secure if there is lots of metal around him. An absurd and dangerous feeling, of course.
32. Äripäev, Sept. 2, 1994, p. 10.
33. Urmas Tooming in "Postimees," April 7, 1995, p. 10. (In Estonian)
34. It was one of the typical versions in our empirical study in Estonia. As most of the enterprises produced only parts or custom-made products, the switch from one product to another within MIC occurred all the time.
35. Novoye Russkaye Slovo, v. LXXXVI, N 29872, p. 1.
36. A. Vaganov in "NG", N65 (991), April 12, 1995. "NG" stands for "Nezavisimaya Gazeta," Russian weekly most actively involved in political debates over the future and the current status of the Russian military and MIC.
37. According to the estimates of experts, the current volume of a nuclear-power-market is about 50 billion. Thus, the piece of 9 billion is more than just a considerable share of it. (Sergei Cekhmistrenko in "Commersant," Russian Weekly Edition, 1995, N13 (124), April 11; p. 11)
38. In the dilemma between politics and economy, not all conversions (in economic and technological sense) by themselves serve the purpose of political stability. Here I refer to a somewhat unclear U.S. policy towards the denuclearization of Ukraine and Kasakhstan aimed at making Russia (or its not sober leadership--literally) the only and completely unbalanced nuclear power in the area. The rationale behind this thinking is not very clear, but what is, though, is that the military instability in the area of the European Belt is increased by such a "conversion" most radically.
39. I truly believe that the nuclear sales of Soviet technology by Russians to Iran are of civilian nature. But if it were not? Would that have been a sort of a conversion for Russia?

    And then, if to replace Iran in this equation by some democratic European country? CEO of "Rosvoruzhenye" Gen. Viktor Samoilov points to the fact that after the free redsitribution of Soviet military hardware by NATO (that was formerly owned by GDR and now given to Sweden, Austria, Greece, Spain, and Turkey) that served as a free advertisement for Russian MIC a new market was created for it. And not only for the additional products but for the spare parts as well. (Andrei Chernakov in "Commersant" (Russian weekly edition), Nov. 29, 1994, N45 (107), p. 30). Now there is a question--where is the conversion here, if at all?
40. After: Arthur A. Alexander, The Conversion of Soviet Defense Industry, RAND Corp., Jan. 1990, p. 35.
41. The Soviet Military and the Future, p. 106.
42. Soviet Conversion-91, pp. 12-15.
43. Soviet Conversion-91, pp. 12-13.
44. ibid; p. 1. Let me put aside one other problem striking any methodology-orientated mind: what is meant by "broadness" and "narrowness" here? It could easily be the other way around. But we must hope that the "conversionists" are much better engineers and politicians than philosophers and logicians. That is what matters.
45. The "humanization" of the development in general is evident. To compare with the whole Gulf War, Russia managed to kill about 120 civilians in Chechenya by its "dumb bombs" during one day—December 20, 1994—only! More than that—the President of Ingushetia, former officer himself, Gen. Ruslan Aushev has pointed at the fact that Russia uses in the neighboring Chechenya also conventional weapons banned by the international law (like needle-shells Zsh2 and Zsh1 with 8 and 7 thousand needles correspondingly). ("NG" Jan. 27, 1995: So, even binding herself under the international rules of "normal" warfare would mean in this case—a sort of conversion.
46. Soviet Military and the Future, p. 106.
47. ibid.
48. Thus we exclude here as the exceptional ones, the case of a use of a sports-gun to commit a murder and the use of AK-47 as a museum item. In this sense, it is pretty hard to understand from the outside-of-U.S.'s point of view all these debates on the banning of assault weapons under the pretext of proper interpretation of the 2nd Amendment. As far as I understand the Amendment, it is not about target-shooting or hunting, but about "well regulated militia" that "keeps and bear arms." If that doctrine is outdated, then all arms are to be excluded from private ownership. If it is not, then there is no difference between assault and defense weapons. I may be dead wrong, but in Europe and in the USSR, I was taught to take law (not legal propaganda) as it has been written.
49. This is the whole concept of the brilliant, and perhaps the most important book ever written about WWII: Viktor Suvorov, Ledokol (in Russian), M: Novoe Vremya Publishing, 1993.
50. Combination of actual social relations and the socio-psychological readiness for MIC-related "sacrafices" (higher fares, inflation, budget deficit, unequal availability of funds, subsidies, etc.).

51. This point—the military viability—was taken into consideration in our empirical case where we were told that one of "our" companies had actually a "double" set of workers as well. It meant that in the case of war (when most of the men from the assembly line would be called for duty or might be killed) there were other people—workers in civilian factories, housewives, etc.—trained and able to replace each and every assemblyman in the company and assigned to it as its active reserve.
52. The commander-in-chief of the 12th Russian Army, stationed in Moldova.
53. "NG", N219, Nov. 16, 1994.
54. Prof. E. Rozin, in his latest works, (published, unfortunately, partly posthumously) proved in the most brilliant way that the Soviet aggressiveness or the subversive activities of communists all over the world did not result from historically accidental circumstances (like the personal brutality of Lenin, cruelty of Stalin, adventurism of Che Guevara, etc.), but were the natural and actually the only possible result of the Marxist doctrine itself. (E. L. Rozin, Svyaschenoe Pisanie Bolshevizma; Bratislava, Priroda Publishing, 1994. Lenin—Organizator Gosudarstvennogo Terrora; Bratislava, Priroda Publishing, 1994—both in Russian).
55. Suvorov, Ledokol, p. 71-72.
56. Ibid., p. 113-117.
57. Ibid., p. 121.
58. ibid., p. 27.
59. ibid., pp. 28-30.
60. Chemical...p. 77.
61. The general WTO scenario could be summed up in the following way: "Operationally, victory was to be achieved by suppressing NATO's air power and forcing breakthroughs against the weakest ground forces in the main TSMA in order to encircle NATO's strongest forces. Encirclement and destruction of NATO's forward deployed corps in Germany, and a successful effort to coerce Denmark, the Netherlands, and Belgium out of the Western coalition was perceived to offer the greatest hope of ending a war before it escalated to nuclear use and before protracted conflict created unbearable strains on the Warsaw Pact coalition." ("The Soviet Military..."p. 11).
62. More detailed description of the shift, pp. 94-104.
63. Estonian MIC typically produced technologically relatively independent custom-made parts and was similar to those in Latvia and Lithuania, with some irrelevant exceptions.
64. The Soviet MIC was integrated on the national, not regional basis. Once the break-up started, the last step of the Soviet federal government to save the MIC was the administrative redesign of it along territorial lines. (Robert W. Campbell in: Making Markets. Economic Transformation in Eastern Europe and the Post-Soviet States. Council on Foreign Relations Press, N.Y., 1993, p. 134). But evidently (and to some extent, luckily) this effort came too late.
65. The Role of Military...p. 100.
66. The Soviet Military, p. 102.
67. Chemical weapons...p. 9.
68. ibid., p. 22.
69. The NK-33 booster engines mentioned earlier, and initially designed for the Soviet manned moonflight program, are very marketable even today. The reason they did not work for the program they were designed for was not in their own quality, but the inability of Soviet designers to synchronize the performance of 30 NK-33s in one booster (already mentioned article in "NG" N65, April 12, 1995). So after "sweeping away" the whole system of NK-33s, what remains is a superb and marketable engine--NK-33, itself.

    Analogous, although an unusual case of taking advantage of the valuable leftover of a destructive product, can be found in the Czech Republic: one can find there the infamous name SEMTEX (the explosive produced by Czechoslovakia that is most beloved by the IRA and Mid-Eastern terrorists) as a brand name for a new ... soft drink!
70. This gives me an opportunity to clarify Estonia's position on the acceleration of the conversion of the former MIC on her territory. The actual danger from Russia against Estonia is not related to the actual temptation to regain the elements of MIC with the goal of their reconversion, but the very existence of such a pretext that may be added to the other ones (like the defense of ethnic Russians in "near abroad" etc.)

    And another point--not all versions of reconversion can be valued negatively. To continue the story from the footnote 33 it has to be said that the most marketable products of the Soviet MIC in the West are the ones outdated for Russian Army herself. So Russia now faces the opportunity to restart the production of hardware or its spare parts for some NATO and neutral countries in Europe ("Commersant," 1994, N45 ... ibid.)
71. Alan W. Dowd. Reconsidering the CSCE, "Hudson Briefing," Feb. 1995, N173.
72. A.A. Konovalov. "NG," Dec. 7, 1994, p. 5.
73. The Chief of Russian Staff, Colonel-General Mikhail Kolesnikov writes: "As prescribed [by the CFE Treaty] of the general level of 6,400 tanks, 11,470 APCs...after 1995 we can locate in the Caucasian and Leningrad Military District no more than 700 tanks and 580 APCs. At the same time their territory combined covers more than a half of the European Russia. Thus the quotas granted to us do not

correspond to the needs of creation of the absolutely minimal defense systems..." ("NG", November, 10, 1995, p. 5). I leave it to the military experts to decide how much of a defense (and not offensive) power do the tanks and APCs carry and what they have to do in the Leningrad Military District strategically neighboring with the Baltic states and Scandinavia, but we have to admit one fact: the playing field is evidently uneven here.

74. More specifically—the counselor to the President of Russia, Andrannik Migranyan, has expressed concerns about the realization of APC and tank quotas established in Vienna in favor of not only Ukraine, but the Caucasian states as well (A. Migranyan Vneshnaya Politika Rossii. "NG", Dec. 10, 1992, p. 3; D. Hearst, Competing Loyalties Tear Away at Hopes for Real Peace; "The Guardian," Dec. 6, 1994, p. 5.)
75. The Role of the Military...p. 182.
76. Konvalov, ibid.
77. After the Cold War; pp. 114-115.
78. On Conversion of Defense Industry in the Russian Federation (Law of March 20, 1990, N 2551-1), after: After the Cold War...pp. 116-123.
79. After: Henry S. Rowen, et al., Report from Iron Mountain; in: Peace and War Industry...pp. 54-55.
80. Jonathan Hughes and Louis P. Cain, American Economic History, 4th edition, Harper Collins, 1994; look at the Table 25.1 on p. 446.
81. Towards a Peace Economy...p. XIII.
82. The logic here goes as follows: the governmental ability to spend influences the aggregate demand and thus its relation to supply. But , I have to say that even that logic is not correct. 1) The government's purchasing power is within the limits of aggregate demand, not outside of it, so the increase is not possible through it by definition; 2) The government may influence the demand and supply in a non-governmental sector, but only in one direction—towards the suppressing of free-market demand. I.e., the actual increase, if it happens, occurs only in the governmental, socialized and socialist sector at the expense of the suppressing of free market.
83. ibid., p. XV.
84. Here I have to refer to one of my own earlier essays, where I pointed out a dichotomic exclusiveness—you may have a company competing under the rules of civil law and contracts or the one that operates under the administrative state law and is sheltered by governmental supplies and procurements. You cannot have them both at the same time and in the same economic unit. Only in this sense Marx was right—it is really whether "we" or "them." (I. Grazin, The Rule of Law: But of Which Law? Natural and Positive Law in Post-Communist Transformations. "The John Marshall Law Review", Spring, 1993, v. 26, n. 3, pp. 719-737). Those familiar with the Soviet academic legal discussions of the late '20s on so called "Soviet-trust-property" understand what I mean.
85. On such a type of mechanism in general Heinz Köhler, "Soviet Central Planning" in: "The Road to Capitalism" D. Kennett and M. Lieberman, eds., The Dryden Press, 1992, pp. 5-14. Do not be misled by Soviet realities. It must work the same way for the Pentagon as well, or not work at all. The opposite naive, socialist idea by Elwin H. Powell (the U.S. "military establishment is modeled after the business corporation, and not conversely; generals behave like board chairmen, soldiers like clerks") could be accepted at least after some factual proof and the author has provided us with none whatsoever. (Elwin H. Powell, Paradoxes of the Warfare State, in: "Peace and the War Industry," Transaction Books, 1970, pp. 14-15.) The only case I have ever heard about when privates and officers voted on whether to fight or not was that of "commandos α - group," of KGB in August, 1991. But even that beautiful story turned out to be just a fairytale.

    But the ideological consequences of the Powell's theory are evident: more civilian-like you manage to show the military the easier it will be to turn the whole society into a barracks.
86. The Role of the Military Sector...p. 89.
87. Economic Developments in...p. 114. Also: The Role of Military Sector...p. 281.
88. i.e., conversion that leaves the civilian and military production within the same economic unit-I.G.
89. Soviet Conversion.... p. 21.
90. Economic Developments...p. 116.
91. After the Cold War, p. 34. The lack of adequate transitional financing was named as one of the main obstacles for conversion by all CEOs and CFOs in our empirical study. It is remarkable that it is not only the problem of "underachievers." The inability to get credits under reasonable conditions was considered to be one of the main problems by the CEO of a company that was a recipient of "Euromarket Award—1994" and of the 19th International Award for the Best Trade Name (granted by the European Trade Leaders' Club)!
92. Profits Without Production...pp. 152-153.
93. ibid., p. 151.

94. Although politically extremely sensitive, the answer to the question—how far to go, will be unavoidable. Yuri Andreev recently proved that and, by the way, put the current MIC conversion's target-level on a quite reasonable (for Russia) level: between 20 to 50% of the level of the early '90s ("NG", March 3, 1995, p. 3). That first margin—20%—may seem to be even surprisingly low, but it has to be taken into consideration that the current volume of Russian military production results to a significant extent from the reaction (and the inability to halt it immediately) to the U.S. Star Wars program (Sergei Rogov in "NG,", Nov. 3, 1994, p. 5).
95. Look at our footnote 1.
96. The term "private asset" needs clarification. I admit that not all MIC all over the world has been state owned and vice versa, evidently (and unfortunately) very few of all civilian producers have been doing so under the conditions of free market. But one truth still remains: whatever is the basic economic system of the society, the moving out form the MIC is always moving from the more-state-supported-and-privileged sector to the less-protected one. And that is the point here.
97. Oleg Antonov in "NG," Sept. 6, 1994.
98. Look at the "NG's" publication in Jan. 10, 1995 issue and articles by Andrei Vaganov in the issues of Feb. 2 and Feb. 22, 1995.
99. Alexander Malyutin in "Commersant" (Russian weekly edition), Aug. 30, 1994, N 32, p. 29.
100. It was Milton Friedman who so brilliantly proved that economically socialist ideology of U.S. Senator Joe McCarthy in the early 50s was not economically feasible just as any other socialist economy wasn't. (M. Friedman. Capitalism and Freedom, Univ. of Chicago Press, 1982, pp. 19-21.)
101. The fact that the conversion of MIC is not a merely technical or even purely technically complicated problem was proved by...Stalin! Under his iron fist and with the aid of the GULAG System, the Soviet conventional wartime MIC was converted for the civilian sector in three years. (Anatoli Sitnov in "NG," Nov. 24, 1994, p. 4).

CONVERSION AND CONTROL OF TECHNOLOGICAL CAPABILITIES IN THE MISSILE FIELD: THE "DUAL-USE PARADOX"

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1. Introduction

It is often assumed that an economic unit specialised in the development or manufacture of military products will be better placed to face a conversion or diversification process if these products have potential civilian applications ("dual-use" items). In other words, producers of "dual-use" items can enjoy a "technological bridge" that allows them to cross from military to civilian production. This paper points out that there is a less palatable side to "dual-use". The same technological similarity that facilitates conversion makes it easier to revert to military production should the need or the desire to do so arise. In areas where weapons proliferation raises special concerns, this possibility can create difficulties of a political nature for conversion policies. If, for instance, foreign countries feel that technological efforts carried out under civilian programmes may result in future military applications, they may regard conversion attempts with suspicion. If devoid of foreign support conversion attempts falter, "dual-use" may have had the paradoxical effect of posing an obstacle to the conversion process. This paradox will be discussed here with the help of examples extracted from the ballistic missile field. The paper will illustrate how the dual-use applications of rocket technologies affect conversion initiatives in the rocket and space industries.

There are two main reasons to justify the choice of ballistic missiles. Missile proliferation, specially of medium and long-range ballistic missiles, is raising serious concerns. Even old, first generation ballistic missiles may pose a massive threat against population centres located hundreds of miles away from the launch sites, against which no effective Defense has yet been developed. This threat is compounded by the potential use of chemical or nuclear warheads. Second, ballistic missiles share their technological foundations with space launch vehicles, a technological area of growing importance and which is being pursued by several industrialised and developing countries. Even more, medium and long-range ballistic missiles can be adapted to be used as "space launch vehicles" with relative ease, and vice versa. The paper presents the paradoxical effect of such "dual-use" capability; precisely because of the technological flexibility in this area,

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the dismantlement of ballistic missiles has often resulted in the closure of associated research and production facilities.

2. Dual-Use: A Double-Edged Sword

2.1 A BRIEF INTRODUCTION TO THE CONCEPT OF DUAL-USE

Governments and firms are paying increasing attention to dual-use technologies. The concept of "dual-use" is deceivingly simple: a technology is "dual-use" when it can be applied to both military and civilian uses. In other words, dual-use is a technological characteristic that enables the transfer of technology between military and civilian applications. Yet, the same concept of technology is very broad: products, processes, "know-how", skills, designs, blueprints, they can all be said to be part of the "technology"; and the ways in which the technology transfer between military and civilian applications can occur reflect the breadth of forms that "technology" takes. Dual use becomes a complex issue. It is also worth recalling that the transfer can take place in both directions: technologies developed in the military field can find their way into civilian applications and vice versa.

Table 1 summarises the different forms of dual-use technologies susceptible of transfer across military-civilian "lines". We will refer to this classification below when addressing the "dual-use paradox" in the missile field. We will only point out here that while most conversion and diversification efforts stem from the dual-use potential of components, materials, or the scientific and technological knowledge developed during military-related research, in the case of missiles the systems themselves, can be construed as being, with a few modifications, dual-use. This will turn to be more a source of problems than a springboard for conversion.

TABLE 1. Potential "Dual-Use Technologies"

Products:	Final systems
	Major sub-systems
	Components and materials
	Tools and machinery (both software and hardware)
Blueprints, designs, scientific and technological (codified) knowledge	
"Know-how", skills	
Management techniques and systems	
Management and organisational "principles"	

2.2 DUAL-USE AS A SUPPORT FOR CONVERSION: THE TRADITIONAL APPROACH

The decline in the volume of most Defense markets is forcing military producers to seek new customers beyond the military field. In this effort they often consider how to adapt for civilian markets some of the products they have developed for the military. It is uncommon for specialised military producers to be able to apply their military products to civilian use without modification. There is usually the need for some adaptation, which at times can be conducted "in-house" using technological capabilities previously employed in the military field; in this case not only a product is transferred but also technological expertise. The cost of adapting military products to the new environment is often very high and fraught with technological and managerial difficulties. In the technological front, product specifications and costs have to be adapted to the new use; as civilian and military demand differ in their performance requirements and cost constraints, modifications may need to be substantial [1]. In the managerial front, the practices developed in the military field have to be adapted to those dominant in the civilian industry. When the military and civilian markets are very different this is not an easy transition. Military producers have developed well-entrenched practices that have become part of their corporate culture, and which have to be changed in order to become competitive in the civilian field. At times, this cultural change has proved impossible to achieve [2].

Despite these difficulties there are plenty of examples of firms and research organisations attempting to enter new markets in the civilian field, and of proposals suggesting how this transition should be conducted. The traditional approach is to seek technological areas with civilian applications that are technologically close to the firms' traditional activities in the military field. It is assumed that the more similar the new civilian technologies are to those that have been applied to Defense production, the easier will be the adjustment of the enterprise to the new markets. In other words, the clearer the dual-use potential, the smoother the transition required in a conversion or diversification process.

2.3 DUAL-USE AS A TECHNOLOGY CONTROL PROBLEM

"Dual-use" as an enabler of conversion presents the positive side of the concept. Yet, the same concept had first become fashionable in a different context: technology controls. In this environment "dual-use" presented a serious problem. Dual-use technologies constituted a grey area where controls were more difficult to implement and justify, despite the fact that some dual-use technologies were arguably key for the enhancement of the adversary's military capabilities.

This is not a new problem. Dual-use technologies have long been the object of technology controls. The Co-ordinating Committee for Multilateral Export Controls (CoCom), which was created in 1949 to prevent the flow of Defense technologies to communist countries, had from the outset included among its controlled items a list of

industrial products with both military and civilian applications. CoCom's so-called "Industrial List" was concerned mainly with what today we would call "dual-use" items. To make matters worse, the relationship between military and civilian technologies changed [3] and by the 1980s military production was growing increasingly reliant on civilian-developed technologies. With military hardware embodying a growing proportion of general-purpose industrial components [4], the control of dual-use items became a cornerstone of non-proliferation policies. Export control legislators had to come to grips with the fact that the main proliferation threat did no longer come from the hand of the munitions and artillery supplier, but from the activities of so-called "techno-bandits" [5, p.232].

As East-West tensions heightened in the 1980s, the export to communist countries of dual-use technologies triggered considerable anxiety in the West, and particularly in the United States [6]. It was in this framework that the Missile Technology Control Regime (MTCR) was established in 1987 by the 7 leading industrial countries conforming the G-7 group (US, Canada, France, Germany, Italy, Japan and the UK). The MTCR's main goal is to limit the proliferation of intermediate and long-range missiles capable of delivering weapons of mass destruction (nuclear, chemical and biological). Since its formation, MTCR's membership has expanded to 25 countries.

The military environment that surrounded the formation of the MTCR provided ample evidence of the destabilising potential of intermediate-range missiles, even when they were only armed with conventional warheads. Older-generation "SCUD" ballistic missiles and its derivatives were extensively used in "war of the cities" during the Iran-Iraq war, in the Afghanistan war, and were also used in the Libyan failed missile attack against the Italian island of Lampedusa in 1986. Besides, ballistic missiles were being acquired by a number of Third World countries, some of which had active nuclear and chemical weapon programmes, and several new suppliers were emerging.

All these developments alerted countries to the need to limit the spread of missile technology, regardless of its age (the notorious SCUD technology had been developed in the 1950s). The result has been the formation and consolidation of the MTCR, which is an example of a technology control regime addressing a set of dual-use technologies. The following section will analyse the dual-use character of ballistic missile technology and the effects it has had on conversion efforts. The heightened awareness that resulted in the establishment of the MTCR has appeared as a further hurdle in the conversion process of ballistic missile research and production facilities.

3. Missile Technology and Dual-Use

3.1 THE TECHNOLOGY OF BALLISTIC MISSILES AND SPACE-LAUNCH VEHICLES

Historically the technological development of space launch vehicles (SLVs) has been intimately linked to the development of ballistic missiles. The technological base from which they have evolved is basically the same. The research and manufacturing skills needed for the construction of large rockets can indistinctively be applied to both military and civilian purposes. Although, in general, liquid rockets are preferred for SLVs and solid rockets for ballistic missiles, this does not preclude the possibility of using any kind of rocket (solid or liquid) for any of these two applications (SLV or missile). In fact, some countries have followed heterodox development paths; India, for instance, is mainly using solid rockets for its SLV projects and liquid rockets for its intermediate range missiles.

Initially, the main developments in the field of large rocketry were led by military applications. During the Second World War the German V-2 programme established the technological base on which a large part of the US and Soviet ballistic missile programmes developed over the following decades. Yet, already in the late 1950s, the competition between the superpowers to develop missile forces was coupled to the "space race". The rockets that had been initially designed as ballistic missiles were adapted to their new role as space launch vehicles. For instance, in the United States, three upper stages were added to the first U.S. Intermediate Range Ballistic Missile (IRBM) (Jupiter) to transform it into a SLV (Juno II). Jupiter missiles had in turn developed from the first U.S. ballistic missile ever deployed (Redstone), which in another of its modified versions (Mercury-Redstone) was used to launch the first American into space in May 1961 [7]. This early close relationship between ballistic missiles and SLVs persisted in the decades to come, and not only in the United States. For instance, the U.S. Department of Defense (DoD) has extensively used converted Titan II ICBMs as space launchers. In the Soviet Union a development of the SS-5 IRBM was used to form the SL-8 Kosmos space launcher, and the first liquid propelled ICBM (SS-6) was used as the basis of a whole series of satellite launchers (SL-1 to SL-6).

The fluidity of the military-civilian relationship in this field goes well-beyond the adaptation of military systems to space launch tasks. First, not only are the systems adapted to new uses, but missile stages and components are also routinely transferred from one application to another. In the US for instance, NASA's sounding rockets usually incorporate components from surplus missiles, and most rockets employed by the DoD to launch scientific experiments into space use powerplants from old dismantled missiles. This business is important enough to have spawned companies, like Space Vector, specialised in incorporating old missile components into new light rockets. Second, the direction of this relationship is not only from military to civilian applications. Brazil and India, for instance, have followed development paths initiated in

the civilian arena (sounding rockets and SLV programmes) and leading later to ballistic missile programmes [8].

To sum up, the historical developments in the field of ballistic missile and space launch technology show a continuous exploitation of the dual-use opportunities that the technology presents. These opportunities appear at the different levels of "dual-use technologies" presented in Table 1. The next section will analyse how the character of the dual-use opportunities that emerge in the missile field will have a discernible effect on the nature and possible scope of conversion initiatives.

3.2 DUAL-USE AND CONVERSION IN THE MISSILE FIELD

There are two elements in the dual-use potential of missile-related products that have a substantial bearing on the conversion of the missile industry. The first is the "modularity" of missiles and space launch vehicles. The issue of modularity in missile technology has been analysed in some detail elsewhere [9]. In short, it means that components and even major sub-systems can often be applied with relative ease to other missiles for which they were not initially designed. New systems can then be designed by "mixing and matching" major subsystems, either new or from older designs. Although this "mixing and matching" may not be as straightforward as it sounds, to tackle the difficulties that may arise in the process is well within reach of the technological capabilities of the original developer. Sometimes, exchanging the main sub-systems of a missile does not even require a major restructuring of the whole missile design. As a consequence, missile systems are remarkably flexible. An element of this flexibility that is of particular interest here, is the possibility of exchanging the payloads to be delivered by the same rocket system with a few modifications. In other words, one can see a ballistic missile as a delivery vehicle, capable of carrying a variety of payloads, from conventional warheads to weapons of mass destruction, to satellites. Consequently, the whole delivery system can be seen as dual-use.

This is an important difference between ballistic missile systems and many other dual-use technologies. Following the classification in Table 1, it can be asserted that dual-use technologies usually involve scientific and technological knowledge, know-how and skills, management principles and techniques and, when involving products, machinery, materials, and components. In the case of ballistic missiles the dual-use potential extends to the rocket stages (major sub-systems) and eventually to the whole system minus the warhead. Compare this situation with, for instance, that of main battle tanks where some of the technology, tools, materials and components may have dual-use applications, but the final system is completely useless for civilian applications.

Usually, dual-use potential stops short of extending to the whole system; the fact that this is not the case for ballistic missiles throws into sharper contrast the two "sides" of dual-use discussed at the beginning of this paper. When not only components, but even the main systems themselves can be construed as being dual-use, the "technological bridge" to cross from military to civilian applications (and back) becomes much wider. Diversification may be relatively easy but may raise concerns about the diffusion of

military technologies "disguised" under the skin of civilian programmes. This is the paradox of dual-use as concerning conversion in the missile field: the easier the technological adaptation to different uses, the higher the proliferation threat posed by the development of civilian applications.[1]

Because the effects of missile modularity are much more pervasive than the mere capacity to exchange payloads, the relationship between the military and civilian applications of missile technology becomes intricate. It is possible, for example, to combine stages from different missiles and SLVs to create new rockets which can in turn be used as powerplants for new missiles or SLVs. For instance the first stage of the Indian Agni IRBM, is taken from the first stage of the SLV-3 satellite launcher (which in turn was a copy of the US Scout rocket), while the second stage is built with motors derived from a Russian surface-to-air missile [10]. One of the largest Russian conversion programmes is the modification of the SS-25 ICBM into the Start SLV. The three-stage SS-25 was modified with the addition of another stage to form the "Start-1" booster which was successfully tested in 1993. A further stage was then added to turn Start into a five-stage SLV, which had its first commercial launch (and first failure) in March 1995 [11]. This diversification effort is probably not disengaged from the fact that the SS-25 is one of the very few Russian missiles which production is continuing into the 1990s.[2] Incidentally, the first stage of the SS-25 is also almost identical to the first stage of the SS-20 IRBM. The INF Treaty prohibited the production or flight testing of intermediate range missiles, their stages and launchers, and besides required the elimination of all "support structures," including production and repair facilities. Given these conditions, the fact that the SS-20 continued its life as the SS-25 first stage (being an ICBM the SS-25 was not covered by the INF Treaty) appeared to some observers as undermining the validity of the whole Treaty. This case was put forward as an example of the deficiencies of the whole INF Treaty [12, p.112]. Now the same rocket that was the cause of considerable debate and disaffection among members of the US Congress is the main protagonist of Russian conversion efforts.

The case of the SS-25 missile - Start SLV exemplifies how the close relationship between military and civilian systems provides an avenue for the diversification and conversion attempts forced upon the industry by the cuts in the number of deployed ballistic missiles that have followed the INF and START-2 treaties. It is not then surprising that the conversion of the ballistic missile industry has been fraught with problems of a political nature. These are detailed in the next section.

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[1]Off course, different systems will pose different military threats. The threat of ballistic missiles can be formidable as an effective Defense against them has yet to be developed. Yet another large system with clear dual-use application like transport aircraft does not appear as so menacing from a military point of view.

[2]Besides, a new version, code-named "Fatboy" in the West, is now being developed.

3.3 DUAL-USE AS A PROBLEM IN MISSILE CONVERSION

3.3.1 *Proliferation Concerns as an Obstacle to Conversion*

The modification of the SS-25 for use as a SLV has been mentioned as an example of how technological similarities between missile and SLVs provide opportunities for diversification and conversion. Yet the same modularity that links the resulting Start-1 SLV with a group of missile relatives, has raised suspicion about Start's development. Rumours about the possible export of a Start-1 SLV to South Africa were received in the United States with undisguised apprehension. Even the *Wall Street Journal* referred to the reports that Russia was preparing to export SLVs based on the SS-25 as a move that would give countries without an ICBM capability the ability to buy it "off the shelf" [13]. The Start-1 has not been exported so far, and the only commercial launch of foreign satellites took place in Russian soil. Not that launching from the former Soviet-Union will put an end to the problems. In December 1991, a SS-19 missile was launched by the former Soviet Union from Kazakhstan, allegedly to test the space launch capabilities of the missile. In this case it was the use of encoded telemetry, forbidden by the START Treaty and suggesting a military intention, which resulted in loud international complaints. Yet, at the end of the day it remains impracticable to ascertain what the final goal of the test was.

Another example of how the difficulties to separate military from civilian applications may curtail attempts at steering military programmes into civilian applications is the case of the Argentinean Condor programme. The programme aimed at developing a sounding rocket (Condor 1) and a two-stage, solid propellant system (Condor 2) with much longer range and payload, and which was internationally perceived as a ballistic missile. The military character of the programme was reinforced by the fact that the organisation in charge of developing it (the National Commission of Space Research, CNIE) was controlled by the Argentinean Air Force. Besides there was evidence that Egyptian and Iraqi interests were also involved in the project. After considerable international pressure Argentina suspended the programme in 1990, and in May 1991 the Argentinean Defense Minister stated his intention to "deactivate, dismantle, reconvert and/or render [Condor 2] unusable". Just a couple of months before, Argentinean president Carlos Menen had transferred CNIE's activities to a newly created National Commission of Space Activities (CONAE). In contrast to CNIE, CONAE was a civilian organisation under the direct authority of the Presidency [14]. This organisational change suggests an attempt to convert the Condor-2 missile into a SLV programme. This conversion would have received the support of influential Argentinean policy circles that had made clear their displeasure about the apparent intention of terminating the project. It was argued that scrapping the Condor programme would obliterate Argentinean capabilities in the field of satellite launchers. The Argentinean Defense Minister made clear his desire to transfer the whole project (personnel and materials) to the space research programme [15]. Simultaneously, the US was increasing its pressure on Argentina to force the complete scrapping of the project. While US experts insisted that the Condor-2 could not be transformed into a SLV, the US administration had tightened

the control on high technology exports to Argentina until the Condor's destruction. Finally, and despite domestic opposition, the programme was completely abandoned, existing Condor rockets were destroyed, and the research facilities apparently dismantled. The dual-use potential of missile systems had proved to be a major obstacle to the conversion of a missile programme into civilian use.

The Condor saga had not ended yet. Once the dismantlement process had started it was the destination of some of the Condor's components that continued to raise concerns. It was feared that some of the components could assist missile programmes in other states or facilitate an eventual Argentinean re-entry into the ballistic missile field [16]. Surprisingly, with US consent, the rockets were transported to Spain for destruction. At the time Spain had its own, rather controversial SLV programme, code-named Capricornio. The Capricornio programme had been launched in Spain as a "purely" civilian initiative linked to the also commercial MINISAT satellite programme. Yet, it was rapidly pointed out that the project could have military applications. Press reports argued that Capricornio could easily double as medium-range ballistic missile capable of delivering warheads to most of Northern Africa. The Condor rockets were shipped to Spain where they were disassembled, the missile bodies crushed and the propellant sent to the United States for disposal. No sooner had the process started that rumours about some of the missile parts getting "lost" started to circulate. Special interest was raised by the destination of Condor's guidance sets. Argentina claimed that the missile lacked this essential part, but there were insistent press reports that the components either remained in Argentina or ended up in Spanish hands. Be as it may, these incidents were used by the U.S. administration to increase the pressure on Spain to abandon its own SLV programme, which Spain eventually did.

The importance that the United States attached to the movement of missile (or SLVs) sub-systems and components is explained by the modular and flexible character of missiles and space launch vehicles. Under conditions of modularity a missile system can be completed, or upgraded by adding or exchanging some components, without needing to modify the whole system. The path towards upgrading or completing a system with the addition of new parts is a relatively plain one. When a new component becomes available is usually possible for potential proliferators to incorporate it into existing systems or to use it in the production of a new missile. It is even conceivable to build a whole missile by reassembling its parts or using "recycled" ones. Because of system flexibility these parts can be obtained from both civilian or military programmes. As a consequence some analysts feel that the proliferation of some components that would follow the diffusion of civilian launch capabilities would open substantial opportunities for countries determined to gain manufacturing competence in the field of ballistic missiles [17]. Under these conditions, the control of components and sub-systems to prevent missile proliferation becomes extremely important, and the issue of conversion from military to civilian applications is bound to raise suspicions. The control on dual-use components, as those established in the Missile Technology Control Regime can stifle the civilian space programmes of newcomers, and prevent military programmes in developing countries to be converted into civilian projects.

3.3.2 *Missile Conversion as a Problem for Industrial Diversification*

As we have discussed above, ballistic missiles are quite exceptional in that the whole delivery system can be construed as having dual-use potential. So far we have discussed the political implications of this peculiarity, but there are more consequences for the conversion of missile facilities. Because of the dual-use applications of the missile systems, conversion is not necessarily limited to a process of industrial readjustment; unlike other military systems, ballistic missiles can themselves become the object of conversion. Once decommissioned a ballistic missile can be transformed into a SLV, while other weapons systems, for instance tanks, have no potential civilian application and once withdrawn from service have to be scrapped. Therefore, the missile field is exceptional in that conversion affects both the manufacturing firms and the missiles themselves. It is noteworthy that such capability is recognised in the START Treaty, which explicitly allows the use of missiles to deliver payloads into upper atmosphere.[3] This potential poses problems at the some time that opens new opportunities.

In the United States and the former Soviet Union, where the stocks of surplus ballistic missiles are very large, their final destination may decide the future of some missile producers. Surplus missiles can result from the "retirement" from active service of missiles that have become obsolete, or the withdrawal of systems resulting from disarmament agreements. Because the START treaty and the general conditions of disarmament have given rise to a large stock of surplus missiles, the United States and the former Soviet Union have had to pay careful attention to the feasibility and potential effects of recycling surplus missiles. An important consideration in this context is that the space launch market is already a highly competitive market in which the total number of launches has remained fairly stable since 1967 [14, p.4]. Although projects like the Iridium constellation of communications satellites could induce a growth in demand in the near future, it is unlikely that present space launch capabilities will be stretched.[4] In this context, the conversion of missile systems into SLV can be detrimental to the future of the prime contractors involved in ballistic missiles and SLVs work. This question has originated substantial debate in the United States, where a well-developed space industry has had to face the prospect of hundreds of ICBMs being turned into space boosters. In a U.S. House of Representatives Hearing, users, large rocket producers and firms specialised in adapting missiles to space launch tasks gave widely disparate assessments of the economic costs of such conversion vis-à-vis the cost of manufacturing new launchers. It is no surprise that the SLVs manufacturers came up with cost estimates that favoured scrapping the missiles and continue building new SLVs. It was clear that some firms treated the conversion of missiles into SLVs as a very serious threat to their future.

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[3]The treaty specifies the control mechanisms to monitor the process. The conversion of a controlled ICBM into a SLV has to be notified, and certain constraints apply. Such converted missiles are then classified as "non-deployed missiles" (NDMs). START does not establish any limits on the number of NDMs that can be hold, except for converted MX missiles.

[4]Although the launch costs were to come down new possibilities would open, for instance, for academic researchers wishing to place experiments in space but unable to afford the prices of a commercial launch.

To the decision-makers the problem was more complex than it may have appeared at first sight. As the Chairman of the Subcommittee on Space of the US House or Representatives put it:

> "at first glance the removal of a thousand or so strategic missiles from our arsenal appears to be an opportunity to, so-called, beat the swords into ploughshares by using these rockets in our space program. A deeper look at the issue shows that while these missiles may turn out to be very useful, we must also be very careful that use of these missiles by the US. Government, or their release outside the Government as surplus assets, does not harm commercial companies or discourage private investments in new launch vehicles" [18, p.1]

SLV assemblers are often the same firms that are prime contractors in the large ballistic missile programmes. When faced by the contraction in the demand for ballistic missiles, these companies will have to seek new markets into which expand their commercial launch activities. If a decision is taken to convert the missile systems into SLVs, potential alternative markets for these firms are further eroded. How to proceed becomes an industrial policy matter.

For countries which are starting in the SLV-missile industry the situation is very different. Conversion in this context can only be understood as the transfer of research and emerging manufacturing capabilities from military to civilian goals. In a country like Argentina, after the termination of its missile programme, there were neither large number of missiles to convert, nor an established industry. The question is then more straightforward: should the country use its capabilities in the missile industry to build a commercial space launch industry? Apart from the commercial benefits that can accrue if the market expands, countries may expect to reap technological benefits for the rest of the economy from their space programmes. Most of the literature about the technological benefits of space research for the rest of the economy emerged from the United States; it is not surprising then that the new literature of US origin underlining the costs of SLVs programmes and arguing that these do not make any economic sense for newcomers [17] will meet with an sceptical audience. Despite US recommendations and pressures to stop space launch programmes in newly industrialised or developing countries some projects are going ahead, and conversion to civilian use remains an option for countries that in the future chose to abandon their domestic missile programmes. Besides, more often than not, these countries will have run a civilian programme in parallel with the military project. In the unlikely event that a country like Israel terminates development and production of its ballistic missile systems, it is to be expected that at least some research and manufacturing facilities will be moved to reinforce ongoing activities in the commercial launch field. As it has already been discussed, this is a transfer which comes facilitated by the technological proximity between both fields, but which would raise concerns among international policy circles worried by missile proliferation. Observers

may fear that the dual-use nature of missile systems is bound to fuel attempts by countries with a fledgling ballistic missile force pending withdrawal to keep and improve their missile capabilities in the guise of "civilian" systems.

4. Conclusion: Managing Dual-Use in a Conversion Environment

The conversion of missile industries cannot be delinked from the broader security environment in which the missile industry operates. Because of dual-use, conversion in the missile field cannot be approached only as an industrial policy problem. If missile-related industries base their conversion policy in the intensification of their operations in the commercial space sector, they will be subjected to the often hostile scrutiny of foreign powers. Therefore, conversion initiatives in the missile field have to take into account the potential proliferation implications of such policies. This is easier said than done. Mechanisms can be devised to persuade critics about the final use of the items being developed and produced under the conversion initiative. Yet, even if a mechanism of safeguards is put in place, it will always remain difficult to verify the final use of rocket technologies. Even more important, it is practically impossible to ensure that the facilities used for SLV research and manufacture will not in the future turn their effort to ballistic missile development taking advantage of all the technologies developed under SLV programmes. Any such facility will always provide a technological base for the production of ballistic missiles.

Some authors have argued in favour of a regime similar to that of the Treaty on the Non-Proliferation of Nuclear Weapons (NPT) [19]. Such a regime would promote and assist research on launch and space technologies among member countries in exchange for guarantees that these technologies would not be diverted to military use. As a verification mechanism the regime would include the establishment of a system of safeguards and intrusive inspections. In similar lines, an international space agency (modelled on the IAEA) could be established to monitor the use of space technologies [20].

Had such an international framework been in place, many of the problems that this paper has presented may not have emerged. Past and present conversion initiatives in the missile field would have benefited from a clearer political environment within which to develop their activities in the civilian area. Yet this is not the international setting that missile producers are facing today, and it is now that many of them, particularly in the former Soviet Union, are facing the need for change. It is the present political and strategic situation that is forcing ballistic missile developers and producers to abandon most of their military activities and seek alternative roles. Many producers cannot enjoy the luxury of waiting for an international nonproliferation regime before embarking in conversion initiatives; they must do it now or perish. In the absence of a general missile nonproliferation regime incorporating a system of safeguards and verification measures, it is difficult to see what can be offered in the way of assurances to sceptical observers opposing the development and transfer of missile-SLV technologies. Nevertheless,

missile producers wishing to intensify their operations in the field of space launch technology as a conversion policy, have to be aware and sensitive to the proliferation concerns that such activities may raise. A policy of openness may help gain some acceptance among the international arms control and foreign policy communities. Yet, it can be expected that an element of suspicion about the motives and effects of the firms' new activities will remain. The difficulties that such suspicions may raise for the new ventures may tilt the balance against their commercial viability in what is a highly competitive and very expensive business. The "dual-use paradox" would have eventually worked against the interests of conversion.

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THE GLOBAL ECONOMY AND INTERNATIONAL STABILITY:

Beating Old Swords Into New

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The book of Isaiah, in the Christian Bible, says: "They shall beat their swords into ploughshares, and their spears into pruning hooks: nation shall not lift up their sword against nation, neither shall they learn war any more."

Many leaders thought that the end of the Cold War would usher in the era of peace and goodwill: the era of swords into ploughshares. But these hopes merely reflected the failure of most analysts to understand human nature and geopolitics, and a particular failure to comprehend in advance the actual consequences of the West's "victory" over communism.

Du Mu, the Ninth Century Tang Dynasty official, said: "A victory gained before the situation has been crystallized is one which the common man does not comprehend. Thus the author of victory gains no reputation for sagacity. Before he has bloodied his blade, the enemy state has submitted." It could be said that the Cold War ended before the situation had crystallized in the minds of the publics of the NATO bloc or those of the Warsaw Pact states. These two camps had neither prepared for victory, nor for defeat. The result is that much of the world at large is now reduced to an aimlessness; to a leaderless, structureless, anomic or lawless community.

At present, the overall global economic condition is fairly positive: inflation is under control in most industrialized states, and growth is at an acceptable level. But the political and strategic factors which will ultimately govern the world's economy are unstable and unpredictable. The global economy and international stability are inextricably intertwined, and economic trends cannot be measured in any meaningful way in isolation from the political and strategic environments.

We today see attempts to use international political institutions, such as NATO and the United Nations, which were the pillars of the Cold War political and economic structure, to cope with situations which are completely outside the scope of the experience of these organizations during the past 50 years. In fact, there is no alternative to this, just as there are few alternatives to the use of the *military* force structures of the Cold War era to cope with the military challenges of today. And yet we can see that the

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military or security challenges facing the world at the close of the 20th Century are very different from those which it faced in the Cold War's 40 years.

The end of the bi-polar world of the Cold War era means an end to the validity of the political alliances which bi-polarization established: NATO, the Western European Union, the Warsaw Treaty Organization, and, to an extent, the United Nations. It is true that some of these institutions *could* be re-fashioned to suit future challenges. but as none of the leaders of the major powers has any real vision of the future, then it is safe to say that no one has any real idea how to transform the institutions. To be fair, it is probably true that any vision of the future must be tempered by the overriding phenomenon of our present decade: the presence of a massive number of variables in a volatile environment.

What is likely to happen is that new alliances, new structures and new concepts will gradually rise and replace the old forms, and these older structures will either wither away. or become absorbed into the new systems. or major schisms in the global framework will dissolve them rapidly.

US Senator Sam Nunn said in a speech on *The Future of NATO in an Uncertain World,* delivered at the SACLANT seminar in Norfolk, Virginia, on June 22, 1995: "A multilateral security system is forming across Europe that reduces nuclear and conventional armaments and makes a surprise attack by Russian conventional military forces toward the West increasingly unlikely. I have in mind the cumulative effect of such agreements as the INF Treaty, the CFE Treaty, the unilateral US and Soviet decisions to reduce tactical nuclear weapons in Europe, the START I and pending START II Treaties, and the pending Chemical Weapons Convention and Open Skies Treaty." He added that Russia currently possessed more than 20,000 nuclear weapons and at least 40,000 tons of chemical weapons, advanced biological warfare capabilities, hundreds of tons of fissile material . . . plus thousands of scientists and technicians skilled in manufacturing weapons of mass destruction. And he cautioned that, in the longer term, the West could not dismiss the possibility of a resurgent and threatening Russia.

But Sam Nunn concluded that "rapid NATO enlargement will be widely misunderstood in Russia and will have a serious negative impact on political and economic reforms in that country".

We are now in an age in which the two great imperial blocs of the past 50 years have been stripped of much of their ability to successfully dictate to smaller sovereign states. Russia, without the over-arching ideological power of the Soviet empire behind it, has adapted to its new reality fairly well, and has begun re-asserting itself in the world through diplomatic means. The United States, which in this Century has known no other situation than its own imperial power, finds it difficult to operate successfully in a world which it cannot dominate completely by either political, military or economic leverage.

The great powers -- those of less than superpower status, but still historically and strategically significant, such as Britain, Germany, and France -- find it easier to recall the balance of power philosophies which kept Europe fairly stable before the balance of power system was shattered, first by Bismark and then by the Versailles Treaty which led

to Hitler. Today, we are in a world of multiple middle powers, scattered through Europe, the Middle East and Asia, and there is no scope in the short term for the rise of an empire to dictate a "New World Order" which follows any central discipline. But this situation does not preclude the emergence of new power blocs of global significance.

At present, we can still see what we loosely call "the West" as one such power bloc on the global stage. North America, Western Europe, Australia and Japan and South Korea, remained contained within a fairly normal political-economic structure at the end of the Cold War and the collapse of Soviet-led communism. But what has happened within this Western grouping is that coordination and common purpose have to a large extent evaporated with the disappearance of a strong common enemy. And not only has the imperative for close Western alliance been removed, so too has the motor of technological research and development been turned off by the lack of competition from the Soviet camp. Attempts -- whether subliminal or deliberate -- to create artificial new enemies to the West have not been successful, except for the brief foray against what turned out to be a relatively powerless Iraq.

So the West today is bound by a strong web of inter-linked trading interests, multinational mutual investment, common cultural themes (up to a point), and the most unifying factor of all: prosperity. But these ties lack the strength, purpose and vision of a common defense against a great enemy, such as the Soviet bloc represented for five decades. Today, with the feeling that the Cold War priorities have disappeared, few in government or the media recall earlier and more fundamental links which had -- until World War II -- existed between many of the West's states. Britain today no longer knows how to call upon its old Empire and Commonwealth, either in political, economic or cultural terms, and yet the ties which bound the former colonies to Britain are still remembered within the Commonwealth states. The United States today has forgotten the links of culture and language which had tied it to Britain. And, indeed, the changing cultural nature of the United States means that it will be increasingly difficult to re-kindle in the hearts of Americans the "special relationship" which once bound the UK and the USA.

Even though Washington today tries to establish new links with the Continental Western European states, there is a profound mis-matching of goals and cultural ideals. Indeed, much of Western Europe (and almost all of the United States) has forgotten why the US wanted to maintain a foothold in Europe: and that was to stop the revival of future European wars which could endanger the US itself.

Western Europe is itself consumed with the task of completing a structure which was envisaged and started during the Cold War: the European Union. And yet this European Union is being compiled as a major, multi-national, multi-linguistic, multi-ethnic, multi-religious, and multi-currencied state, just as -- with the collapse of rigid bi-polarism -- the world is increasingly turning back to petty nationalism, or nationalism in the older sense. So what keeps the European Union moving ahead?

There is a fear within Western Europe that to stop the creation of an all-embracing European Union would open the doors to the revival of competing imperial tendencies. In this particular instance, the fear is of a revival of German expansionism, or German

domination of the Continent. And the fear is felt most among Germans, who would rather embrace a pan-European philosophy than risk reverting to German imperial tendencies. The difficulty is that, even within a European Union, the Germans cannot, politically, resist the temptation to dominate the rest of Europe. And, for the time being, the rest of Europe attempts to embrace Germany even closer as a means of having at least some influence over what is now a larger Germany than the other European states envisaged during the Cold War.

There is the start of a tendency within the European Union to act in the manner of a single state, in terms of foreign and Defense policy, so as to ensure that Germany does not feel the need to act unilaterally. The result, where this has happened, has been a most unsatisfactory set of political-military initiatives. Germany's insistence on committing the European Community to recognition of the independence of Slovenia and Croatia caused and perpetuated the current conflict in the Balkans. As well, Europe's subsequent actions in the Balkans -- some successful, some unsuccessful -- have highlighted the fact that the United Nations is itself in some ways even less capable of dealing with the problems emerging from the multi-state chaos which have developed out of the former Eastern bloc of states, including both the former Yugoslavia and some of the states of the former Soviet Union.

The more that the global situation is viewed, the greater the sense of chaos. But some trends are emerging:

The first trend is that conventional military power structures cannot cope with, or inhibit, crisis or instability under present conditions, or even conditions which are foreseeable within the next five to 10 years. This does not mean that certain *events* cannot be dealt with militarily on a tactical or theatre level, but rather that even tactical or theatre security problems are able to be perpetuated and made virtually intractable by external forces to a degree which was not seen during the Cold War;

The second trend is that the reduction of research, development and deployment of strategic Defense mechanisms -- that is, Defense against ballistic missile attack, whether with nuclear or biological weapons -- has occurred (because of the end of the Cold War) at a time when ballistic missile proliferation has expanded dramatically. The resultant imbalance has already allowed some key missile states to coerce states without resources to adequately defend themselves, and this trend will get considerably worse even over the coming couple of years;

The third trend is that existing military doctrine, as well as existing military structures, Defense industrial bases, and the political frameworks for national, regional and global security must change in almost all states if they are to cope with the newly-emerging threats to stability. Similarly, the actual threats to stability are those posed by states and movements which are themselves developing, on an *ad hoc* basis, their own new offensive force and capability structures

As a sub-set of the third trend, it is fair to say that the ability of all states to project sustained power at a distance has declined for the most part. At the same time, the capacity for regional conflict has expanded almost exponentially since the end of the Cold War, as has the ability of certain states to mount credible long-range ballistic missile attacks, using weapons of mass destruction. There are some exceptions to this, of course.

The fourth trend is that *the principal threats to* the security, prosperity and stability of most states are, apart from the threat of ballistic missile blackmail, *unconventional threats* That is, they come from irregular warfare which is based in part upon informal, undeclared hostile acts, ranging from advanced psychological warfare to terrorism, guerilla warfare, sabotage and the like, to regional low-intensity conflict. There are exceptions to this trend, of course, such as the possible military invasion of the Republic of Korea (the RoK) by the Democratic People's Republic of Korea (DPRK). It is fair to say that most advanced Western states are, because of their focus upon legalities and structures of forces which have evolved over the past two or more centuries, less able to adapt in order to cope with these irregular forms of conflict.

The fifth trend is that strategic changes of a most profound nature are occurring because of *changes in population balances* within countries and regions. The collapse of the USSR, the Soviet Empire, was, in no small part, brought about because of changing demographic patterns: the non-Russian, or non-European element of the Soviet population began to numerically dominate the European element. We see similar transformations occurring on varying levels and to differing degrees in the United States -- where language, culture and religious diversity is overwhelming the priorities which had been established by the earlier population base -- as well as in Britain, France, Germany and the like. National resolve, and national unity in the face of intangible crises, is difficult to sustain when there is a fragmenting sense of national identity among a population as a whole.

We tend to forget that what we today call a "nation" is merely a modern sovereign state defined by physical boundaries, whereas the fundamental concept of a nation relates more to culture, blood and identity. *The Diplomat's Dictionary* describes a nation as "A people, unified by a common history, language, culture, religion or ideology. or territory, considering themselves distinct from other peoples, and recognized by others as possessing distinctive traits as a people." The modern nation-state, such as the European Union or the United States of America, or even, say, Nigeria, is often a disparate agglomeration of peoples. What we see emerging out of the former USSR, for example, are nations in the classic sense: narrowly and tightly defined ethically, culturally, religiously and linguistically. And where even

the slightest differences exist in these newly-sovereign states, there is internal conflict. The result, however, is a string of newly-sovereign states with fairly homogeneous populations capable under some circumstances of far more unified and determined direction than the so-called "modern" nation states.

One question which must be asked is whether the evolved and self-proclaimed "democratic, industrialized states" can re-structure their thinking to permit the creation of deliberate population strategies which would enable them to build their societies in ways which most enhance their stability, security and economic viability. I do not believe that they can, for the most part, do this.

These are just a few of the trends which we can see impacting the global strategic environment over the coming few years.

Within the overarching framework of these, and other, trends, we need to see which geopolitical blocs or groupings of states are emerging which themselves represent strategic factors. There are six major blocs, with distinct overlapping among some of the member states:

(a) The Western, Pro-Western and *de facto* Pro-Western Bloc;
(b) The Anti-Western and effectively anti-Western Bloc;
(c) The Transitional Bloc;
(d) The Independent and Neo-Independent States;
(e) The Alienated States; and
(f) The Disenfranchised and Forgotten States.

Each of these six major areas contain fragmented and often mutually hostile, or at least mutually competitive states or sub-groupings. So these major strategic groupings do not necessarily reflect cohesive or effective units in their own right. The sub-groupings are, in many ways, more interesting at this time. Many states belong to more than one subgroup. Some of the components of the sub-groups are listed below, although there are many additional countries which could be added into these lists.

The Western Bloc:

(a) North America (US and Canada);
(b The European Union states;
(c) The non-EU states of Western and Eastern Europe;
(d) Japan, the Republic of Korea, the Republic of China (Taiwan), and the Philippines (+ Hong Kong temporarily);
(e) Australia and Oceania;
(f) Israel;
(g) The bulk of the South American and Caribbean states;
(h) The Gulf Cooperation Council (GCC) states, plus Lebanon, Jordan and Eritrea.

The Anti-Western Bloc:

(a) The People's Republic of China, the Democratic People's Republic of Korea (DPRK), Iran, Sudan, Yemen, Somalia;
(b) Iraq and Libya;
(c) Albania in concert with Iran;
(d) Cuba *(dce facto* and becoming neutral);
(e) Afghanistan and Tajikistan;
(f) The so-called Islamist bloc of states and the radical Islamist movements within states with substantial Islamic populations.

The Transitional Bloc:

(a) Russia and the bulk of the CIS states;
(b) The former and current Yugoslavia;
(c) Ethiopia;
(d) South Africa, Mozambique, Zimbabwe and Angola (all moving back toward the pro-Western camp).

The Independent and Neo-Independent States:

(a) India;
(b) The Asian "Tiger" economies, including the ROK, Vietnam, Singapore, Malaysia (potentially anti-Western), Indonesia, Thailand;
(c) Pakistan (fluctuating, and caught, between pro-Western and anti-Western blocs);
(d) Mexico (fluctuating also between pro-Western and disenfranchised);
(e) Brazil (both pro-Western and a potential bloc leader in its own right, if it had the political motivation to be so).

The Alienated States:

(a) Iraq;
(b) Libya;
(c) Yugoslavia;
(d) Liberia;
(e) Nigeria (also fluctuating between pro-Western and independent);
(f) Pakistan;
(g) Somalia;
(h) Yemen;
(i) Burma (Myanmar).

The Disenfranchised States:

(a) Bangladesh;
(b) Nigeria;
(c) Liberia;
(d) The bulk of the Central African states;
(e) Some of the Latin and Central American states such as Bolivia, Nicaragua, etc.
(f) Afghanistan.

One of the major transformations in the world is that the two major superpowers are no longer in business to woo voting support from smaller states in the United Nations. Nonetheless, the UN is doing business and taking a more active role than ever before in global operations. An option potentially still available to the smaller states is to once again weld themselves into a voting bloc at the UN; a bloc which needs to be "bought off" with attention, economic aid, and the like. The lack of clear political divisions in the world has meant that UN votes are being lobbied for and won on an ad hoc basis to support certain UN directions. This situation will presumably change as the global situation crystallizes into more clearly-defined patterns.

What is likely to happen is that the disenfranchised states will either be wooed for their UN votes, or abandoned to their own struggles. Some, like Nigeria, will rejoin the broader community at some stage, The pariah and alienated states will join (or already have joined) one of the blocs, and the anti-Western camp is the only option which affords them trade, contact and military supplies. Western Europe is likely to isolate itself more rapidly from North America and, as a result, the US will, in relative terms, continue to lose strategic influence. I should stress that the loss of US power will be relative only to the overall diversity of problems and challenges. In absolute terms it retains its power, but the challenges of the coming decade are embodied in the massive spread and multiplication of threats which do not lend themselves to the kind of focussed power which the United States has developed.

It seems likely that, in the kind of force and doctrinal reorganization discussed earlier, the US will tailor some of its forces for small and theater sized operations. But the US cannot afford to neglect its high-value military capabilities, such as its ABM (anti-ballistic missile) systems, its globally-effective surveillance and communications systems, its antisubmarine warfare (ASW) capabilities, its global command and control systems, and its submarine force projection capabilities. This is because, despite the proliferation of less formal types of conflict and instability, new technologies mean that it is possible for a wider range of less stable countries to deploy submarines and ballistic missiles, often with strategic warhead capabilities. The major powers -- or those with real power projection capabilities -- would abandon their defenses against such submarine and ballistic missile threats at their peril. While the US and its key allies are capable of handling the sophisticated threats, they are prohibited by manpower and budget constraints from being able to deal with the remaining, lower-intensity threats.

We are seeing another trend develop in which economic power and financial flexibility is no longer solely in the hands of the traditional Western camp. The concentrations of real economic power (and not just money), over the coming decade, will be:

(i) North America;
(ii) Western Europe;
(iii) Japan; and
(iv) The Asian "Tigers" .

The major Western economic groups have always been mutually competitive in a business sense. We are, however, already seeing signs of mutual economic antagonism between North America (mainly the US) and Japan, and North America and the European Union. But we are also seeing signs of real political-economic streaks of independence from within the Asian "Tiger" states. Countries such as Singapore, Malaysia, Indonesia, the RoK and Vietnam have very different political agendas than those of the European or North American states, despite their apparent Western-style consumerism.

What this means, potentially, is that real economic strength and skills could conceivably be used to support a strategic bloc of states which is opposed to the West, or to support the re-emerging Russian strategic posture. Should such a trend develop, then this could indeed change the global strategic balance quite considerably.

Strategic Technology: This leads us to an analysis as to which geopolitical groupings are likely to lead in strategic technology, both for the purposes of economic leadership as well as for military leadership. There seems no reason to doubt that the combination of R& D and production capacity will continue to favor the North American states, the Western European states and Japan for the foreseeable future; that is, for the next five to ten years. That is not to say that some ground-breaking technological advances will not occur in, say, India or Australia, and even if significant discoveries are unveiled in those countries they would accrue to the benefit of the West.

But what will be strategically important in the coming decade will not be those technological leader states and their maintenance of the *status quo.* Rather, the dynamic element of the strategic technology balance will be the anti-Western, or independent states developing (or re-inventing) second-grade military technology. That is, technology of a strategic nature which was developed and deployed some time earlier by the Western industrial powers, but which is nonetheless still of a significant nature, such as nuclear weapons. The PRC's development of strategic weapons, or those developed by North Korea or Iran, are key areas in this regard.

Strategic technology proliferation will be the major problem, militarily, for the coming decade. Significantly, only Israel has pressed ahead with the development of an operational anti-ballistic missile (ABM) system, the *Arrow, to* cope with the problem, although, of course, the US, Britain and the (then) USSR have also undertaken the bulk of the pioneering work for space- and ground-based applications of an advanced, global

ABM system. What appears to be the case is the likelihood of a window during which states with a moderate ballistic missile capability -- in advance of the basic SCUD, but at levels well below those of the US -- will have the capacity to blackmail target states which do not have the ability to politically or militarily withstand attack. And we should be conscious of the fact that some forms of attack or blackmail do not have to be militarily complete or victorious in themselves to cause the political collapse of the government of a target country.

I do not believe that we should delude ourselves that the kind of currently deployed ABM technology which we saw during the 1991 Gulf War -- namely, the Raytheon *Patriot* surface-to-air missile -- *is* capable of dealing with the threat of strategic warheads on the post-SCUD series of ballistic missiles. The *Patriot is* too slow, or the re-entry of the post-SCUD missiles too fast, for destruction of the incoming missiles in any way which effectively stops the dissemination of the incoming warheads over the target. In the case of biological weapons (ABOs) deployed on such weapons, the interception of the ballistic missile by a *Patriot* would merely enhance the spread of the ABO payload over the target area. What is needed is the type of performance profile of the *Arrow,* which takes out the incoming ballistic missile high in its trajectory, ensuring that the payload is scattered in space, and not over the target which is being defended.

We saw with the Gulf War, in which Iraq was woefully under-prepared to meet a sophisticated adversary, that even a state which is not regarded as a defense industrial power, and which was unprepared, could actually deploy strategic weapons in such a way as to cause an extreme defensive reaction by its adversaries. This message was not lost on North Korea, which has ballistic missiles which are far more advanced than those of Iraq, and which has a significant number of deployed nuclear weapons. And it almost certainly has deployed biological warheads, or the capability to deploy biological warheads on its ballistic missiles. Certainly it has a strong chemical warfare capability. It seems likely, in fact, that the recent terrorist uses of chemical weapons in public areas in Japan can be tied in some way to North Korea. The Japanese Government acted as though North Korea was involved, using the chemical terrorism as a warning. Japan immediately made significant strategic concessions to North Korea. This, in turn, alters the US ability to control or confront North Korea, even if the US itself had not handled the whole confrontation with North Korea well in the first place.

States such as North Korea (DPRK) and Iran are classic "gunpowder states", and feel that there is a minimum of risk and a maximum of strategic return in the use, or threat of use of strategic weapons, even though these strategic weapons are clearly not in themselves "war-winning" weapons. The concessions already won in different areas by the DPRK and Iran by the threat of action, or by the prestige of having certain weapons capabilities, has already been worthwhile for them. This all harkens back to the question of what defines "victory". Victory is, for different leaderships, different things. In the last Vietnam war, victory for Hanoi did not mean the military or political collapse of its main opponent, the United States, for example. Victory in the Cold War did not mean defeat on the battlefield for the Soviet bloc forces, and so on.

Isolating the Problems - The Mis-Use of Embargoes: The United States has used its own strength, as well as its ability to coerce its allies in the UN and Europe, to attempt to isolate states which it finds do not comply with Washington's view of acceptable international behaviour. It even attempts to isolate those states which it finds do not comply within their own borders with Washington's view of accepted democratic standards. This form of artificial isolation, or quarantine, of the states deemed by Washington to be unacceptable, worked fairly well during the latter stages of the Cold War. But it is significant that isolation through embargo has not resulted in the collapse of a single state, nor has it led to the compliance of any such target state to the political demands of the United States. South Africa will be cited as an example of a successful international embargo, but this is not the case. South Africa was already well on the way to change, and any persuasion it had to hasten that change came not from the UN embargoes, but rather from internal pressures and also as a result of help from -- and the promise of a stable future relationship with -- a number of African states.

Embargoes and quarantines do hurt *people* there should be no doubt about that. But they also reinforce the identification of the target population groups with their leaders, and reinforce the will of the target nation as a whole to resist such pressures, even if the cost is enormous in economic, personal and military terms. We need only to see the current Balkan conflict to understand that the warring there could have ended considerably sooner if the new Yugoslavia had not been isolated from the diplomatic and regional economic process.

Indeed, the Balkan process and other incidents of recent times show that it is the democratic states, which had portrayed themselves for 50 years as the peacemakers, which have initiated or perpetuated war. The former US President, Woodrow Wilson, held that peace depended on the spread of "democracy", or the US version of democracy. Clearly, this messianic vision implies that "democracy" will be forced upon peoples around the world. And this, just as much as the messianic threats to impose communism or to impose an Islamist condition, is viewed as frightening to those parts of the world which wish to choose for themselves how they wish to be governed.

The Intelligence Situation: Chaos, uncertainty and inexperience currently reign in the intelligence communities of virtually every state, just as it does in the Defense and political communities. The horizon has, for the past 50 years, been constant, unwavering and close; the tasks clear; the focus finite. Today, we have broken through into a new vista: the horizon and visibility is unlimited, but we cannot determine all of the factors which lie between ourselves and tomorrow.

One of the most significant factors facing the major intelligence services today is that they do not have the databases, the skills, nor the political direction from their governments to handle what are essentially problems which have not been faced before in living memory. In the case of the United States, for example, it is necessary to remember that the intelligence community as a whole was unable to foresee the collapse of communism in the Soviet Union. How could it be expected now to see all of the ethnic, religious, communal, national, linguistic, historical, economic and military reasons

which were the underpinning of the collapse of Soviet communism at the beginning of the 1990s? And how these factors play into the post-Soviet community of new states?

The failure of Western intelligence agencies to understand in real depth the historical, national and cultural issues behind the structure, and ultimate collapse, of the Soviet empire has contributed to the subsequent failure of these services to adequately advise their governments on the crises which have emerged in Georgia, Nagorno-Karabakh and Armenia and Azerbaijan, Moldova, Chechnya, and the Tatar territories, for example, not to mention the ongoing conflict in Tajikistan.

One of the major tendencies within the intelligence community in the US and much of Western Europe today is the tendency to suppress that which cannot be handled. The US Central Intelligence Agency knows, for example, that if it accepts the fact that Iran has nuclear weapons, then it follows that the US political community will demand that something be done to curtail that situation. In other words, the US will bc forced by its electorate or politicians to take steps against Iran. The CIA, therefore, feels that by denying that Iran has nuclear weapons, it can stave off the time when action must be taken against Iran. The same arguments apply to North Korea. The US intelligence community has taken the view that North Korea has no deployed nuclear warheads on its missiles and aircraft. Clearly, North Korea does have nuclear weapons, as does Iran, but the US political leadership has stated publicly that it would not allow North Korea to possess such weapons. So, in order to forestall a situation in which Washington is forced to confront North Korea militarily, the US intelligence community states that North Korea has no nuclear weapons.

Clearly, these decisions to "deny" that the weapons exist are welcomed by Iran and North Korea, respectively, and they help these two states by giving them time to perfect or at least improve their military capabilities without pressure from the one opponent they fear most, the US. Thus we have an ironic situation where the US is contributing toward the construction of a more credible adversary to itself and the West. It should be pointed out that, in the case of Iran, the intelligence services of Britain, France, Israel and the like have all undertaken their own investigations and have confirmed the presence of nuclear weapons in Iranian hands.

We are at a time, obviously, when intelligence services need to be reviewed and restructured in the same way that Defense services must be reconfigured to meet the new challenges, but during this hiatus we also can see that the US intelligence services -- at least the CIA -- is itself in chaos. The loss of direction caused by the end of the Cold War is one thing But what has also happened is that virtually all real security of intelligence material appears to have gone from the top level (the political appointee level) of the CIA. In other words, the CIA has a security problem. The despondency of the professionals within the organization reflects not the end of the Cold War certainties but the introduction of radical political agendas into the management of the intelligence collection and analysis process by the staff of political appointees in the CIA, put in by the Clinton Administration.

This may be all that is necessary for the CIA to be totally overhauled and rebuilt by the next US Administration, assuming US President Clinton is not re-elected to office.

One senior intelligence community professional told me recently: "We have two more years of hell to undergo, and during that time the US will not have any effective intelligence. "

Today, the CIA is spending a lot of its time trying to discredit those other US (and foreign) agencies which attempt to bring a more balanced view of global affairs to the attention of elected officials. A similar situation applies in Germany, where the BND is being used to hound and discredit those political and information agencies which produce information contradictory to its own line.

The intelligence services which have adapted best to the current situation seem to be the military intelligence services of Britain and France, and possibly the Russian military intelligence service. What clearly is necessary, to make the best use of intelligence assets at a time when they are more vital than ever, is to review the whole process of tasking and structuring of such services. A realistic review of national priorities must occur in every country at this stage, and this must be followed by a prioritization of intelligence goals This logically must he followed by a review of procedures, structures and assets of the intelligence communities concerned.

In reality, this process has not happened. Some lip-service has been paid to changing structures at the end of the Cold War (and, of course, the Russian and CIS intelligence services have been completely re-launched), but the old mentalities still prevail. The only reason the French and British military intelligence functions have adapted so well to the new situation is because they are a vital and practical part of the survival and mission-effectiveness of the troops of those countries on the ground in the Balkan war zone. Ironically, the US intelligence function does not appear to have improved through deployment with US forces in, for example, Somalia, after the end of the Cold War.

In Conclusion: There is no single area of the strategic environment of the world which does not today merit broad and deep scrutiny. And the review of the global climate must be undertaken separately by each country with the priorities of that country in mind. It is true that there are a wide range of global trends which affect all states, but these trends do not affect all states equally. And each state needs to not only understand the impact of these trends on itself, but also what action the state needs to take as a result. This may seem fundamental, but, upon reflection, it can be seen that virtually every state has operated its policy intelligence, analysis and management functions in a virtually unchanged manner for the past 50 years. Except, of course, those states which have only come into being as sovereign entities during that time.

It is a time when all reviews must start on the one hand with a clean sheet of paper, and on the other with a library of historical reference material to show how the world operated in an earlier multi-polar time.

But there are several things which are fundamental to our understanding of strategic trends over the coming decade, and they are the fact that:

a. The frequency and unpredictable nature of conflict will increase over the coming decade, and will not be limited geographically to any single part of the world;

b. No Defense force in the world is currently well-equipped or well-structured to deal with the irregular and highly psycho-political nature of the new conflict which is emerging. This means that forces need to be re-structured and, to an extent, reequipped;
c. A greater number of countries than ever before now possess strategic offensive weapons -- such as ballistic missiles, nuclear and biological warheads, and submarines -- and the will to use these weapons even though these weapons on their own cannot necessarily achieve a conventional military victory in the sense that we historically view "victory";
d. Trans-national phenomena, such as the radical political use of religion or religious-like dogma for strategic purposes, will increase and will be difficult to combat by normal political or military means. Within this framework I include both Islamism -- the radical mis-use of Islam as a mechanism to overthrow national governments -- and the demagogic mis-use by some governments of alleged "democracy" to isolate, intimidate and overthrow national governments;
e. We will find that economic power in the coming decade will not be held exclusively in the hands of a cohesive Western bloc of states. This is a phenomenon we have not seen since Germany declared war on the Western Allied states and the USSR in 1939;
f. We will also find that the proliferation of second-level strategic technologies, including nuclear and ballistic missile technologies, will pose grave threats to regional and global stability over the coming years largely because the end of the Cold War stopped R&D and production of effective anti-ballistic missile systems; and
g. We will also find a fracturing of the perceived unity of "the West" which will contribute to many strategic issues, including the abandonment of many of the poorer states.

In all, it is not a time to beat swords into ploughshares, but rather to beat the physical swords and the political and psychological swords into new weapons to meet the new age. The growing chaos will not be suppressed by the abandonment of the means of Defense, nor the abandonment of power projection capabilities of the great slates. It is not a time to look inward and to reap the fruits of peace or victory. It is a time to begin the task of constructing a new world.

THE ECONOMIES OF DEFENSE CONVERSION

The Global Impact

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Abstract. *The significance of the economic impact of the Cold War has not yet been fully realized. National priorities and investments, attributable to this conflict, distorted communities and industries. Although many countries, east and west, who were participants have already significantly downsized their militaries and reduced the budgets to support them, the industrial base does not have a similar process or measurement. In discussing the broad term of defense conversion, it is important that a definition of conversion is agreed upon. Conversion is not dual use, particularly in terms of industrial strategy. Conversion on this order of magnitude, within national economies and industrially, has no precedent. Nations, economies and industries developed and grew during a unique era in world history. The challenge now is how to accommodate a new global priority of trade and economic security, within an international framework of stability and national security.*

1. The Economies of Defense Conversion

Although this paper will discuss primarily the current experience of the United States, with which this author is the most familiar, the situation has its parallels within the other NATO partners as well as those countries who were the adversary against which western resources were committed. We have yet to fully absorb the economic impact of the Cold War, politically, militarily and most importantly, industrially.

Historically, the United States has had a long tradition of not maintaining a large standing military capability. Americans have not intellectually or financially supported a large military infrastructure, and this has always been part of the national and political culture. The military and its support organizations have purposefully been maintained at minimal levels. Even between World Wars I and II, the military was small, numbering barely 100,000 in the navy and less than 200,000 in the army, despite the threats which appeared imminent. Draft legislation which was passed in anticipation of the United States joining its European Allies placed a ceiling of 900,000 conscripts to be taken

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from a pool of 16 million eligible candidates. (Ultimately, the military numbered almost 16 million with over 10 million as draftees.) It is the impact of World War II and its post developments which we are dealing with today as we consider industrial rationalization, facility closures, work force dislocation and possible unemployment, in both the United States as well as in other countries who were involved, at whatever level, in the Cold War.

The US ultimately not only mobilized a tremendous amount of manpower, but industrially, its output was unprecedented. It was indeed the "arsenal of democracy," as manufacturers began to dedicate research capabilities and critical production space to military products. Research and development became a significant national security resource and force multiplier for the United States and its Allies. The majority of this research was performed in the "black" arena as some of the efforts, such as the atomic bomb, became critical for a national and allied strategy of hastening the conclusion of the war with Japan. Initiated by the different industrial infrastructure which cold war weaponry required, the distortion of the United States' economy, and its relationship to the military had begun.

Although the United States initially reverted to its traditional role of rapid demobilization after the conclusion of World War II, international priorities exceeded this national culture, and the United States found itself in a position with which it was not totally comfortable. Requirements for military presence to establish stability continued after the peace agreements had been signed. The succeeding security agreements, such as NATO, required political, financial and military support. Not all military members were able to return home, but instead became part of occupying forces or forward deployed contingents. Industrially and politically, the United States emerged as the unchallenged leader of the western world. All of these were unprecedented for the US.

1.1 ECONOMIC IMPACT

The enormity of the tasks before it was not lost on the political and diplomatic leadership of the United States. The world, as many had known it, would never exist again. Economies and entire nations had to be rebuilt, replacing dictatorial political institutions with democratic ones. Countries, many of them now part of the NATO Alliance, modeled their own constitutions and branches of government after that of the United States and embraced the concepts of free enterprise and capital markets, rather than those controlled by the government. Most of these initiatives were philosophically and financially supported by the United States, further pulling the United States into the global arena. The intertwining of economic security into the traditional arena of national security was already occurring, against the backdrop of interdependence.

During this period, the economy of the United States had to change as well. Defense spending as a share of GNP decreased from 38.7 percent to 3.2 percent in the four years after World War II, as national mobilization for a war effort was no longer required. Alternatives for utilization of this industrial development occurred, and the economy of the United States continued to grow. Additionally, it was this very industrial capability

which sponsored growth of new industries such as aerospace and communications which continued to be drawn upon as a major national resource during the next forty-five years. The government would continue to develop new requirements to implement a new strategy against an opponent which remained politically elusive and unpredictable.

Although the Soviet Union had actually suffered the most severe losses of any nation during World War II, it emerged as the major political and military challenger to the United States. Rather than encouraging fledgling democracies, it seized the opportunity to increase its own borders and protect the heart of Russia with an extensive border of satellite states. Even in the very heart of Germany, the US found its leadership and will challenged. After only three years of peace, the United States found itself drawn into an unprecedented conflict, ultimately named the Cold War. This began another buildup of defense, so that at the end of the Korean War, the United States was spending 13.4 percent of GNP on defense. Another bulge occurred during the Vietnam War when defense reached 9.6 percent of GNP. Interestingly, after the post Vietnam low of 5.6 percent in 1974, and despite no major conflict to significantly expand spending, the United States defense expenditures of 1986 represented 6.5 percent of GNP. This was our investment to continue to counter the perceived threat of the Soviet Union, the only peer adversarial competitor to the United States.

During this same period, the NATO countries began their own industrial recovery and rebuilding of military capabilities. They rebuilt major industries and pursued research in key areas such as electronics, propulsion systems, power generation, as well as aerospace. Like the United States this industrial capability was a resource for national security as well as for economic and industrial development and growth. Often, the government participated as a major investor in these industries which became significant national employers, and as a consequence, were legally and financially discouraged by their governments from conducting major layoffs which would result in an economic impact.

While Europe's combined defense budget consistently remained less than that of the United States, it nonetheless represented a significant percentage of each country's GNP. Ultimately, Europe began to develop its own independent systems which became competitors to the products they had once purchased or co-produced with the United States. Some countries, like France and Great Britain also integrated nuclear capability into their force structure, developing some of the same unique cold war infrastructure and industrial commitments as the United States.

1.2 THE MILITARY

This is the legacy with which we are dealing today. Most of us alive today have only known the Cold War arena which is woven with large military capabilities, major industries to support them, and communities who often host both. The majority of the population today did not exist prior to the Cold War. We grew up believing that the United States and its Allies was locked in a tremendous contest of wills, which could destructively erupt at any time. Nuclear capability was no longer the exclusive

possession of the United States, and the world began to realize the vulnerability of civilian populations. With the advancement of weapon capability and war would no longer be restricted to the traditional battlefield. Nuclear weaponry added an even more complex dimension. Today it is difficult for many not involved in military strategy to believe that our national defense strategy was discussed in terms of Mutual Assured Destruction (MAD).

Populations performed civil defense drills and dug fallout shelters in the event of a nuclear attack. Since the United States was the primary rival of the Soviet Union, the once "isolated" American population found itself vulnerable. Distance and geography were no longer the protectors they had once been. Thus the United States was allowed to continue to pursue a significant military presence, supported by the American taxpayer and Congress.

Overseas rotations began to be extended, and families were moved around the world. A significant international military infrastructure was built and often manned by US forces. Additionally, many of the NATO countries increased their own military infrastructures and militaries. Even within the United States, the military families became the gypsies of the American landscape. The spirit of democratic patriotism prevailed, witnessed even in movies which were developed during the next 35 years. Significant portions of GNP's were dedicated, either directly or indirectly, to the support of the "defenders of the free world."

1.3 INDUSTRY

Another significant impact of the Cold War was the industrial and population dislocations. Throughout history, the pursuit of war, arming for war, and defending against aggression have all impacted the civilian part of society. From early forts and encampments where soldiers were deployed to the cities where quantities of weapons were made, the "business" of war has gathered, and at times dispersed, populations. Prior to the Cold War, major industrial cities were the core of production for "hot" wars which were conducted with mass-produced weapons wielded by human beings. The very nature of the Cold War, underpinned with nuclear capability, significantly altered this pattern, in both the United States and the Soviet Union and their western and eastern allies.

Industrial development was not driven by traditional factors--access to raw materials, transportation costs, and regional capital markets which played a secondary role. Cold war weaponry could not be stored or stockpiled in urban armories, close to centers of population, and the requirement for scale of activity, experimentation, secrecy and security became the key decision makers. The industrial and population distortion which occurred is significant in its size and current impact on the economy of the United States, and to a lesser extent its allies.

Communities which previously had none or very little contact with the military due to their remoteness, now found that they had become a preferred location for the new weapons, some of them in support of a new service, the Air Force. Bases were established around the perimeter of the United States to maintain a twenty-four vigil

against attack. Missile silos were built in the heart of the midwest as well as in remote locations. Bases for testing of faster, more technologically advanced aircraft and systems were built in the desert of the western United States, and proving grounds for nuclear weapons were established in small communities of Utah and New Mexico.

Additionally, an intertwined network of posts and bases internationally was also developed to train, maintain and, if necessary, deploy a large standing military. Ports for support of navies, and in particular the nuclear powered US navy, were developed to accommodate the navies' growth and requirements. Nuclear powered submarines became a strategic part of defense. Carriers and other surface combatants became accustomed to nine month deployments for forward presence and force projection. All of this required manpower and support functions. Thus, a large supporting infrastructure developed simultaneously.

1.4 POLITICAL DEVELOPMENT AND COMPLEXITIES

The development of the military organization as we know it today did occur primarily in the post World War II era. It does indeed represent a deviation from our traditional past. As America began to define its security through its military, it also required industrial support to research, design, build and ultimately produce the weapons which were required to implement policies and counter potential threats. The status of being a significant government contractor which could compete in the technological arena became an integral part of many companies' culture. The military's industrial and technological capabilities became a significant part of this nation's economy.

To oversee this level of activity, in the interest of security, Congressional committees and subcommittees were created or expanded, and portions of the Executive and Judiciary branches of the government were dedicated to security activities. The complexity is best illustrated in the chart developed by Graham Allison and Gregory F. Treveton in *Rethinking America's Security.*

In addition to the complexity of the system developed within the United States, many of its NATO allies also developed their own national organizations for systems development, acquisition as well as political oversight. NATO itself then developed an additional joint system designed to coordinate and integrate many of the nationally generated research and systems.

Another layer of organizational complexity was initiated under a separate European organization, called the Independent European Programme Group (IEPG), designed to improve international cooperation in the acquisition of defense equipment and to strengthen defense industries. Like the United States, it is a complex system. EUCLID, which is to encourage European collaborative research for defense, is also sponsored under the IEPG.

1.5 IMPACT ON NATIONAL AND LOCAL ECONOMIES

During this entire era of the Cold War, which spanned almost a half a century, the United States did, on occasion, close some bases or posts which were no longer needed in the new defense or security strategy. Generally, though, these were the exceptions, because "The Threat" of the Soviet Union continued to exist. Although some have cited the post Vietnam era as a significant period of military and industrial draw down, the shadow of the Russian bear still loomed, and during the late 1970's, the United States, as well as its Allies to a lesser extent, once again began a significant build up--militarily as well as industrially. This lasted for almost a decade, when finally the United States and its Allies began to sense that they were indeed the victors of the Cold War.

Thus, the Cold War victory was not without its costs. The economic pressures brought to bear on the Soviet Union had their impact on the United States as well. Although initially the focus was on the defense budget at large, we are just beginning to realize the full significant, penetrating economic impact that the Cold War had on the United States. Although we speak of "defense conversion," as an achievable goal, some argue that it is a permanent reallocation of resources, for which no precedent or comprehensive strategy exists.

We are challenged to revisit pre-World War II definitions of national security which included industrial capability, competitiveness and economic strength, coupled with a small but capable military. Perhaps the biggest challenge of the 90's then is indeed "the dismantling of the Cold War economy." Included in this dismantlement is not only the industrial conversion but the political and economic conversion as well. What was not anticipated was the local economic impact once the US and its Allies began to strategically respond to the end of the Cold War.

2. The US Base Closure Process

2.1 HISTORY

Due to the enormity of the United States defense infrastructure, the impact of the Cold War downsizing is most visible within the United States defense network, both within the United States as well as in countries which the United States had used as forward basing facilities. Many of the European countries, as NATO Allies and hosts to US forces, have been impacted by the Base Closure process occurring the United States, coupled with their own national downsizing of the defense infrastructure.

A significant irony of today is indeed exemplified as one observes the base closure process, and its ultimate impact on communities, families and sometimes entire states' economies. Although some general lessons can be gleaned from earlier closures which occurred in the 1960's and the 1970's, they are limited for the following reasons: 1) There still existed a significant perceived threat to the security of the United States; 2) The economy of the United States was stronger than today; 3) Industry was not

simultaneously going through its own contraction; 4) The level of industrial reorganization and the elimination of jobs was not occurring. Today, many communities are receiving multiple economic blows as bases close and industry downsizes or leaves altogether.

As reported in 1990, only 100 bases and installations closed from 1961-1990, as cited in *Civilian Reuse of Former Military Bases,* completed by the Office of Economic Adjustment, Office of Assistant Secretary of Defense, resulting in the creation of 158,104 civilian jobs to replace the 93,424 DOD jobs lost. What needs to be underscored when citing these impressive figures is that at this time alternative jobs continued to be created within industry's growth. This is not to minimize the efforts of those communities who successfully adapted to change and developed alternative and successful uses for facilities closed in their areas. There are indeed some lessons to be learned. Nonetheless, the defense, political, economic and industrial environment of today is singular in its complexity and challenge.

The base closure process has not only a historical precedent but a legal one as well. As a result of many base closures which occurred after the Vietnam War, members of Congress, in an attempt to protect the interests of their constituents, enacted Section 2687 of Title 10 of the United States Code. This statute required the Department of Defense to notify Congress if a facility was being considered for closure or realignment. Additionally, this law also subjected proposed closure actions to lengthy environmental evaluations which at a minimum stalled and often halted the base closures. The economic and political tensions and challenges of the post Cold War era had begun.

Many communities were negatively impacted by this limbo status. Furthermore, as the force structure began to decline, the Department of Defense was required to spend a significant portion of its budget to maintain facilities no longer needed or fully utilized. Readiness began to be threatened and ultimately, the Secretary of Defense, in close cooperation with Congress, proposed a base closure law to close obsolete military bases and bring the base structure in line with the declining force structure.

2.2 THE CURRENT PROCESS

Public Law 100-526 was enacted in October, 1988, and created the Secretary of Defense's Commission on Base Realignment and Closure. This law charged the Commission with recommending installations for closure or realignment based on an independent study of the domestic military base structure. The 1988 Commission recommended the closure of 86 military installations, the realignment of 59 installations and estimated that this would result in an annual savings of $693.6 million. However, the Department of Defense determined that as a result of the rapidly accelerating end of the Cold War, further cuts were needed. Since the charter of the 1988 Commission had ended, the Executive Branch attempted to propose additional cuts of its own.

In 1990, Secretary of Defense Cheney announced additional base closures and realignments. Congress, as expected, protested these selections as being biased and politically influenced. Ultimately, to establish a continuing, fair process, Congress, by

enacting Public Law (PL) 101-510 under Title XXIX established an independent five-year Defense Base Closure and Realignment Commission, " to provide a fair process that will result in the timely closure and realignment of military installations inside the United States."

Unlike its predecessor of 1988, this Commission was intended by Congress to be a model of open government. This Commission was to conduct public hearings on the Secretary of Defense's list of closures and realignments and on any proposed changes to those recommendations. In addition, its records were to be open to public scrutiny. The 1988 DOD Commission, working for the Secretary of Defense, generated its own list of recommended closures and realignments. The Commissions of 1991, 1993 and 1995 independently reviews and analyzes the Secretary of Defense's recommendations and submits its findings directly to the President. Additionally, the law requires the General Accounting Office (GAO) to provide a detailed analysis of the Secretary of Defense's recommendations and selection process to the Commission and to assist the Commission in its analysis of the Secretary of Defense's recommendations.

In 1991, the Commission recommended 34 base closures and 48 realignments, which estimated FY 1992-97 net savings of $2.3 billion and recurring savings of $1.5 billion annually with one time costs of $4.1 billion. The 1993 Commission process additionally required that the Secretary of Defense base all recommendations for closure or realignment on a force-structure plan, submitted to Congress with the Department's FY 1994 budget request and on selection criteria developed by the Secretary of Defense and approved by Congress.

The proposed list was submitted on March 15, 1993. On March 29, 1993 and on May 21, 1993, the Commission voted to add a total of 73 installations for further considerations as alternatives and additions to the 165 bases recommended for closure or realignment by the Secretary of Defense. Ultimately, the 1993 Commission, on July 1, 1993, recommended to the President that 130 bases be closed and 45 bases be realigned. These actions are projected to produce net savings of approximately $3.8 billion based on annual savings of $2.23 billion and a one time cost of $7.43 billion.

Additionally important are some of the 1993 Commission's recommendations for 1995. These further underscore the process and its economic penetration. Time constraints did not permit the 1993 Commission to thoroughly review and recommend action concerning the various service depots. However, it had identified these as opportunities for further savings and stated that DOD should conduct an exhaustive review and present its recommendations/actions during the 1995 Base Closure process. Included in this review was to be a comprehensive review of private-sector capability. Leased office space was also to be reviewed for further consolidation and maximum use of government owned facilities.

Another identified area of potential savings was in military run health facilities, which in some instances are underutilized. The Commission recommended that DOD again review its health care facilities organization, coordinate with other organizations such as the Veterans Administration and lastly, during this process, integrate the Administration's policy on health care reform to ensure that maximum savings are being afforded to the taxpayer.

Although cumulative economic impact is also a criteria to be used during the evaluation of the closure process, "to remove a base as a closure or realignment candidate based solely on cumulative economic impact in isolation of the military value criteria could be inconsistent with DOD's and the Commission's mandate." (p.2.5 Base Closure Commission Report) The Department of Defense measures community economic impact by reviewing the *direct* and *indirect* effect on employment at closing, realigning and receiving locations.

The economic area was defined by DOD as the area where most installation employees lived and where most of the economic or employment impacts would occur. The threshold criteria established by DOD of five percent or greater for economic impact and that the employment population of the impacted community was 500,000 or more was not supported by the 1993 Commission nor supported by the GAO in its April 15 report. This criteria was deemed arbitrary and discriminatory. As a result, the 1993 Commission stated that "economic impact alone is insufficient cause for removing a base with inadequate military value from consideration. Economic impact should be given weight only when analyzing candidate bases with comparable sufficient military value."

The sobering language of the 1993 Base Closure Commission Report is underscored by the acceleration of the process. The Base Closure Commission for 1995 has submitted its list of recommendations for the President. The respective services have once again trimmed, realigned and, if necessary, closed additional facilities. Communities which still maintain a high profile within the defense establishment, either industrially, militarily, or both, are vulnerable to even deeper cuts by the 1995 Commission coupled with industrial adjustments.

Although the law does not extend beyond this 1995 Commission, it is anticipated that the realignment, consolidation and closure process will continue. Although this current process is highlighted in the political arena, on occasion resisted by the affected communities and industries, and on occasion subject to reconsideration, it is the most direct component of the economic and structural adjustment which is required.

The era of the government being the major industrial customer, like the Cold War, has ended. Simultaneous to the base closure process is the industrial consolidation and downsizing which will continue. The recent announcement by Lockheed Martin of a projected elimination of 35,000 jobs in the next five years is but one instance. There are many others, in both the United States as well as internationally. The industrial faction which must make independent, business decisions will have its impact on communities and populations as well. Ironically, there is no lack of publications or advice of what to do. However, since there is no precedence, clear, defined strategies are often crafted from painful experiences.

3. The Challenge

The challenge for us today has three major dimensions. First, we must be aware that the very defense and security environment, which we have all experienced as the norm, may indeed have been an anomaly. As we begin to redefine the components of the future security of the United States and its Allies, we will be required to reexamine even some of the most basic of premises. Secondly, the pervasiveness of the Cold War permeated the basic social and industrial structure of the United States, its Allies as well as its adversaries. As previously discussed, entire communities were the creations of the Cold War. Some of these were communities who hosted a significant military presence, and whose economies came to rely on the military infrastructure.

The trimming and realignment of military facilities and industrial capabilities will significantly change their landscapes. These facilities were also accompanied by an extensive network of adjunct and support organizations. These will be less discernible in the initial analysis of the economic impact that the current process will have and may become visible only afterwards. Thirdly, most of the affected communities affected will simultaneously have to absorb another economic shock--that of industrial shrinkage, relocation and on some occasions, closure. All of these are indicators for a requirement of an effective economic development strategy which transitions us from the past into the future.

Included in this strategy might be a candid assessment of a nation's economic assets which are currently dedicated to superfluous military activities, including labor and capital assets as well as facilities. Secondly, initiatives which do not increase the strained budget should be encouraged. Elimination of archaic and constricting regulations replaced by incentives for cooperation would provide an economic impetus to both communities and industries. Thirdly, R&D dollars should be invested in a dual use to encourage the movement of science and technology's commercial growth and economic contribution.

Thus far, many attempts to deal with the challenge have been not been as successful as one might have hoped. Impatience, resistance to change, and most importantly, a lack of good strategic insight have prevented the realization of goals and full potentials. Communities and industries cannot change a business practice cultivated for more than forty years overnight. Just as the public and its political supporters accepted the costs and benefits of the Cold War Economy, it must now accept the responsibility for its conversion. Leadership, both political as well as industrial, will be the key components of a new formula of economic, industrial and ultimately national security.

> *It must be considered that there is nothing more difficult to carry out, nor more doubtful of success, nor dangerous to handle, than to initiate a new order of things. For the reformer has enemies in all those who profit by the old order.*
>
> *Machiavelli*

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THE EUROPEAN ARMS INDUSTRY: BETWEEN DOWNSIZING, INTERNATIONALIZATION AND INTEGRATION

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The last five years have seen major transformations in the various components of the defense economy in Europe. The end of the Cold War and the reduction in defense expenditure that followed it have destabilized defense companies. In addition to the reduction in activity, the defense economy is undergoing a process of transformation that affects many of its constituent parts. The justification for the size of defense budgets, and the economic and industrial policies associated with them, are challenged, beginning with their cost and place in the economy, the examples of defense production and technology are questioned principally in comparison with the state of the civil economy; the pace of internationalization of the defense sector is increasing and the traditional relationship between buyer and producer is changing; the demand is less predictive and the turnover and the employment is constantly decreasing since the mid 80's.

In fact, more than a crisis or the reduction of activity, it is a complex adjustment process that the European defense industry is facing. In order to present briefly this adjustment process only some specific dimensions will be analyzed here.This paper is structured in three parts. After a brief presentation of the defense industry of the European states, the first part will analyze the crisis affecting the defense industry in Europe five years after the end of the Cold War.

The second part of this paper will deal with a twin-faced process which has accompanied the development of the different national defense and industrial bases since the end of the Second World war. The reconstruction of national defense industrial and technological bases -DITB- was mainly driven by national consideration, but the public authorities and the industry had to make compromises with the internationalization of defense activity. This apparently contradictory process has constructed a very specific industrial and political paradigm in Europe. This paradigm is going to determine deeply the nature and the modalities of the integration process of markets and industries in Europe.

The third and final part discusses the current dynamic leading to the Europeanization process of the defense industry and markets in Europe and specially amongst the 13 member-States [1] of the Western European Armament Group (WEAG) in charge of

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setting up an European Armament Agency. If we add that the Intergovernmental Conference to review the Maastricht treaty is due to begin in 1996 and it will tackle the question of the future integration in the fields of security policy, and, no doubt, defense policy, and that shortly after this, the Western European Union should review its founding treaty, the Brussels Treaty, it appears opportune to detail this integration process. An analytical framework will be presented in order to help to understand the current modalities of the Europeanization and its most probable future [2].

1. The Crisis In Defense Industry

In 1992, the defense industry of the EC directly employed 661,000 people. During the same year, its consolidated turnover amounted to 48.8 thousand million constant 1990 ECU, of which 10.4 thousand million were exports. This turnover represented 1.1% of Community GDP, exports 1% of the Community's total amount, and 0.55% of the active population was directly employed in firms producing goods and services of a military nature. This industrial sector would be classified in thirteenth position in order of importance in the EC using the employment comparison [3].

This employment approach is insufficient to assess the real the national innovation systems. The defense R&D investment represented 20% of the total public R&D investments of the European Union. The Member States of the European Community invested the equivalent of 11.3 thousand million ECU in 1990 in research and development for defense purposes. This represents the equivalent of 11.6% of total gross interior R&D expenditure (public and private). This figure of 11.6% only represents the efforts made by the States; information regarding R&D expenditure for defense purposes by companies is, in fact, hard to come by and only fragmentary. According to estimates, however, to the 11.3 or so thousand million ECU of public investment can be added the figure of 1 to 2 thousand million ECU of company investment.

In 1990 the defense expenditure of the European members of NATO began to show a significant decline, ending a period of continuous increases that had begun in 1970. After five years of reductions in defense budgets it is possible to draw some initial conclusions regarding the reduction of the different defense aggregates.

Table 1 summarizes the main changes that have occurred since 1989. The first fall in the defense expenditure of the European NATO countries appeared in 1990 due to a twofold constraints : the crisis of public finances and the end of the Cold War. Between 1989 and 1994 there was a reduction of 12%, an average of 2.6% per year. Purchases of military equipment fell by 23% during the same period. More detailed examination shows that the reduction was greatest in Germany. It is interesting to consider the different aggregates of defense activity in a broader historical context to understand the changes affecting the defense industry.

TABLE 1. The Impact of the end of the Cold War on the European Defense Industry

	FR	UK	D	IT	EU (5)	USA
Defense expenditures (1)						
1989	28479	28392	25630	13553	115547	352019
1994e	27709	24248	20635	12973	102017	282508
variation	-2.7%	-14.6%	-19.5%	-4.3%	-11.7%	-19.7%
Equipment expenditures (1)						
1989	4048	6246	4870	2778	17090	89061
1994e	3722	6329	2249	2244	13204	56219
variation	-8.1%	1.3%	-53.8	-19.2%	-22.7%	-36.9%
Defense GBAO/RD (2)						
1989	5223	3524	1674	450	11406	34860
1993	4339	3224	1271	480	9644	31821
variation	-16.9%	-8.5%	-24.1%	6.6%	-15.5%	-8.7%
Arms exports (3)						
moy.1987-1989	2205	1680	780	393	5675	9755
moy.1991-1993	736-	674	1600	269	3646	9016
variation	66.6%	-59.9%	105.2%	-31.5%	-35.8%	-7.6%
Turnover (4)						
1989	17236	16832	9868	5215	56290	134885
1992	15470	14390	9034	4224	48822	123952
variation	-10.2%	-14.5%	-8.5%	-19.0%	-13.3%	-8.1%
Direct employmet (4)						
1989	237000	257000	111000	78000	812000	1394000
1992	195000	204000	93000	67000	662000	1178000
variation	-17.7%	-20.6%	-16.2%	14.1%	-18.5%	-15.5%

Sources et legendes: (1) En millions d''ECU constants, prix et taux de change de 1985. Tableaux realises sur base des "Donnees economiques et financieres de l'OTAN", Communiques de presse annuels, Service de Presse de l'OTAN. Donnees 1994 cstimcss par l'OTAN; sauf pour les dspenses d'equipemcnt de la Francc (Fabrication dc matericl militairc a l'exclusion des munitions et des pidccs de rechange) issues de *Budget de la Defense "Equipements"*, Rapport parlcmcntairc n°1560 du 5 octobrc 1994, Assemblee Nationale, Paris, pp 23-27. (2) En millions d'ECU constants 1992. CBPRD = Crcdits Budgctaires Publics de Rccherche et Dcvcloppement; pour 1989: "Lc financement public dc la recherche ct developpcment", 1980-1991, Eurostat. Pour 1993: "Recherchc et dcveloppement: statistiques annuelles", 1994, Eurostat, sauf pour les Etats-Unis: "Principaux indicateurs de la sciencc ct dc la tcchnologic", 1994-1, OCDE, Paris. (3) En millions d'ECU constants 1990. SIPRI Ycarbook 1993 (pp. 272 ct 309) ct SIPRI Ycarbook 1994 (pp. 484 ct 511), SIP RI , Oxford Univcrsity Prcss . La variat ion dcs cxportat ions d 'arms portc sur deux moycnnes dc trois ann ces afin de lisser les importantes fluctuations d'une annec a l'autre. (4) En millions d'ECU constants 1990. Chiffres extraits du Memento defense-desarmement 1993, GRIP, Bruxelles, 1993, pp. 337-390. (5) Pour les dcpenses de dcfense ct d'equipement: pays de l'Union europrenne membres dc l'OTAN (les 12 moins l'Irlande); pour les autres agrcgats: l'Europes des

1.1 EQUIPMENT PROCUREMENTS

At the end of the 60's, confronted with the financial and human cost of the Vietnam's war, the United States raised inside NATO the issue of the inequitable sharing of the burden and stressed the low productivity of European equipment expenditure. Responding

to the American concern, the Europeans increased their defense efforts, especially in the field of equipment procurement.

Figure 1 shows the growth in equipment purchases by the principal European NATO countries (less France). Between 1973 and 1983, for example, major equipment purchases by European members of NATO, with the exception of France, rose by 60% in constant terms [4].

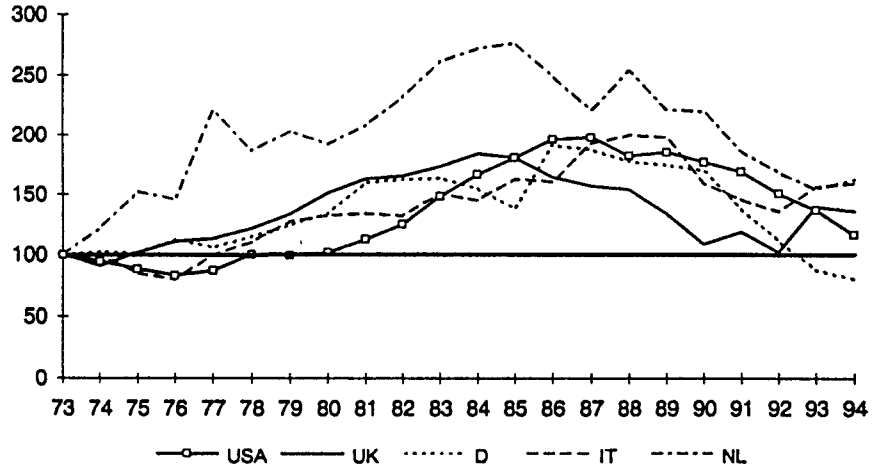


Figure 1. Evolution of the European equipment expenditures, 1973-1994 (base 100 =1973)

Sources: original table realized on the base of the successive editions of "Financial and economic data relating to NATO defense", Yearly press release, NATO Press service. 1994's data estimated by NATO. NATO docs not give the French equipment expenditures.

The graph shows a general reduction of equipment expenditures before the formal end of the cold war [5]. This anticipated reduction was due to the end of a modernization cycle of the European armies and the growing crisis of public finances. France, (not presented on this graph) presented a different evolution with a later increase of its equipment expenditures (at the beginning of the 80's) and a later decrease since 1993.

1.2 THE RESEARCH AND DEVELOPMENT

In parallel with the equipment expenditure, the European countries increased their defense R&D investments by 68% between 1975 and 1990, increasing from ECU7.3 bn to ECU11.9 bn (1992 constant) as shown in Figure 2. This increase made it possible to launch an impressive series of armaments projects in Europe, either collaborative or national. Most of these projects showed a big increase in quality in the European defense industry. The ambitious technological objectives of the new programs indicated the wish of governments to establish powerful defense industrial and technological bases (DITB) capable of competing with that of the United States or more simply capable of producing the major part of the armaments required by the European countries.

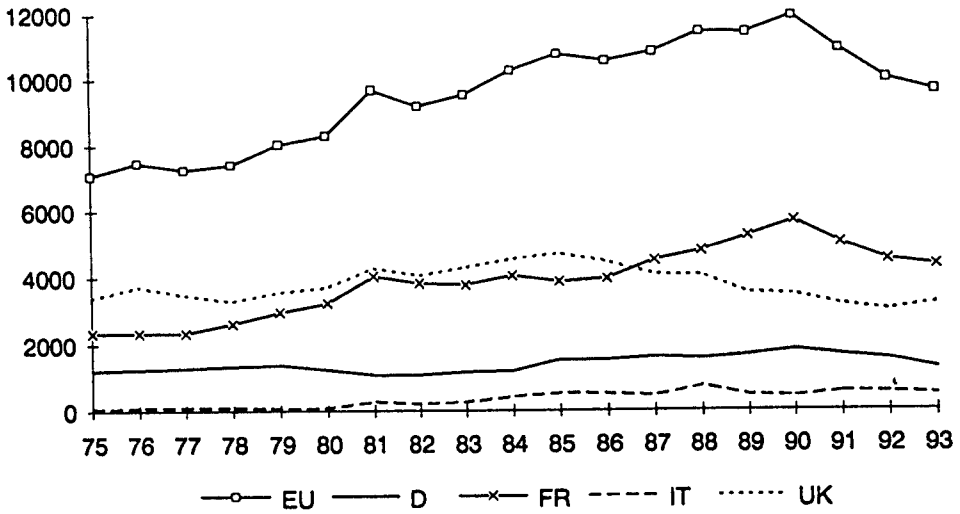


Figure 2. Government financing of defense R&D in the European Union, 1975-1993 (billions ECU constant 1992).

Sources: original graph using: from 1975 to 1990, the successive editions of "Government financing of research and development", Eurostat, Luxembourg. From 1991 to 1993: different editions of "Research and development: annual statistics", Eurostat, Luxembourg. EU = 12 except Ireland, Portugal only from 1991, Spain only from 1985, Greece only from 1977.

R&D investments by the members of the European Union followed a fairly similar pattern sete equipment expenditures. Following a growth of 68% in real terms between 1975 and 1990, R&D expenditure fell by 16% between 1989 and 1993. Figure 2 shows how this expenditure evolved in each country. The fact that the reduction in R&D investment was less than that for equipment purchases suggests that the level of R&D was maintained, relatively speaking, compared with production. As for the equipment expenditures, France presents a very different evolution with an important increase of its R&D investment in the 80's to the point overtaking the United kingdom in 1987 for the first time since the WW II.

1.3 ARMS EXPORTS

Since 1984 - a record year for European exports (17.4 thousand million ECU)- there has been a steady decline, and European exports can be estimated at about 10.4 thousand million ECU for 1992, i.e. a 40% drop in comparison with 1984. Among the European exporters themselves, the hierarchy is changing: in 1991 the United Kingdom caught up with France, which was by far the most important European exporter, and overtook it since 1992. German exports, which are difficult to assess, seem to have increased in the 90's. The other European exporters never recovered the level of arms exports they enjoyed during the first part of the 80'.

1.4 TURNOVER AND EMPLOYMENT

Turnover of the defense industries of European Union member countries began to decline in 1985; it fell from ECU60 bn in 1984 to ECU49 bn in 1992; the reduction has been 19%. A twofold phenomenon is responsible for this drop. First, chronologically speaking, was the drop in exports of European arms. Second is associated with equipment purchases. Up until 1989, the continuing purchases of equipment and the growing R&D investments by the European Ministries of defense enabled the consequences of the drop in exports to be kept within bounds. As of 1989, purchases of equipment also fell, from 48.4 thousand million ECU to 41.9 thousand million ECU in 1992.

The national situations vary considerably within the European Community itself. Some industries have felt the effects of the sales market losses noted above much earlier than others. For example, the British and Belgian defense industry realized the most important drop of their activities and employment between 1985 and 1990. The German defense industry was harder hit by the cost of reunification between 1990 and 1995, and the French industry is only now entering into a period of significative reduction of national equipment expenditures.

The number of job losses followed a similar trajectory, although accentuated by the effects of the increase in productivity. Between 1984 and 1992 some 410,000 people out of a total of 1,001,000 directly employed in the defense industry lost their jobs, an average of 51,000 per year. According to estimates of the reduction in the defense business made in 1993, average annual job losses in the industry between 1993 and 1996 should be between 37,000 and 56,000. It now seems that the number will be nearer the lower limit. Indeed, the stabilization in exports and equipment expenditure during the last two years and budget forecasts of the main European countries seem to indicate a slowing in the reduction of the turnover at the European level.

The social consequences of the reduction in the defense business and the increase in companies' productivity have often attracted much attention. Although the social situation may be difficult, it has to be said that no European defense company of significant size has foundered after five years of crisis [7]. An analysis of the situation of companies in European countries does not show any serious risk of collapse in the short term [8]. The crisis in the defense markets is neither as dramatic as some suggest [9] nor is it having the paralysing effect that the combination of figures for job losses, drop in business and rise in unit costs might suggest. The great majority of companies are managing to cope with the drop in military business (in some cases compensating for it by engaging in other activities) and consequent restructuring.

Of course the situation varies from country to country and sometimes between companies. British companies, which have been privatized and saw a drop in business from 1986, do not react in the same way as French or Italian nationalized companies. In the latter two countries, no steps to restructure have been taken, or if they have only very patchily, and what is in a state of crisis is the type of relationship between companies and the state more than within the defense industry itself. On the other hand, companies

like Daimler-Benz Aerospace, a subsidiary of the largest European industrial group, or Bae and GEC which have been privatized and exposed to competition (to cite only the largest) have been able to manage the much stronger reduction in equipment orders from their respective defense ministries.

It appears now that after a important decrease of activity spread over these last 5 or 6 years, the defense industry in Europe is going to enjoy in the coming years a more stable period marked by a slow and more manageable reduction (and for some firms a stabilization or even an increase) of their defense activities. The only significant exception will be the French industry which is only now entering into a phase of deep adaptation to the new strategical and financial context. The equipment budget will be severely reduced and the firms will have to deeply restructure themselves.

The European defense industry is undergoing a far-reaching process of adaptation that goes beyond a mere reduction in its activities. The economic and political context in which the industries are developing has in effect changed. Three main developments can be distinguished. First, there is the process of internationalization of the defense industry, which has widened the traditional national framework in which companies developed. The technological context has also changed under the effect of the very considerable growth of civil technologies or those of civil origin. Military technologies, which were formerly at the forefront of progress, are increasingly challenged by technologies developed outside the restricted field of military innovation. Defense markets (transactions between producers and buyers) have in a number of countries been affected by the influence of free trade and competition. Moreover, the sometimes very close relationships between the state and producers have also adapted in varying degrees to the modern world, especially regarding the privatization of public firms.

Amongst the various dimension of this adjustment process, one is particularly interesting in industrial and political terms: the process of the internationalization of the defense industry.

2. The "Internationalization" of Defense Industry

At the end of the fifty years that have followed the Second World War, a period that has seen in particular the reconstruction of national defense industrial and technological bases in Europe, several conclusions can be stated. The first is that the national framework continues to be the main reference for the construction and maintenance of a defense industrial and technological base.

Under the cover imposed by the East-West confrontation and on this side of the Iron Curtain by US strategic hegemony, some authors use the image of a Europe over which an overlay had been thrown [10]. The defense industry has been one of the few areas in which European countries have been able to show, without outside interference, their existence and competence, at a time when the security and defense context imposed on them a reduced margin of strategic autonomy. The necessity to close ranks in the face of the Soviet threat within a political and military alliance under American hegemony was

accepted relatively well by the European countries (with the exception of France), partly because beneath the American military and political umbrella, there remained significant room for manoeuvre. It is without doubt no exaggeration to suggest that the rebuilding of national defense industrial and technological bases in Europe during this period has been the privileged domain in which national existence has been expressed.

Could it be otherwise? The production of military equipment stems from three closely connected functions. The first functions are identification and assertion. The governments of the United Kingdom and France, but also of Germany, Italy (to a lesser degree), Spain, and Sweden have invested, sometimes as a matter of priority, in the defense industry to assert their strategical autonomy and contribution to the maintenance of a national identity. Next are economic functions. Defense industrial and technological policies, like their civilian equivalents, take into account national considerations. The investment of public funds in an economic activity is necessarily made with a view to the national economy gaining the maximum advantage from it. It is hard to imagine forms of altruism or internationalism in matters of industrial and technological policy, all the more so as the benefits in terms of jobs and technological progress are and will remain a powerful way of justifying military expenditure in the eyes of the public.

That said, it should not be concluded that this national dimension is unchallenged. Several elements combine to limit its influence and the consequences of that influence. The first limitation comes most often from finance ministries, and more generally from the collectivity, who refuse to finance dreams of national grandeur completely. If the defense ministries and industrialists have been able to use the funds made available to them to rebuild defense industrial and technological bases, they have had to cooperate.

The national dimension is preponderant. It is a reality, but a reality that has evolved. There are several differences between nationalism in questions of armaments production as it was expressed prior to the Second World War, and which usually took the form of a quest for self-sufficiency [11], and the national dimension as it is expressed today. Obliged to cooperate, faced with the globalization of the economy in general and the internationalization of defense industries in particular, influenced by the dominant economic ideology and lastly grappling with a reduction of defense budgets, the national defense industrial and technological bases as they have been variously developed have emerged from the period of the Cold War both strengthened and modified.

2.1. THE THREE PHASES OF EUROPEANIZATION

The internationalization of defense activity or the cooperation between Government and firms on industrial and technological programs is a long tradition in Europe since the end of the WW II. This "Europeanization [12]" process (when the process is limited to European partners) can be divided between three phases by using a comparison with the civilian internationalization process.

The process of internationalization of civil industry in the industrialized countries is usually presented as roughly occurring in three phases. The first is the golden age of international trade, extending over the 1950s and 1960s. The second was dominated by

direct investments abroad. In the 1970s the large, multinational enterprises invested directly in many countries. The third phase began in the 1980s and its main objective is technology as an essential factor in companies' competitiveness. Companies have created new types of relations between themselves, either through the creation of joint ventures or through agreements of varied kinds but most often centered on technology. The notion of technology networking has become central, as has that of 'techno-globalism' [13].

To what extent does the process of Europeanization of the defense industry follow this pattern? It too can be said to be divided roughly into three stages, with technology playing a determinant role much earlier than in the civil sector. From 1945, when European countries had to rebuild their defense industries, access to the technologies developed in the United Kingdom and the United States (but also in Germany: one has only to think of race to find German scientists in the postwar period) became the major element in all forms of internationalization. It also appears that direct investment abroad played only a marginal role in the defense industry. Additionally, arms exports were on the same scale throughout the three phases of the internationalization of the European defense industry [14].

- The first phase, from 1945 to 1960, was characterized by numerous cases of production under license and technology transfers which enabled national industries to be rebuilt. This was the age of licenses and American military assistance. International agreements were marked by unilateralism and the technological connection.
- The second phase, from 1960 to the mid-1980s, can be considered to have been the period that saw the birth of Europeanization. European countries earmarked technological areas in which they wished to develop international partnerships. International cooperation in which European companies dominated, more balanced and aimed at acquiring technological competence, symbolized the best of this period. This was the era of the all-powerful state both leading and organizing cooperation agreements.
- The third phase of Europeanization, its period of maturity, began towards the middle of the 1980s and was characterized by the necessity for European countries to choose technologies that they wished to preserve nationally, those that they wished to develop in international partnership and the areas for which they would have to rely on the international market. This period was also marked by an extremely wide development in the number and type of agreements between companies. Their new autonomy, resulting from a generalized reduction in state control of economic activity (privatization), allowed them to adopt modified civil forms of globalization.

This third phase, and this is doubtless the most important political lesson, depended both on the reaffirmation of the national dimension, renewed via the more flexible, more eclectic links between the state and national champions (through privatization, larger autonomy given to firms concerning their relations with other firms, and through the

introduction of some sorts of competition), and a growing need, which is no contradiction, to cooperate with foreign partners. The big European states are compelled to choose which technologies and productions they wish to handle on a national level, which ones they are willing to develop in international (transatlantic most of the time) or European partnership and which ones they will acquire through imports.

2.2. THE MODALITIES OF INTERNATIONALIZATION

The study of the internationalization process [15] and especially the Europeanization of the defense sector clearly indicates that states and firms tend to cooperate increasingly at an international level and particularly on the European level. This trend accelerated in the early eighties. Figure 3 [16] shows that manifestations of the internationalization process have increased a lot in the 80's and 90's but also that the nature of this process has evolved. The 60's and 70's were marked by a quite steady figure of standard cooperation programs within the frame of consortiums under the direction of the governments. During the 80's and between 1991 and 1994, different schemes of internationalization expanded rapidly. The number of consortiums remained steady between 1981 and 1990 (about 20) but doubled (38) between 1991 and 1994. In the second half of the 80's, the number of mergers and even more the number of acquisitions increased. The number of strategic alliances has also increased for the last eight years.

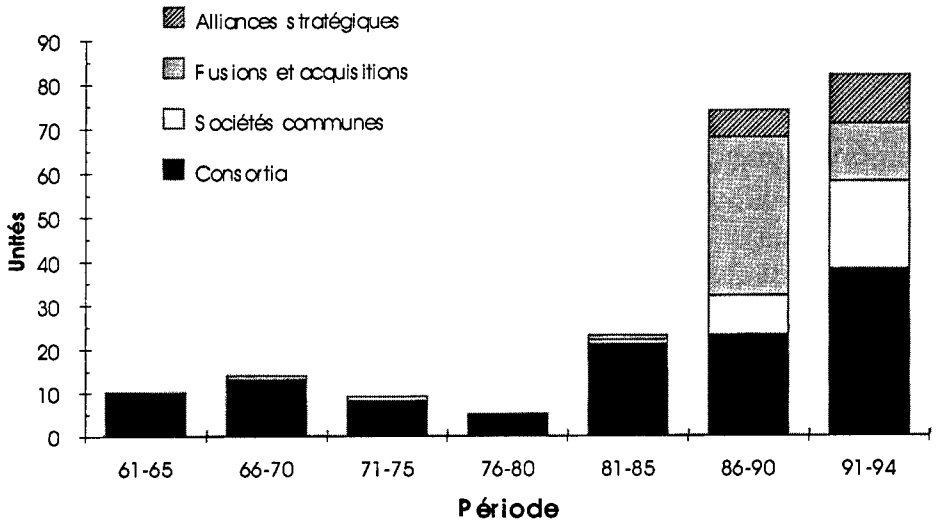


Figure 3. Number and type of intra-European agreements between 1961 and 1994.

Source: Table realized on the basis of the Defense Budget Project (DBP) Globalization Database.

Other elements support these observations. K. Hartley and S. Martin have produced a more qualitative evaluation of collaborative agreements [17]. In the most thorough analysis of European armaments cooperation, the authors conclude that states are having increasing international cooperation, and that the number of these projects is rising. Regarding aerospace, the average number of partners rose from 2.4 in the 1960s to 2.9 in the 1980s; corresponding figures for aircraft engines were 2.1 and 3.5, and for missiles 2.5 and 3.4. The phenomenon, originally very noticeable in the aerospace sector, has moreover a tendency to spread in the other sectors.

If the duplication of effort in R&D is obvious in Europe with the multiplication of similar programs, a growing tendency on the part of states to engage in R&D projects of an international type must also be noted. Eurostat, the European Union's statistics office, supplies interesting although incomplete statistics of the proportion of defense R&D investments made in international projects. Such expenditures have been growing since 1983. The proportion of international R&D projects in defense R&D budgets rose between 1983 and 1991 from 31% to 38% in Germany, from 10% to 23% in the United Kingdom and rom 16% to 30% in the Netherlands [18].

In France, the non-nuclear part of R&D carried out through international cooperation rose from 5.5% in 1984 to 23% in 1992 [19]. Among the main European countries, it is Germany that devotes the largest part of its R&D and equipment procurement investment to collaborative projects: 70% of equipment purchases were collaborative, of which 30% were bilateral and the remainder multilateral. In 60% of cases, the cooperating partners were European [20].

More recently, the seven principal European centers of aerospace research - CIRA (Italy), ONERA (France), DRA (United Kingdom), DLR (Germany), FFA (Sweden), NLR (Netherlands) and INTA (Spain) announced that they were to work towards improving cooperation between themselves and in time build a union of aerospace research bodies in Europe [21]. The figures and tendencies mentioned reveal an evident fact: the process of internationalization is real, deep and doubtless of greater intensity than estimations have traditionally suggested. The member countries of the European Union devote at least a quarter of their defense R&D investments to international cooperation [22]. This is a significant proportion, at least when compared with the corresponding figures in the civil sector.

International cooperation assumed various forms, reflecting the variety of companies' situations and objectives. E. Skons has proposed a topology of defense cooperation agreements, which in a number of cases overlap: from direct investment abroad to the various types of subcontracting; from production under license to mergers and takeovers: from joint ventures to more specific *ad hoc* agreements and in between these strategic' alliances and provisional association to respond to invitations to tender (teaming arrangements) [23].

One form of cooperation is worth highlighting. The forming of joint-venture companies is the most interesting form of cooperation. Since 1972, when Aerospatiale and MBB created Euromissile, the number and size of joint ventures has grown steadily, particularly during the last nine years. Two joint ventures companies were created

between 1970 and 1986 but nine were created between 1986 and 1990, and twenty between 1991 and 1994. The aim of forming these companies which are concerned with a range of types of armament, is to share the costs of R&D and share the national markets of the different partners. A further aim is to make economies of scale and better position in external markets.

To what extent does the forming of joint ventures imply a true integration and rationalization of armaments production? In reality, in the absence of sufficiently detailed case studies, the observer has no alternative but to form hypotheses. Given the very close nature of relations between parent companies and the state (through the financing of R&D, or official orders), and given the fact that technologies are considered by parent companies to be strategic assets and that moreover defense ministries exercise close control over any transfer of technology [24], it might appear that the integration of R&D and thus its rationalization within joint ventures is relatively weak, in any event not optimal from an economic standpoint. Joint ventures in reality appear as the national form of internationalization of the defense sector. This type of structure, in which the partners maintain control of their technological, and often their industrial assets, and where business and profits are shared in accordance with the size of national markets is a very good reflection of the current organization of defense markets in Europe.

Management of this move to internationalization is shared between governments and industry. Countries have been obliged to or have accepted to allow companies a margin of autonomy [25]. In reality, the relationship between the 'national champions' created in each European countries and the state are very interdependent. Without the support of the state, its funding and access to its defense market, companies would disappear. It is in a way a pledge of the state's ability to exercise control over companies that the international context attracts. Further, it is increasingly linked to its national champions for social, industrial and technological reasons and sometimes reasons of national identification. The combination of national champion and state is apparently becoming increasingly solidly connected, and for a still relatively long period [26]. This political-industrial structure is going to determine strictly the form and the modalities of the European integration process of defense markets and industries.

2.3. A NEW INDUSTRIAL PARADIGM

In parallel with the modification of their political and institutional environment, companies have undergone profound internal changes, increasingly making them adopt the characteristics of modern, high-technology companies. The multiplication of agreements between companies, the necessity to adapt to fluctuating political environments and technologies, and shrinking markets, oblige companies to adopt complex, flexible internal strategies. Companies take the form of a strategic core made up of the essential technological competence, which gives privileged access to national markets and political decision makers. Their periphery is composed of many activities shared with external partners. The search for partners in order to share the costs of R&D and markets is constant. Aerospatiale is without doubt the best example of this new type

of organization of companies. More than 70% of this French company's turnover comes from international cooperation (with Daimler Benz and in the Airbus and ATR consortiums). The multiplication of joint ventures increasingly makes Aerospatiale resemble holding company whose principle activity consists in ensuring the coherence and coordination of the activities of its joint-venture companies [27].

On the other hand, companies pursue their strategies at three different levels: national, European and global. Companies have organized their strategy and relationships with other companies in accordance with this structuring of their environment. The national level, which as has been seen is dominant, is both the starting point for conquering other levels but also the zone where technological, financial and industrial expertise are in particular concentrated. The state, which is both protector and source of finance, indeed demands a return on its investment in the form of more developed technologies, more competitive equipment for its armed forces and possibly a lower financial burden thanks to profits earned abroad, whether direct (payment for equipment exported) or indirect to the sharing of R&D costs.

The European level is natural even though it is not institutionalized. It is in this area, where the convergence of economic and political interests, that national champions must necessarily be present and invest. It is also doubtless the most promising in terms of new armaments programs and new legitimacy for defense business. Beyond Europe, the global level is mainly formed by American technology but also in recent years Japanese technology (see, for example, the Daimler-Benz Mitsubishi strategic alliance) as well as certain opportunities in newly industrialized countries. Russia and Ukraine, but also to a lesser degree the other countries of Eastern Europe, also offer the potential for technological and commercial cooperation. The following diagram is based on information taken from three databases [28]. A comparison of the information contained in these databases allows this overall view of relationships between companies to be obtained. It is in a sense a picture of the new European defense industrial paradigm. For simplicity, only the most important companies in terms of turnover have been shown. The size of oval is proportional to turnover [29]. The width of lines connecting companies is a function of the number of relationships identified (collaborative projects, strategic alliances, participation in capital, etc.). Joint ventures, the national equivalent of internationalization, have been represented so as to show clearly this relatively new trend towards adapting companies to the market's new technological demands and policies. The most important relationships between the United States and the rest of the world have also been shown.

The process of internationalization, including Europeanization of the defense industry, is not only a reality but will continue in the medium term. Armaments development costs will continue to rise and defense budgets, which are falling or stagnating, will no longer permit numerous national projects to be supported. Increasingly, the major European countries will have to choose which sector of technology they wish to dominate at the national level (combat aircraft and nuclear technology in the case of France and the United Kingdom, for example), the sectors they wish to develop in more or less institutionalized cooperation between countries or

through agreements between companies, and lastly the sectors in which they will have to rely on imported technology.

The management of internationalization by European countries is an old process and has formed part of the technological and industrial policy of all European defense ministries since the end of the second World War. What is changing is the rate at which these transfers from the national to the international level will have to occur, their extent and the political and institutional framework into which these transfers will take place.

3. The Europeanization of Defense Industry and Markets

The wish to integrate the defense industries and markets in Europe has been repeatedly expressed since the early fifties. The European Defense Community plan and its common program on armament procurements" has been the deepest endeavor into the matter [30]. Afterwards, various initiatives have been taken within the WEU, NATO and the IEPG. The European Parliament and the Commission have also put up proposals. Secondly, the French and German governments have revived the debate around the European Armament Agency.

The will to set up an economic pillar of defense is currently shared by some national actors, the WEU and the European institutions. Following a scheme which has now become a classic of the European integration, the economic aspects of defense should constitute the third pillar of the forthcoming architecture of the European defense, beside the pillars "Common Defense Policy" and "military tools". As for these first two pillars, the building up of this third pillar has merely started. But foundations do already exist. These are composed by numerous intra-European cooperations in the field of armament production.

The main problem for defense markets and industries in coming years will be how to go beyond decentralized cooperation as it exists today (hundreds of bilateral and multilateral agreements between governments or firms) to the definition and adoption of a regime that can support and if possible increase the number of instances of cooperation.

The analysis of internationalization has brought out the process of Europeanization that is occurring in the defense industry and markets, quietly and in the form of ad hoc agreements. Both the Independent European Programs Group [31] -IEPG- and the European Commission have tried unsuccessfully to systematize and hasten this Europeanization by operating on the defense markets.

Paradoxically, at a moment when these institutions were proposing to construct a European market by trying to apply rules of competition and open markets uniformly, the armaments markets structured themselves almost naturally at three levels, one of them being the European level. This creation of a formal structure for the defense markets at these three levels, and an institutional structure made up of the three institutions responsible for defense questions in Europe will be used to draw an analytical framework able to illustrate the most likely scenario of integration of markets and industries in Europe.

3.1 A THREE-LEVEL MARKET

States and firms adapt to their new financial, technological and political environment reflecting what already occurred in the civil aerospace sector. European states and their national champions are slowly setting up a European dimension for the defense economy, between a national dimension still dominant for the big European countries and a global dimension covering mainly the relations with the United States. Armament markets are already structured in three levels: national, European and transatlantic. These three levels are distinguished by the sort of requirement, the number and the nationality of partners involved in the procurement and production procedure of various military equipment. The left part of scheme 1 gives an outline of this three-levelled structure.

First is the national level, which corresponds to national requirements, which are met from national sources. The defense ministries manage these transactions alone and in 1985 they represented a figure ranging from 75% of total procurement of military equipment in France and the United Kingdom, to about 20% for the small countries [32].

Second is the European level. It is useful to distinguish between those projects involving all the countries and those that bring together only some of the potential partners. The latter type of agreement is more usual at present, and examples are the two projects for the development of a new generation of frigates, which involve in one case Italy, France and the United Kingdom and in the other Germany, the Netherlands and Spain.

In the future, a series of projects involving a greater number of European partners should be developed. The idea of Common Requirements (common that is, to the Europeans) and Collective Access - CRCA - seems the most appropriate. At present, two programs actually deserve the description European. There are firstly, and to a limited extent, the contracts associated with the setting up of a WEU satellite center at Torrejon, and secondly and more significantly the Future Large Aircraft (FLA) which involves practically all the European defense ministries that are interested in this type of aircraft. These two programs are likely to be joined by other European CRCA projects in domains where the pooling of European financial and technological resources is necessary, such as intelligence, space and transport.

Lastly, the third level at which defense markets are structured comprises transatlantic projects. There, too, a distinction has to be made between limited transatlantic projects in which American companies or the Pentagon are associated with one or several European partners (as, for example, the AV-8B Harrier and the X31), and transatlantic CRCA projects. As a general rule, all the European members of NATO may be able to participate in the latter. The most well known examples of these are the NATO infrastructure and programs like the modernization of AWACS airborne radar aircraft, the

telecommunications infrastructure (in particular satellites) and in the future possibly anti-ballistic missile missiles and airborne ground surveillance radars.

This structuring of the markets is evolving. The line-up and the relative share of the three levels do change. Although remaining dominant in the big European countries, the national level will have to keep transferring new armament programs to the other levels on financial and technological grounds and according to the political opportunities. This is the meaning of the arrow on scheme 1.

The European level is the least institutionalized of the three and the main question facing the Europeans in the coming years will be how to make a reality of the political rhetoric and set in place from an economic point of view the many manifestations of the Europeanization of the defense economy. The challenge faced by the Europeans lay into the successful construction of a European level in defense markets. That should have a number of advantages for an improvement in the quality of equipment and a contribution to the creation of a European identity.

3.2 A SLOW PROCESS

Achieving this European dimension will be a gradual process for at least three reasons. The first reason is an economic one and concerns the divergence between the different "national models" of organization of the DITB. A deep and long process of convergence has to take place between the major European states and defense industrial and technological bases.

The second reason has to do with a peculiarity of defense industrial and technological policies. These are the armaments programs which are structuring the markets and the relations between firms. The requirements for new armaments in Europe and therefore the opportunities to harmonize requirements and engage in European collaboration will gradually appear during the next two decades.

The last reason why the process will be a gradual one is that the integration of defense markets at the European level is happening in a restricted political framework. If the end of the Cold War and the Maastricht treaty will doubtless appear as events that started a true process of integration of European security and defense, it must be said that at present only a few very small steps have been taken, and that the forming of a European security and defense identity will take time. This strategic dimension of Europe will develop gradually [33] stage by stage and will be interrelated with international events. Moreover, the development of the process of European integration to date and in the light of the key position of actors like France and the United Kingdom leaves no doubt that defense integration will remain essentially a cautious intergovernmental process in the coming years.

3.3 EC, WEU, AND NATO: BETWEEN COMPLEMENTARITY AND COMPETITION

Moreover, three international institutions are supposed to work together in the field of the economic questions of defense: the European Community (the Council, the Commission and the European Parliament), the WEU and NATO. Waiting for the relations between the Community and the WEU to become clearer, the future of the defense markets and industries integration in Europe must be considered within this three-institutional framework.

This peculiar structure is depicted in scheme 1 as an architecture in three pillars (the European Community, WEU, NATO) having their foundations in the defense markets as they are organized. Such a depicted architecture, even if it appears very complicated, will allow a listing of the scope of skills already existing in the different institutions, place on it potential political initiatives and finally put the future European Armament Agency in its broader context.

3.3.1 *The European Union*

After a first attempt at the end of the 70's, owing to the Single European Act enforcement and the revival the political integration process in the early 90's, the European Commission and Parliament tried to interfere in the debate on the defense market's future. In 1990, the Commission appealed [34], unsuccessfully, to deletion of article 223 of the Rome Treaty, which rules out the armament production of the European Union competence, in order to rationalize the defense industry on a European level and to introduce some competition rules in this market.

The supporters of a "communitarization" or of a rapid integration of the defense market could measure the tremendous gap between their ambitions and the realities, but they also could find out that it was very difficult in this matter to make use of economic concepts, relevant in a commercial field but which hardly apply to a sector very specific in many ways. Nevertheless, the institutions of the European Union, more especially the Commission, still have in their scope of activities some aspects of the defense economy and they might put up new proposals.

Among these, the first one applies to a part of military markets. If a single market for the armament remains out of the question, some aspects of the defense markets might fall under the rules on public procurements rules applied in the Single Market. This proposal is distinguished on scheme 1 by the figure 1 in a circle. Some 38% of the procurements of the Defense ministries concern dual-use [35] equipment. In fact, the vast majority of these goods and services are civil. The purpose of this proposal would be to limit the field of application of the much-advertised article 223 of the Rome Treaty which exempts military markets from the competition rules in the public procurement contracts.

In the long term, a progressive liberalization of other parts of military equipment procurement contracts might be considered on the sole condition of a viable competition. It's the central point of a scenario worked out in research for the European Commission

on "The Cost of Non-Europe in The Defense Markets". This scenario, said "double way", aims at introducing competition for small and medium military procurement contracts while the big programs would be most of the time devoted to international cooperation [36].

The Community is also concerned with the question of the future links between some civil and military technological areas specially into the research "framework programme". The Community already takes care of the social and regional outcome of the cuts in military spending through the KONVER program especially, but also in general through regional policies. Europeans have set themselves a mid-term goal: to play a part in the international scene as a strategic actor. A European arms export policy was noted down as a potential "joint action" in 1992. This issue should be discussed within the Council and to a smaller extent within the Commission.

3.3.2 *WEU and NATO: "Separated But Not Duplicated"*

Nowadays, the matter of European defense, and also its related economic aspects, currently concerns mainly NATO. It's impossible to list in this paper the huge amount of NATO activities in the field of defense economy. The uneasy point for Europeans lies in the fact that they must build up a common defense identity while dealing with changing transatlantic relations. The Europeans are then in an awkward situation. The United States are both partners and competitors according to the circumstances. The expression of "separated but not duplicated" is probably the best one [37] to describe the situation between NATO and the Western European Union in the field of armament programs and infrastructure. The European have to build an European dimension of armaments by avoiding the duplication of efforts with NATO. A situation which could be difficult due to the large capabilities already existing inside NATO in the field of communication, intelligence, warning etc. and due too to the relative competition existing between the two organizations.

It falls to WEU to deal directly with the armament production [38]. It is within this institution that was set up the Western European Armament Group (WEAG) replacing the IEPG, which joined the WEU in December 1992.

In November 1994, the Defense ministers of the thirteen members [39] of the WEAG agreed upon the setting up in spring 1995 of a research unit to back the EUCLID research program. Germany initiated an informal group in charge of studying the options in the matter of a European armament policy. They also approved the working rules [40] of a European Armament Agency. In the course of 1995 or 1996, the WEAG members should put a proposal before the Council to set up an Agency as a subsidiary body of the WEU.

3.3.3 *An European Armament Agency*

What could this Agency look like? The tasks that might be given to a ambitious project of the Agency could be the following [41]: the follow-up of European cooperation programs; the follow-up of the EUCLID program; the management of common research

and test infrastructures centers; the conduct of technological and operational research; the setting up of an information and data bank service.

The construction of the Agency will probably progress step by step and will be conditioned by three elements uneasy to assess: the pace at which the States will transfer armament programs to the European level and especially the rate at which they will define common requirements and programs; - the advancement of the definition of a European common defense policy and the reassessment of transatlantic relations; - the development of the European strategic context, and in particular, the existence or non existence of external pressures which would bring together the Europeans more rapidly.

Scheme 1 pictures the place where the future European Armament Agency would stand and its environment (point 2 on the graph). Nor central, nor on the fringe, it stands at a point much disputed, among others, by the trend of the States to favor bilateral agreements or by the NATO role. The comparison with the European Space Agency gives a quick outline of what an Armament Agency capable of following up common programs of research and infrastructure could be. The Agency also should work in a flexible way in order to allow the joining in of States which are willing to work closely on the defense integration process and those which only wish to take part from time to time or in a more distant way.

The Agency will be given birth in 1995 or 1996. Two scenarios come out. It could be a facade Agency, just a mailbox and an address, without any real competence or concrete plans. On the contrary, it could be a serious institutional frame carrying relevant technological and industrial projects.

The Europeans may achieve such a significant Agency if they succeed to transfer important research and development programs to an Agency able to manage a budget and to place contracts. The Agency would then progressively become a developing and selecting regime favoring the European cooperation. The core of the Agency could consist in "mandatory" or a compulsory programs (like common research and infrastructure programs) following the example of the ESA and in an administration endowed with the capacity to manage a budget under the authority of the members. The associated activities of the Agency would then be the complementary programs and limited European cooperations. These could be managed within a frame of juridical structures that the WEU would put at the different partners' disposal, following the model of NATO's "agencies" or "projects". It is the meaning of the two grey tints used on scheme 1. The thicker line delimits the core activities, the thinner one stands for the associated activities of the Agency

What will be the membership of the future Agency? Nowadays, 13 countries are members of the WEAG. The future membership could be defined according to two principles. The countries taking part in the compulsory programs would be full members of the Agency. In all likelihood, it would concerned the current 13 members of the WEAG, inheritors of the Independent European Program Group. The complementary programs would allow the other European countries to participate from time to time in

the Agency. The European Armament Agency would then reflect the famous "core groups" (the members of the Agency) and the so-called variable geometry concerning the involvement of specific countries in the complementary programs.

The principal modalities of participation of States to this cooperations will remain in the foreseeable future the "fair return" principle, or the proportional industrial and technological return of the financial investment made by the States [42]. The "fair return" principle is often criticized for its economical and financial consequences like for example the increase of cost and the multiplication of identical capabilitieS in Europe. But the "fair return" is too a political concept and it can be said that it remains the most important integration tool at the disposal of the Europeans wanting to integrate defense industries and markets.

4. Conclusion

The progressive building of the european dimension of defense market and industry is a reality mainly constituted by various decentralized agreements between firms and governments. The next important step will be the establishment of an institution, the European Armament Agency, able to frame and maybe to speed this process of Europeanization. This European dimension won't be exclusive and will have to live between the national and the transatlantic dimensions of defense. There are good reasons to think that this European dimension will grow progressively in the near future. But there are also good reasons to forecast competition between these three levels of defense, technological and industrial policies.

The real challenge that politics are facing now is the necessity to give to this Europeanization process relatively clear political and strategical goals. Industries and States are trying to lead the way following their own interests. A good example and a test for the capability of the Europeans to build a future European industrial and technological policy will be the definition of a common arms exports policy. European are facing the choice between the limited interest of the industry and the difficult definition of an European conception of arms export policy as a key element of a strategic existence on the international scene.

There is, for example, a risk that the economic dimension of defense (in the shape of the protection of jobs and companies) outweighs the strategic and operational reasons for a security and defense policy in Europe. The balance between the needs of the armed forces and the demands of companies is difficult to establish. There are few points in common between the situation in France and that in the United Kingdom. And the question of the competitiveness of the defense industry in Europe should be posed and evaluated in the correct perspective by the political authorities, as should be a future European policy on arms exports. Other questions arise, like the type of industrial and technological relations to be established with the United States or other countries, the role, cost and place of the European defense industry in the economy or the future relationship between military innovation. These are all questions the answers to which

will lay the foundations of an inevitable defense industrial and technological policy in Europe.

The European defense communities are engaged in a complex reorganization process. They have at the same time to restructure their national defense industrial and technological bases, to build a European dimension of defense industry and market, to revitalize the transatlantic link and to elaborate an defense policy including the need to associate Central European countries and to establish relations with former enemies, Russia and the Ukraine. This is certainly one of the most important challenge the Europeans have to face in the next decade.

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39. The WEAG members are the European Nato's l'ourtheen nations less Island i.e. selgium, Denmark, Erance, Spain, Greece, Italy, Luxemburg, Norway, Netherland, Portugal, Germany, United Kingdom and Turkey.
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41. Rapport de x. sorderas sur Agence europeenne de l armement Reponse au trente-neuvieme rapport du Conseil", document 1419, Assemblee de l'UEO, ls mai 1994, Paris, p. 10.
42. The principle of the *fair return* conceived by the IEPG is partly the sharing of business between partners in international collaborative agreements in exact proportion to financial participation. The idea of a *juste retour* draws its inspiration from the European Space Agency (ESA) on matters of industrial and technological return concerning national financing of ESA activities. Explicit reference is made to the ESA procedure in 'Towards a Stronger Europe' , vol II,, pp. 125-32. 'Towards a Stronger Europe', is a report written by an independent team formed by the IEGP (1986) under the chairmanshlp of H. Vredeling. Volume I lists the proposals. Volume II is devoted to a detailed analysis of the competitiveness of the European defense industry.

BANKING AND DEFENSE CONVERSION

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1. Introduction

The topic of this paper is "Banking and Defense Conversion". I would like to tackle this subject from: the point of view of a banker. I propose to look at the banking risk aspect of Defense Conversion from three essential points of view; these are first the change of ownership of Defense manufacturers from the public to the private sector; second the potential for changes of products of such companies under their new owners; and third new financing structures and techniques which can be used by both the public and private sectors to identify and minimize risks by sharing them.

At the risk of being pedantic, may I take this opportunity to clarify what is meant by the public and private sector. For the purposes of this talk, the public sector means national or local government owned companies and parastatals. Private sector means entities which are not generally owned or controlled by national or local government. It is possible, though, that government could have a stake or an interest in them. A government may have a "golden" share which might restrict the company or its ownership in some way This can be a strategic decision to keep the company locally owned rather than sold to or become controlled by overseas interests.

2. Risk

Perhaps I should start by defining the nature of the risk for banks. When banks consider facilities for companies and governments (including parastatal entities), a rigorous examination of the proposition is undertaken. This, as you can imagine, includes a full credit appraisal of the sponsors, companies and the underlying project. In cases involving project financing techniques, which I shall touch upon later, we need to identify and examine risks also on contractors, operators, offtakers, suppliers of feedstock, insurers, governments and lenders themselves. The risks we run are those of the non-servicing of the agreed banking facilities; and all those risks, however remote initially, which will

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impact on the ability of all the various parties to meet their individual obligations. In turn, this will then enable the banking facilities to be serviced in accordance with the agreed terms and to time.

3. Risk/Reward

The reward factor for banks will reflect the degree and nature of risk, the complexity of the transaction, security and documentation. The latter will cover operational, recourse and legal aspects including the law under which the banking facilities will be governed. The documentation will include the duties and responsibilities of the parties thereto and the rights and remedies which will come into play in the event of anything untoward occurring during the life of the facility. The reward for the bankers and lenders will flow from interest margins, fees, commission and standard and negotiable charges.

The most important element will be the interest margin. This is the figure, usually quoted as a percentage figure, which is added to the cost of funds for the underlying transaction. It is the first indication of the degree of risk of the facility and the ability of the obligor to meet its obligations. Obviously, the higher the risk, the higher the margin. It is possible, though, that some risks are unacceptable regardless of the height of the margin. In such cases, the project would have to be reconsidered or abandoned in that form. Thus for medium term loans, a bank will quote the margin over the 6 months London Interbank Offered Rate (LIBOR) and review the rate each six months. Interest is payable at the end of each period. Shorter term lending facilities will be quoted at a margin over Base Rates. These are quoted daily in London and can be varied by simple advice to customers. Usually this advice is given through national newspaper announcements and notices published in banking branches. Both LIBOR and Base Rates are on a floating basis. For budgetary purposes, the borrower will need to allow for interest rate fluctuations during the life of the project being financed or for the company's working capital. This could make pricing difficult for bidding projects on a competitive basis.

For other medium term lending for overseas projects, concessional rates can be obtained through officially supported export credit schemes. In the UK, the national export credit agency (ECA) is the Export Credits Guarantee Department (ECGD) of the British Government. For exports of capital goods and services, cover of 85% is able to be offered to overseas buyers and borrowers repayable over periods up to ten years and fixed interest rates. These interest rates are provided through official Commercial Interest Reference rates which are based generally on the providing country's five year government bond rate plus a fixed margin. The reward for the bank lending the export credit is a fixed margin negotiated and agreed with the ECA.

Clearly the ability to fix interest costs is highly important for any long term project. If short terms rates were to rise above the budgeted figure, the success of the project could be reduced. If high interest rates were sustained for a long period, projects undertaken in the expectation of lower rates could well be in jeopardy. Conversely, if interest rates

reduce from the anticipated levels, then the project should be able to reduce costs and become more profitable or widen its markets through lower prices.

Other reward elements include fees, commissions and charges. In general, for most banking business, these items are negotiable between the banker and his customer. Many banks, certainly many banks in the London market - and there are now over 500 banks in London - calculate the return to the bank of the underlying facilities and include all the reward factors when doing the sums. This gives a good indication of one piece of business against another, and will be set against the bank's projected and budgeted yield target.

4. Ownership and Product

Two particular risks are pertinent to this topic. The ownership of the obligor of the banking facilities must be clear. And, the nature of the product must be such that it is saleable in the marketplace. For the first, in most cases but not all, a sovereign owner is generally a better risk than a purely private sector corporate. The old maxim which I believe was attributed to Walter Wriston of Citibank *"that countries cannot go bust"* was discredited after the debt crises in the past ten years or so, both in the developing economies and, unfortunately, in some of the more mature countries. However, governments do have the ability to print money and to levy taxes on the local populace and, assuming that such taxes are paid, funds are raised for, *inter alia,* state-owned industries and utilities. It is generally accepted that many, if not most, state-owned and parastatal entities are economically inefficient and clearly will not survive in that form without support from the state. A current example is Air France where the French Government is providing subsidies in the face of severe criticism from other airlines. The rationale for this injection is to make the company ready for its entry into private sector ownership, in other words, privatization.

Allied to the ownership is the nature of the product. Equipment for the Defense forces of the world fall, I suggest, into two simple main categories, namely platforms/delivery systems and consumables. This leaves aside, for the moment, equipment of a less sensitive nature and which can be used for commercial and personal purposes - this includes, for example, radar, radio, communication and other electronic systems. The major delivery systems, such as aircraft, armored vehicles and surface and underwater vessels, have in the past, been manufactured and supplied by a mixture of public and private sector companies depending on the country concerned. In the USA, for example, I understand that all such equipment is offered by the private sector. In the UK, there has been a recent change from public to private sector ownership. In France, I believe that the public sector retains an important stake in Defense equipment manufacturers.

The major delivery systems tend to be high value and their sales successes become widely known. There may be relatively few countries who have the ability to build state-of-the-art, highly sophisticated equipment for export and equally relatively few countries

who have the ability to acquire substantial volumes of such kit. Small scale purchases can be used to make up for attrition rates or for specialist equipment for more limited military needs for countries with smaller economies, heavily committed economies or lesser requirements for additional Defense systems.

Conversely, the consumables - whether ammunitions, missiles, bombs, shells or the like - could be made by a variety of manufacturers in a range of countries. Prices should therefore be keen although the sophistication and quality may vary depending on the supplier. Besides the manufacturers in NATO countries, which are generally private sector, many other countries have the ability to source these items. In many cases, especially in the CIS, for example, the manufacturers are still in the public sector. Because of this, it is possible that prices for the output may not be economic; this means that subsidies may be paid. Most economists will tell you that this is a distortion of trade and that subsidies paid will deprive other parts of the economy of that country of investment and support. However, in some cases, subsidies may be justified by other benefits, such as the acquisition of hard currency in settlement of export sales. It also brings into focus some wider considerations including the effects of reducing inflation (by accepting the lowest price), hard currency implications (foreign currency reserves), employment policy and retraining, and strategic and national interests.

5. UK Privatization Experience

Perhaps, at this stage, we should turn to the experience of the UK of transferring ownership of public sector entities to the private sector. This is commonly known under the generic name of privatization. In the UK, we have gained valuable knowledge of privatizing industrial sectors and the Defense sector in particular. The background to this follows Mrs Thatcher's Government formed in 1979, when the decision was taken to make radical changes to the UK's economic and industrial structure. In 1979, nationalized (state-owned) industries accounted for some 10% of the Gross Domestic Product, one seventh of total investment in the economy and around 10% of the Retail Price Index (an inflation indicator). The privatization programme sought to promote efficiency, to spread share ownership and to obtain the best value for each industry and service the Government sold. The programme has worked well; it is still continuing albeit at a more modest rate as the bulk of the programme has been achieved. To give an idea of the scale involved, the proceeds of the privatizations have raised some £55 billion (say the equivalent of US$80 billion) up to 1994.

There have been ancillary benefits both economic and social. Privatized companies have achieved a higher return on capital and can raise funds in the open capital markets. The subsequent fall in demands on the national exchequer by nationalized industries has fallen by more than £2.5 billion (US$4 billion) during that time; indeed, the companies now privatized contribute more than £60 million (US$90 million) a week to the national exchequer, mostly in the form of corporation tax. Social benefits have been seen in lower tariffs and prices for the consumer, rising standard of service and vastly improved

performance. Both employees and members of the general public have invested in the share capital of privatized companies and are showing handsome increases in share prices. The number of private individual shareholders in the UK increased from 3 million in 1979 to 10 million by 1993 (almost 20% of the total population).

6. Defense Industry

Four major Defense companies were involved in the privatization programme, namely British Aerospace, in 1981 and 1985; certain British Shipbuilders subsidiaries in 1985 and 1986; Royal Ordnance in 1986 and 1987; Rolls-Royce in 1987. Because of the strategic and national interest, the Government maintains a "special or golden share" which can be used to vote at appropriate meetings to veto any actions which might danger the interests of the UK. There is also a limitation on the control of the company to individual or others acting in concert to not more than 15% of the equity.

Faced with the rigors of open competition, the companies have had mixed results. Partly as a result of the peace dividend, there was overcapacity in the industry and with declining orders from the home market, the British Armed Forces, and an inability to export sufficiently, a number of the privatized Defense companies have closed. Several others merged and rationalized production sources and schedules to meet actual and perceived demand. Export markets were and are being exploited and the successful companies are now well placed for the future. There is still competition in the market and an element of over-capacity; with the British Government now widening Defense procurement to sources outside the UK, some observers feel that a further rationalization is bound to take place.

But what of the future? Many companies see joint ventures as the way forward. With the UK being a full member of the European Community now being widened to the European Union - the benefits of cross-border cooperation can be enticing. They can be an attempt to maintain or increase market share in more than one domestic market and as a lever to break into new export opportunities in countries where the UK political and diplomatic influence may not be terribly strong. Economies of scale can be achieved and technical and technological advances made. In turn, these benefits can be translated into lower prices and higher quality for future buyers.

Governments will still seek to have some measure of control over their domestic Defense industries. We have seen the effect of the golden share; in joint ventures, there is a risk that this system may be harder to monitor. However, research and development costs are still occasionally borne by governments, through funded studies or specific contracts, and the output is more easily controlled through this cash basis. It should also be more efficient and, in theory, better value for money for the taxpayers concerned. Many privatized industries in the UK have Government appointed regulators who have the power to set qualitative and qualitative controls for the industries under their scrutiny; in the case of British Telecommunications for example, the regulator sets the parameters of the pricing policy that the company must follow. However, there are no such

regulators for the Defense field, indeed they are not really necessary as the British Government is still the current single largest customer for the UK companies.

7. Change of Risk in Assessing Defense Companies

At this stage, I would like to return to the topic of risk and risk assessment, We touched upon it briefly before, but it is now appropriate to look at it in more detail. As one of the principal of the company or project is ownership, we have to consider the implications of change of ownership of companies from the public sector to the private sector. I suppose it might be safer, for this exercise, to assume that we are dealing mainly with OECD countries and those other countries whose credit risk is highly rated. It may seem odd to say, but there may be cases where companies being transferred to the private sector may have a better credit rating than the country which hitherto owned them.

If we look at the new ownership of the privatized companies in the UK, we will find a mixed picture. Some were floated in their own right to a wide investor base, such as British Telecommunications and British Gas; others were trade sales, such as Jaguar Cars to the Ford Motor Co; others were divided into many parts and sold through trade sales and management buyouts, such as the National Bus Company which spawned 62 separate operating entities, and the water and power generation and distribution companies. A number of companies were sold to the existing management and employees, such as Leyland Bus.

Clearly the risk which lenders now have to assess for ownerships is much more diversified. In many ways, the wider the ownership, the easier it may be for the company to raise funds through capital markets. For those companies sold through trade sales, the ability to raise more money may depend entirely on the merits and credit worthiness of the new parent(s).

But what of the Defense companies, in particular? The records show that British Aerospace was sold in two trenches, just over half in 1981 and the balance in 1985. The shares are widely held. In British Shipbuilders, the Warship building side was sold during 1985 and 1986; four were management/employee buyouts and two were trade sales. Of the former, Vosper Thornycroft has since been floated on the London Stock Exchange; VSEL was subsequently floated on the London Stock Exchange and at the time of writing, is subject to the close attention of GEC who have launched a competitive bid beating an initiative by British Aerospace; Brooke Marine and Swan Hunter have unfortunately ceased operations although Brookes did try to change its product case. The two trade sales were Yarrow to GEC and Cammel Laird to VSEL.

Royal Ordnance was sold in two parts. In 1986, its tank factory in Leeds was bought by Vickers - subsequently Vickers razed the existing plant and built a brand new facility. The remainder of Royal Ordnance was sold to British Aerospace in 1987. Rolls-Royce - the aeroengine manufacturer was sold to a wide range of investors in 1987. The British Government holds one special share in British Aerospace and Rolls-Royce. Some

measure of control is thus retained by the UK in these companies particularly to limit the sale or change of control of the companies to overseas interests.

8. Product Base

We have seen the change from public to private sector. But have the privatized Defense companies widened or changed their product base? Perceiving a shortage of military orders for new vessels, some of the previous warship builders added leisure craft to their product range. These tended to be luxury yachts and motor yachts which fell easily and naturally into the production capabilities of the shipbuilders' facilities and workforce. Of course, extra investment had to be made for the new skills required in fitting out such new vessels but essentially, the ventures did not provide a change in the direction of the companies. The main bread and butter business was still in the previous era and depended on the British Government to place orders for naval equipment. Unfortunately, however, the combination of reduced orders from the traditional source, the lack of export prospects and the economic cycle proved difficult to beat and some of the smaller shipyards were forced to close.

Of the others, British Aerospace diversified for a time by acquiring British Leyland, the motor manufacturer now known as the Rover Group, and a number of other disparate businesses. These were eventually sold and the company now has a core of aircraft production and Defense equipment. Much depends on military goods and the civil side is reducing in comparison. The company has actively and successfully sought major export business and has managed to reduce its dependence on the requirements of the British Armed Forces. It is also entering into joint cooperation with other European and Scandinavian companies as a means of widening the product and marketing base. Rolls-Royce has diversified by acquiring a power generation equipment manufacturer; this seems to be a natural fit as many power stations have electricity generated by gas turbine engines. These can be derivatives of aeroengines and marine propulsion units. Again, export orders are vitally important for the future of the company; the competitive pressures of the international marketplace will clearly impact on future success.

It must be admitted that there has been a gradual reduction in jobs in the privatized industries. British Telecommunications, for example, employed over 200,000 people in 1979 and now have less than half that figure. The same picture applies in all the privatized companies. Another potential concern is the impact of land sales by the British Ministry of Defense as bases and residential accommodation are no longer required. This is having a major effect on land prices, being good for investors who can buy the land more cheaply but bad for the exchequer who receive lower proceeds than originally envisaged. It has a knock-on effect on other people locally who are hoping to sell houses but see prices falling.

Elsewhere, it is reported that the Russians are using the peace dividend as a means to undertake a major structural re-organization of their Defense industry. This is evidenced through an increasing amount of the military R&D effort being devoted to peaceful

applications. A new programme to attract investment was launched in 1994 and since then some 700 projects have been identified valued at over $2bn. The most attractive of these projects has been referred to the authorities who are seeking local and foreign investors. It is reported that over 100 deals have been concluded between Russia's former military enterprises and companies in the USA, UK, France and Germany.

My own experience bears this out in some respect. Last year, after nearly two years of negotiation, we signed financing agreements in support of the sale by Philips Medical Systems, UK, of linear accelerator systems to former military factories in Russia and enabled those factories to convert their production to civil industrial purposes. The end user of the systems, which assist in the treatment of cancer, will be hospitals under the Russian Ministry of Health.

9. Risk Minimization

At this point, I would like to take a look at how project financing techniques can identify risks and the methods of minimizing their impact by sharing them amongst all those involved in the particular project.

Again we shall need to define just what is meant by the term "project finance" as it means different things to different people. For our purposes, I propose the definition to be the structure of financing which is capable of being entirely repaid by revenues generated by the project itself and relies on the assets of the project to act as security for the bankers and investors. It must be free-standing for both liability and ownership.

In the past, this has generally meant projects in the extractive industries which could provide hard currency revenue to meet hard currency financing obligations. More recently, the introduction, or rather reintroduction, of "Build-own-operate-transfer" (BOOT) schemes and derivatives including "Design-build-operate" (DBO), has enabled many infrastructure developments to be financed through this system. Thus transportation systems (roads, railways, ports and airports); power generation, transmission and distribution; prisons and correctional services and, indeed, any development which can show a dedicated revenue stream and securable assets are eligible for project financing.

10. Project Finance Structure

The parties to the project are vital to its success. The principal parties are:

- the **project company.** This is the production heart of the project and can act as borrower. It is owned by the shareholders, perhaps as a joint venture, and might be established as an off-balance sheet entity by the project sponsors
- the **shareholders** can be other parties interested in the project, public and private sector investors, and governments. The shareholders should also be financially strong, industry conversant and have clearly defined objectives for the

purpose of their investment. Shareholders take the upside risks and rewards, as well as the downside

- the **contractors** must be competent to complete their contract to time, budget, output and quality. They should be experienced and well regarded in the industry circles. Proven technology should be used, especially for process plant, to minimize any problems and delays and cost overruns
- the **operator** must have experience of managing similar projects. He should have a good period of contract to manage the project and operate the project company, ideally until the debt has been repaid
- **suppliers,** providing raw materials and feedstock for the project. Ideally they should have long-term supply contracts at competitive prices
- **offtakers,** should be financially strong, well-known in their industry with a proven track record. They should have long-term offtake contracts at formulated prices. It helps if they are users of the product rather than traders or agents
- **government,** could have key roles to play as investor, provider of long-term funding, controller of foreign exchange for the project (subject to sufficient domestic currency being earned), grantor of necessary approvals and licenses for imports, work permits and exports, reaper of benefits from tax revenue, employment and use of local resources and infrastructure
- **insurers,** to cover catastrophes and other insurable events
- **bankers,** as funders of the project, recognizing the risks and seeking to cover them by security and pricing

The **contractual structure** should show linkage between the above parties through interlocking contracts. It is important to understand the relationship between the parties as much of the success of the project will depend on all performing correctly. As the security package will depend on the responsibilities of the parties, the contracts should cater for financial penalties to cover default or lack of performance.

Risk analysis is a key ingredient in the understanding of risk and reward. In project financing, the risks can be divided into two distinct categories, precompletion and post-completion. During the former, no revenue will be generated whilst the design engineering and construction takes place. Bankers will want to ensure that this process proceeds according to plan, budget and time. Obviously, failure to complete the construction of the plant could lead to a loss of investment by the lenders. Thus, bankers will want to feel comfortable that completion will be achieved or to be covered against it. In the post completion phase, when the project is operational, lenders will need to ensure that output and sales volume and pricing are sufficient to satisfy the debt service criteria. The level of supply of raw materials and feedstock, manpower and management must be sufficient to meet the needs of the project and bc consistently maintained.

11. Security

Once the risks have been identified, bankers must consider methods of minimizing them. As before, with two fundamental sets of risk - pre- and post-completion - different security may be required. It may be possible to find guarantors for the project, although in limited recourse financing, such entities are rare. However, indirect and contingent guarantees may be available, sometimes through the commercial insurance market. This will be in addition to the usual security. Bankers will expect to take a fixed and floating charge or mortgage over the assets of the project and the receivables which are generated. Similarly, the bankers will have first call on any monies which are payable to the project from default of precompletion agreements.

For **pre-completion risks,** the important people are the shareholders, sponsors, contractors and insurers. The contractors are responsible for completing the project within the agreed timescale, budget and output. Failure to do so will delay the project and may incur extra expense. The contractors should be penalized if they do not perform adequately. "Turnkey" projects give lenders more comfort as contractors will be given incentives to complete within the agreed parameters. Insurers can provide policies covering the lack of advance profits, contractors risks, contract inflation protection and claims for damages caused by unseen events. Underpinning the undertakings of contractors and insurers, the shareholders and sponsors can give assurances through cash deficiency and other interlocking agreements. The benefits of all these can be assigned to the bankers and thus limit the risks.

After completion of the project, the **post-completion period,** the main parties will be the suppliers, offtakers, insurers, government and other financial counterparties. Most of these can be covered by the long-term contracts. For the offtake contract, sales of output will generate cash for debt services and ensure the continuing success of the operation, it is advisable to seek take or pay terms. Thus the offtaker will be bound to pay regardless of whether or not he takes the output. The role of the government, as described earlier, continues to be important in allowing imports and exports to take place, provide fiscal and other benefits and avoid expropriation of the project assets. Through this, it should be possible to "ringfence" the assets and revenue of the project in the event of any rescheduling of the country debt.

A combination of careful management, operational efficiency, good marketing and sound cash flow should deliver a successful project. Bankers want to see success - but if the project fails, then the bankers will be secured for their risk monies.

12. Summary

To recap, the synopsis of this paper was to identify the risks involved from the banking aspects of Defense conversion. We have considered banking or lending risk on propositions put forward by companies. These included in particular the risks inherent in the change of ownership of companies from public to private sector and, more

specifically, in the change of status of Defense companies. We looked at the experience in the UK of the privatization programme and a brief look at the success or failure of those Defense companies which had to face the full rigors of the open market place. We touched upon the change of products of Defense and former Defense companies to see what effect this had on the future viability of the new private sector entries.

We saw the risk/reward factor for banks and the means of the banks earnings to cover possible provisions for bad or doubtful risks. Mention was made of fixed interest rate funding, of benefit when budgeting, and the role of export credit agencies in providing the relevant support for long-term fixed interest rate schemes.

Consideration was given for risk limitation schemes and the trend toward stand-alone project financing techniques. Here, the different risks inherent in the pre-completion period and the post completion era were brought out, and ways to cover the risks were described.

The views expresses herein are the author's own and do not necessarily reflect the opinion or views of Lloyds Bank Plc

VENTURE CAPITAL AND DEFENSE CONVERSION

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1. The Venture Industry - Economic Impact of the Venture Industry

Venture capital is a recently new industry structured to provide early stage investment capital for innovative technology companies. The industry is predominately in the US with several European and some Asian venture organizations. The primary function of venture capital is to rapidly commercialize technologies for profit and to create superior rates of investment return for its investors.

Technology Funding, Inc., (TFI) was formed in 1978 to manage and invest venture capital funds on the behalf of its investors. The firm manages 12 separate investment funds ranging from $5 million in size to $40 million. TFI has raised over $325 million in investment capital which has been invested in over 200 separate portfolio companies. The total portfolio has created over 10,000 jobs and generates over $1 billion in annual revenue.

1.1 THE VENTURE INDUSTRY

The US venture industry had 637 firms in 1994 which collectively managed $35 billion in investment capital. The industry invested in 1,055 new entities, providing $3.07 billion in capital. Venture funds range from a few million dollars to several billions for the largest. There are 187 firms with less then $10 million under management and up to 36 firms with over $200 million under management (see Fig. 1). In 1993 the venture industry funding of new companies was somewhat up from 1992 to 1,055 firms and $3 billion. Of the total $3 billion, $749 million was invested in early stages, $1,668 million in later stages, and $172 million in LBO's (leveraged buy outs) and acquisitions. These stages are roughly equivalent to idea, pilot, and commercialization.

The majority of venture capital investments take place in California with $1,169 million invested in 1993 (see Table 1). By industry sector, the greatest amount of new investments went to biotechnology, receiving 28% of the total invested, followed by software and communications, each receiving 14%, semiconductor 12%, medical devices 12%, healthcare 5%, and retail 6%. This distribution was similar to those of previous years, although since 1993 there has been a sharp reduction in biotechnology

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investments. The venture industry has generated relatively low investment rates-of-return over the last years from a high of 20% level for funds started in the 1976-79 period.

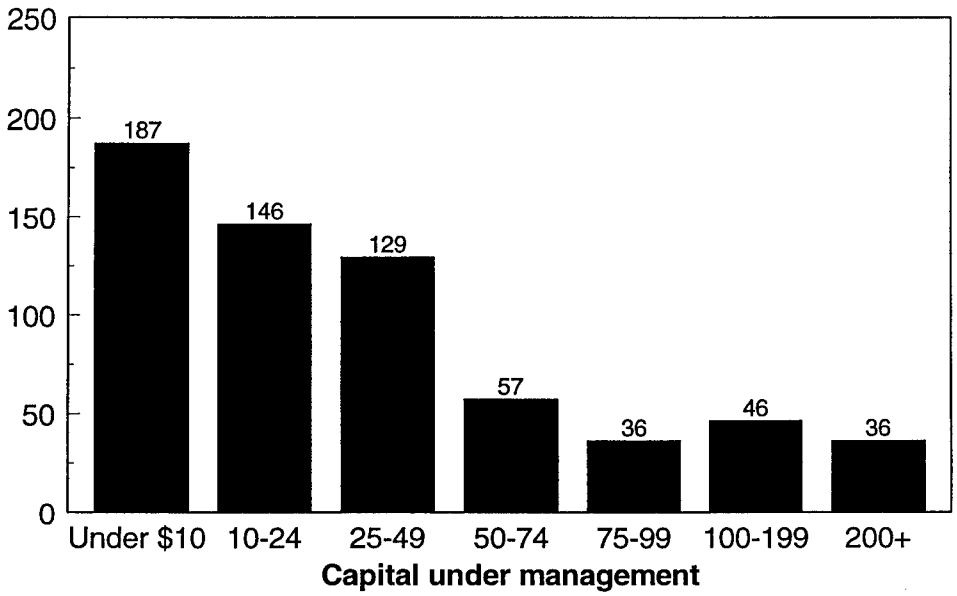


Figure 1. Distribution of firms with increasing capital under management (millions of US dollars)

TABLE 1. Investments of venture capital by state (US)

STATE	INVESTED (millions)
California	$1,169
Massachusetts	$380
Texas	$258
Connecticut	$176
New Jersey	$169
Colorado	$99
Florida	$73
Illinois	$69
Michigan	$68
Georgia	$68

1.2 VENTURE CAPITAL IMPACT ON THE US ECONOMY

The venture community has had a significant impact on the US economy and job creation. From 1989 to 1993 venture-backed companies on average created 152 jobs per company, growing at 88% per year in employment level. R&D investments averaged $8.7 million per company and export sales averaged $4 million per company. The following graphs shows the level of skilled employment, R&D investments, and impact on competitiveness, comparing venture-backed companies with Fortune 500 companies in the US. The comparison shows how the venture investments are focused on advanced technology and extremely rapid commercialization. The primary purpose of venture capital is to finance the growth of technology companies and to accelerate commercialization.

The primary objective of the investors is not to fund R&D per se, but rather to provide risk capital for technology companies in a pre-commercialization stage where they cannot secure traditional financing from commercial banks or other financing sources. This focused activity, with proactive involvement of investors who provide guidance to the start-up company, has led to an average 41% average annual growth rate in GDP (gross domestic productivity) for venture-backed companies vs. 2% for Fortune 500 over the same period from 1989 to 1993 (see Fig. 2.)

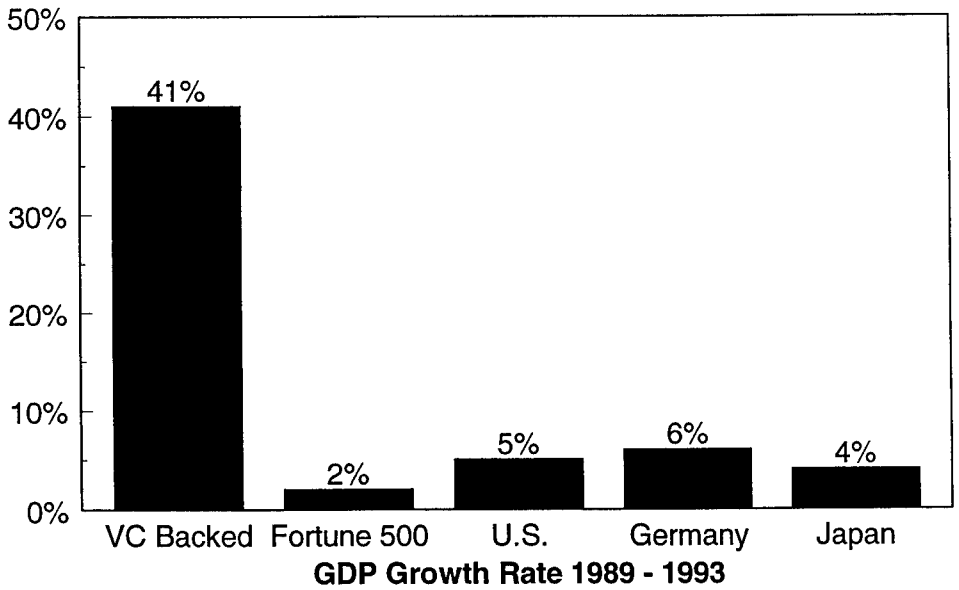


Figure 2. Growth rate comparisons of VC-backed companies to Fortune 500 companies

Traditionally the venture industry has been a major source of early investment capital for leading technology sectors of the US economy. This has fostered a relationship between technology developers and investors which allows each "side" to provide critical value-added to the growth of new technology companies. This relationship has also created a culture which is critical to successful venture investments. In the US this has taken place in Silicon Valley and outside Boston along Route 28. These geographic regions have been able to assemble technology, investors, and a culture of investing which allow the venture "culture" to grow.

2. The Venture Business Model: Attracting Venture Capital

2.1 THE VENTURE CAPITAL BUSINESS MODEL

The function of venture capital is primarily to generate high investment returns. Therefore, to attract venture money a company must be able to generate competitive investment rates of return relative to other investment opportunities. By this I mean, the issue for the investors is not if the technology is superior, but rather if the company will be able to create a viable and growing business based on the technology. Thus, technology is only a tool in the business formation process to reach high investment returns. The investors, therefore, are seeking innovation and new technologies primarily to build a new business on a defensible technology base which can be used to protect the company from competition. It is important that the company be able to protect the technology through patents and rights to prevent others from creating a commercial venture from the same technology. Lastly, the investment return is generated from commercialization and not from R&D and development.

2.2 FUNCTION OF VENTURE CAPITAL

From a technology developers point of view this is a significantly different objective. The inventor is traditionally focused on achieving technology and performance objectives. The investor's is to primarily use the technology as a means to achieve investment returns and profits. It is very important that these objectives are in sync when a venture is initiated.

2.3 CAPITAL REQUIREMENT

Over time the amount of capital necessarily to bring a company from the point of innovation all the way to commercialization has grown to an average of $12 million. This represents the total capital provided by the venture investors to the company. Because of this there is an extreme urgency on the part of the investor that the company reaches the market in the shortest time possible. The venture community has therefore

also become better at understanding the type of investment risks which they are comfortable undertaking.

2.4 ACCEPTABLE AND UNACCEPTABLE VENTURE RISKS

The investment risks are primarily technology and management. That is, will the technology work as expected and will the management be able to commercialize the solution to the customer. Of these two, the technology risk is relatively easy to handle. The more difficult issue is one of management. The investor in effect does not invest in technology, but in management's ability to commercialize the technology. In addition to these areas, the investors make a value judgment on the market and the economic health of the industry for which the technology is focused. Regulatory and political risks are more difficult for the investors to understand. In short, technology and social issues are areas familiar to the venture community; regulation and politics are not.

More importantly, the venture community has a long tradition of being able to rapidly grow a technology company with superior performance and at a significantly lower cost; however, it has no experience in taking political risks. Likewise, businesses which are more dependent upon regulation and less on performance and costs are less attractive since the market can collapse quickly as a result of political and legislative changes. In terms of business models, the venture investor is also uncomfortable financing new businesses in a new market. By this I mean that they are more comfortable funding a new start-up in a market which has proven successful before for other investors, rather then being the first investor in the market.

As an example, the venture community financed many ventures in the interactive video and electronic mail area long before these became viable industries. The early investors did not realize any investment returns from these investments although it was quite clear that one day they would become realities. Therefore, being the very first entry in the market may not be a fund-raising advantage, although it may be from a technological perspective.

2.5 INFRASTRUCTURE ASSETS

The venture investment process is dependent on a large national market. By operating in a large, uniform market the start-up company can grow even if only a small fraction of the market is reached. In small markets, a new company would need to attract a relatively large market share in order to grow. This is too difficult for new companies where established producers are already servicing the customers. Small companies in large markets, on the other hand, can establish themselves and attract customers without being noticed by larger competitors before they begin to compete against the new entry.

There must also be a culture which accepts business failures and allows the management to start over. Equally important for the venture process to work is the acceptance of rapid personal wealth formation as a reward for successes. This has made it difficult in many Scandinavian countries to establish venture funds.

New companies attract management from established businesses to run their companies. Thus, you often see 2nd and 3rd generation start-up management. This has created a specialty within management for the unique issues facing new companies. Here again, the personal wealth creation is very important to attract people who are willing to take the considerable risk new companies present.

2.6 VENTURE-FRIENDLY BUSINESS SECTORS

Above all, the most important characteristic of a venture industry sector is that it is driven by performance cost. That is, the technologies which succeed are on the basis of technical performance and lower costs. This is the most obvious in the semiconductor industry, where performance rates double every 18 months and the prices are sharply reduced. It is also important that the customer base is technology friendly. In other words, that the customer looks to innovation and new technology to improve performance. This has made it very difficult to use the venture financing model for new businesses in agriculture and heavy industries, where the adoption rate of new technology is slow.

Here again it is also important there are clear successes in terms of the business model to copy. Most people are far better at reproducing an event than to initiating one, and this is true for start-up companies as well.

2.7 RAISING CAPITAL

The portion of companies who ultimately receive capital is very small. At TFI we receive 2500 business plans per year and only fund 10-15. The ones who get funded are then capitalized with other venture funds in order to spread the investor risk and allow the portfolio to diversify. The venture investor is seeking to fund the company which is perceived to have the greatest opportunity to make a profit rapidly for the investor. The areas of concern are market, technology, management, and an ability to exit the company and recoup the investment.

2.8 WHAT THE VENTURE INVESTOR SEEKS

The investor above all else looks for good management to support. The management is reviwed according to experience, ability to take risks, technological background, and ability to attract future capital.

2.9 TECHNOLOGY

The technology must be a base on which the business can grow and be protected. It is very important that the company is not a signle product company, but a generic technology from which multiple products and businesses can grow. Signle technologies

often are best exploited by licensing or joint venture agreements with established companies.

2.10 MARKET

The company must both understand the customer and the market and know how to sell the products to the market. This includes distribution channels, market drivers, and customer trends.

2.11 FOCUS

One of the most difficult areas for new management is to focus. Inventors and technologists are often so "taken" by their technology that it is difficult not to try all opportunities at once. It is the role of the investors, therefore, to make sure that the management stays focused on the business, and build future business from successfully having accessed other markets.

2.12 ELEMENTS OF A SUCCESSFUL BUSINESS PLAN

A business plan is the resume for the company. It must contain a clear vision of how the company is expected to grow and reach its goals. It should contain a clear business model which the company expects to use, an understanding of the manufacturing, sales, and marketing process, and financial projections which clearly show how they will capitalize growth and exit the investment. It is important also that it clearly shows how the company will fend off competition and establish itself in the market.

3. Characteristics of the Environmental Market - Venture Capital and Environmental Investing

3.1 THE ENVIRONMENTAL MARKET

The environmental market in the US is very large and growing at 3-4% per year. In 1994 this sector represented 2% of the GDP and is expected to continue growing. Corporations are starting to take environmental issues seriously and are beginning to apply technology to the area. In addition, there is significant legislation which is expected to drive the future demand for environmental products.

3.2 IT LOOKED VERY FAVORABLE

For the venture industry this seemed like a very attractive industry to capitalize. In the mid 80's, several venture companies started to concentrate in this sector and undertook heavy investing. The investors essentially applied the financing applied in other sectors

to the environmental sector and focused on superior technology and good management. In the last several years it has become clear that this approach did not take hold in spite of the enormous level of expenditures corporations are undertaking (see Fig. 3).

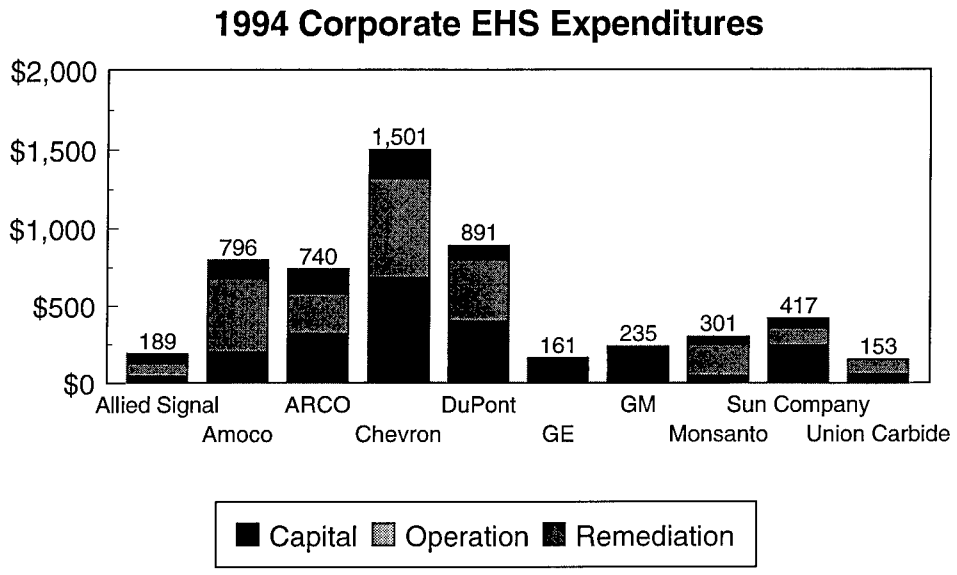


Figure 3. Corporate expenditures (millions of US dollars in the environmental sector)

3.3 COMPANIES ARE SPENDING MONEY

For Fortune 100 companies in the US, expenditures on the environmental, health and safety (EHS) represents 1-3% of revenue and 25% of net profit. This is the largest sector of their operations which is not taking advantage of new technology to reduce cost. The impact on earnings and profits is so large that these companies would be able to have the same impact on profits if they reduced EHS expenditures by $1 or increased sales by $27. The primary reason EHS has grown so large over the years is that the cost is not tracked by companies, nor required by accounting standards to be specifically identified. As for future expenditures, companies are not yet required to report future liabilities from remdiation and clean-up and therefore the senior management of public companies have paid little attention to this area. In addition, EHS costs are a cost center and additional expenditures are not viewed as adding any value to the company. Ironically, most companies would be able to gain greater economic value from effective EHS management and new technology in this area then in their core business.

3.4 BARRIERS TO ENVIRONMENTAL TECHNOLOGY

The environmental technology community has found there to be significant and unexpected barriers to venture investing in the environmental technology market. There is a lack of information regarding the actual problem. Most companies do not publicize their environmental problems and therefore it is difficult for developers to know exactly what problems they are facing.

The product is also largely a legal product in that companies are spending money in this area to meet compliance. Thus, if a vendor cannot show that the technology works exactly as expected, no one wants to be the first user. In the absence of testing and demonstration sites, it has become difficult for developers to get industry to take the initial step.

Most environmental technologies also require permits before they can be employed. Different regulatory standards and requirements have also made it difficult to commercialize the technology. A key part of a new company growth is to have a reference site for the company. In this area few industries want to be a reference for clean-up technologies, e.g., they shy away from publishing the problem in the first place.

Lastly, the venture community has found that there is no established model to commercialize an environmental technology company. The relationship between the pubic, regulators, and industrials is still being developed in this sector and there has yet to emerge a successful model to copy and emulate.

3.5 CAPITAL CONSTRAINTS

From experience in other areas it is clear that the greatest need for capital in growth businesses is in the marketing and sales area. Relatively little is used for R&D and more for commercialization. The environmental technology area expected the reverse to be true and often failed to retain sufficient capital for the commercial stage. And because few experienced positive investment returns from investing in this area, once the commercialization stage was reached there were few investors available. This is the stage where most companies have failed and gone under (see Fig. 4).

3.6 MARKET ACCEPTANCE

It is clear that for an environmental technology company to reach the market there must be a consensus built from the investors, buyers, regulator, and the public in order to accept a given solution for a given set of environmental problems. This process is yet to be defined sufficiently for the investors to know how much capital will be required for success. The dilemma for the investors is that there is no incentive to invest early (see Fig. 5).

1. Idea development
2. Proof of concept
3. Pilot
4. Prototype
5. Application / Demonstration
6. Commercial sales

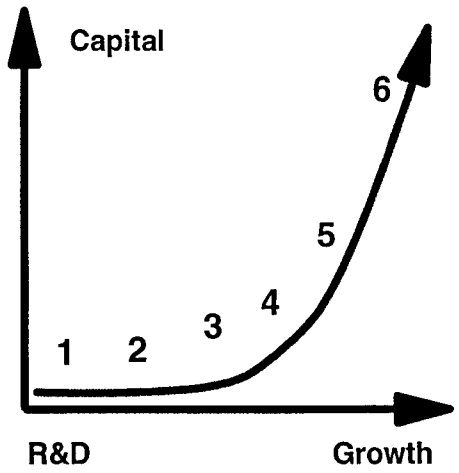


Figure 4. Capital needs vs. Life cycle

- No incentive for early investing

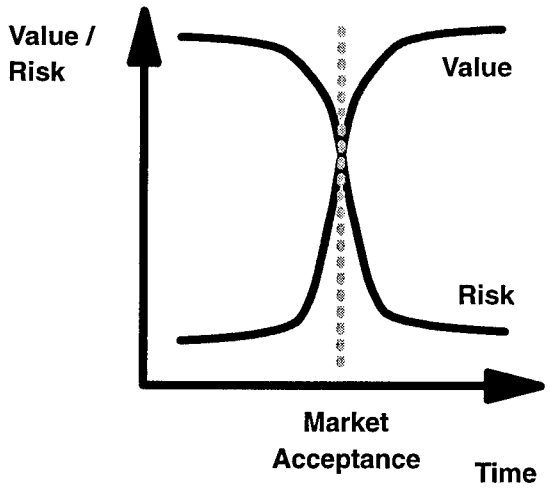


Figure 5. The delima for early VC investment

3.7 RESULTS FROM THE VENTURE INVESTORS

The experience shows that there is a general fear of innovation in the environmental market. Industry does not want to be the first user, regulators are concerned about failure and want to wait for more information, and the public does not accept unproven technology to resolve sensitive environmental issues and also rejects new technology in this area. There is therefore a catch-22 where until a technology is widely accepted it cannot be commercialized, and until it is commercialized it will not receive wide-spread acceptance.

3.8 INDUSTRY NEEDS

The environmental technology industry needs successes in order to attract new capital. It needs economic self-interest drivers over regulatory fines and requirements, large signle markets with even regulation, risk reduction for users so that technology can be relevant, and to understand what is required in order to meet regulatory standards. Most importantly, regulations must be written on a performance basis and not be prescriptive in nature. It has become very difficult to introduce new technology when the regulations being followed also describe the acceptable type of technologies needed to be in compliance. Without performance-based standards little new technology can offer.

3.9 COMPANIES' NEEDS

To attract capital, companies must be a superior investment alternative. They must have a clear plan to build regulatory, public, and industrial consensus around their solution. They must also have professional management which understands what the pitfalls are in this area and a plan to overcome them.

3.10 FUTURE OPPORTUNITIES

In spite of all the barriers and failures of the past, I believe this industry offers some of the best opportunities for the future. EHS-focused technologies can dramatically affect the profitability of industrial companies, perhaps in a greater fashion then new technologies in their core business. There are no technology leaders in this industry and there is therefore an opportunity to establish the leaders. There are no technology standards which offer an opportunity to become market dominant. Because there has not been many successes this industry offers the investor an opportunity to become the primary financier for a whole industry, something not often seen in the venture community. The timing is also such that EHS expenditures are finally affecting operations and income, and therefore economic drivers are beginning to develop.

4. Venture Capital and Defense Conversion - Case Study: Thermatrix, Inc.

4.1 VENTURE CAPITAL AND DEFENSE CONVERSION

As described above, the venture capital community looks for commercialization opportunities more then R&D. They are profit-driven and economically value-added focused. The technology development in the defense industries are primarily technology-driven and cost-plus based. These are fundamentally opposite objectives.

There is a tremendous amount of capital available and used for R&D by the government sector, but little for commercialization. As the R&D ends and the selling starts, one shifts from technology to business drivers. To efficiently interact in this stage with outside venture capital has proven to be difficult.

The different cultures have proven to be the greatest obstacle. On the defense side there is a budget basis and technology focus which is driven towards one signle customer. They view the technology process as programs which have a beginning and an end, and not as a continuos technology development process.

Technologies therefore have a much longer generation then in the civilian side. More importantly, civilian developers use technology as a means and not an end. Also, the defense side does not have the advantage of being driven by competition. Once a program is accepted and budgeted, there are no competitors which drive the development process faster, and there is a tendency to establish rather then build.

The capitalization of defense is also vastly different. On the defense side there are budgets approved up front, often with the R&D cost in the process. Therefore, management does not take investment risk first, they take completion risks. This creates a very different culture. On the civilian side, the developer must venture the initial capital first and then try to acquire customers, quite the opposite of defense procurement.

Risk taken in technology is also very different. The defense process is by design focused on not having any failures and therfore cannot take advantage of trial and error development. In the civilian process the cost of failure is not measured in lives and human terms and therefore there is a much better environment for technology risk-taking. This culture difference is reflected in the management and scientific community as well and makes it very difficult to transfer one technology into products in the civilian community.

Below is a listing of some of the key differences between the defense and civilian technology market:

	Defense	Civilian
Drivers	Technology	Economics
Basis	Cost-plus	Value-added
Market	1 customer	Multiple
Sales	Sequential	Parallel
Competition	None	Continuos, multiple
Product cycle	Long	Short
Product base	Specific	Generic
Sales channel	Direct	Multiple
Customer base	National	Global
Sales process	Build-to-order	Generic
Investment risk	Low	High
Technology alternative	None	Many
Political risks	High	Low

As the above shows there is a vastly different market between the defense and civilian sectors. Therefore, good management and processes have developed differently for the two segments of the economy. Above all, the defense side is heavily influenced by political thinking and risks, which are absent from the civilian sector.

4.2 HERMATRIX, INC.

Thermatrix, Inc., is a venture backed environmental technology company using a technology developed at Lawrence Livermore National Laboratory (LLNL) California.

4.3 TECHNOLOGY

The technology is a flameless thermal oxidation process which is designed to eliminate highly chlorinated VOC emissions. The technology has proven to have 99.999% destruction efficiency (DRE) and is now installed in over 25 industrial facilities. There is ultra low Nox at less then 2ppm. There is also undetectable Co., no catalyst, and completely inert. It is safe, robust, dependable, and requires very little operational skills.

4.4 COMPETITIVE ADVANTAGES

The technology has several features which provides the company competitive advantages in the market place. It is safe and flameless. This allows it to be installed in such areas as oil and gas facilities, pharmaceutical facilities, and chemical facilities. It is highly efficient and requires little energy to be operated. The technology is widely accepted by permitting and regulatory agencies. There is low capital costs and very low operating expenses. It is also scaleable and has multiple applications.

4.5 CAPITALIZATION

The technology was developed at LLNL which invested over $29 million in the R&D. t. The investment was focused on technology and by the end of the laboratory phase was over engineered for the market place. The venture investors have invested an additional $23 million for commercialization (see Fig. 6).

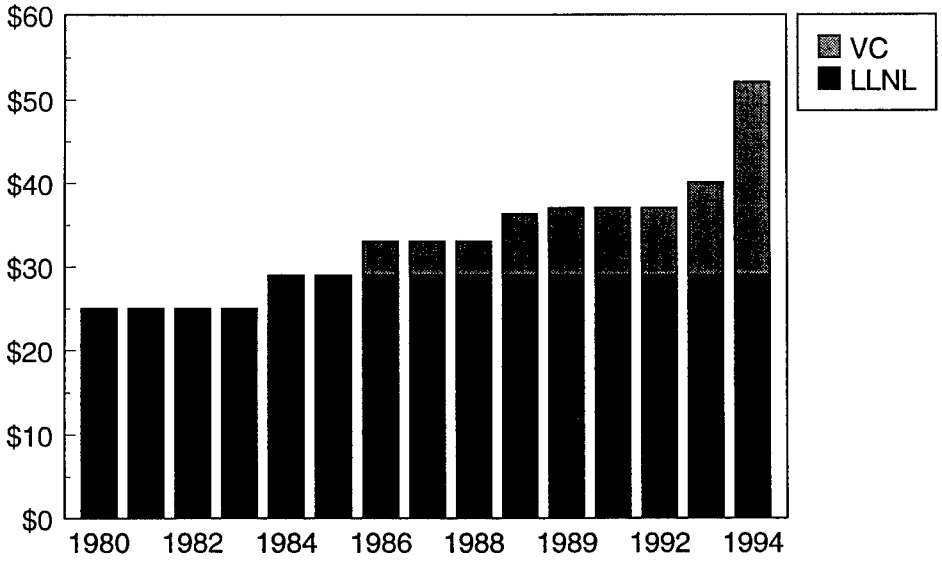


Figure 6. An example from R&D investments

4.6 COMMERCIALIZATION PATH

4.6.1 *Industrial Acceptance*

It was clear that the technology had an application and was a very attractive alternative to incineration for emission control at industrial facilities. It took over 4 years to demonstrate the technology at 15 industrial installations before market acceptance was achieved.

The installations were at close to cost and required continuous involvement by the company. Applications were installed in different industry sectors to increase the market size of the technology. A key concern was regulatory acceptance; this took far longer then anticipated.

4.6.2 *Permitting and Certification*

The company installed its first unit at a chemical facility in California where the regulatory permitting standards were the most stringent. This was done in order to use California as the sample permitting state. However, it took much longer to convince the California permitting agencies to accept the technology then was anticipated. In this

stage the company nearly went under as the cost of keeping the company operational drained the capital available for commercialization.

After California, the company installed units in Texas and New Jersey which have equally stringent conditions for permits and a large industrial base in each state. One unique approach the company took was to go to the regulatory agencies before the industrial customer in order to establish political acceptance of the technology before sales were initiated. This proved to be critical for the industrials to be interested.

4.6.3 *Strategic Partners*

As a new start-up company the technology was not accepted by the market based solely on the company's data and guarantees. The company thus engaged several strategic partners to build customer acceptance for the technology. It went back to laboratories for technology application test and demonstration data, it built relationships with insurance companies to establish it as a credible technology for reducing liability exposure, and hired industrial distributors to ensure industrial marketing.

Compared to traditional venture-backed companies it was clear that Thermatrix, with a clearly superior technology, had to develop much wider customer acceptance before sales could be generated. This was very costly and an unaccustomed role for the investors to finance. In order to access international customers the company also chose a unique approach. The company did not contract with international distributors or set up direct sales offices. Instead, it sold its first international unit to a foreign subsidiary of an existing US customer. This way the acceptance and sales process was shorter and held much less risk for the customer.

4.6.4 *Economic Drivers*

It was also clear early on that the regulatory drivers which were expected to be the basis for the purchasing decision by the industrial customer did not work. In the US one customer bought the unit due to the ease of permits, for example, where permits for an alternative technology proved to difficult. Another customer choose the technology because the application was less costly and they could subsequently reduce the liability exposure. Yet a third choose the technology because of safety and because it could not use an incineration-based technology.

The company is now solely driven by economics and has developed a complete value-added sales approach. For customers to select Thermatirx technology, the company has developed economic value-added data to prove the economic advantage of the technology. In other words, the company can now make sales based solely on the impact of costs, liability, and earnings as opposed to regulatory` compliance. This will become increasingly important as the industry is making economic versus regulatory decisions.

4.6.5 *Criteria for Success*

Thermatrix is now in a growth stage and will require significantly more capital before it is the dominant supplier for this market segment. It is, however, well positioned because of the technology, superior management, and positive economic justification seen by the buying customers. It has a global market both directly and through

subsidiaries of US customers. It is not regulatory driven and provides value-added to its customers. There is broad application for the technology in land gas control, methane conversion, munitions destruction, chemical weapons destruction, and as a non-catalytic converter alternative for diesel engines.

4.6.6 *Lessons Leaned*

Regulatory drivers are not sufficient for sales to take place. By focusing on compliance, Thermatrix found that the industrial sector delayed the purchase as long as possible and did not view the technology as having value-added. The source of the technology is important, and the laboratory validation of performance is critical for environmental applications where the cost of error is high. It is difficult to mix laboratory culture with the for-profit civilian market, and the company went through several sets of management before succeeding.

The venture community has little experience in this area and was not able to provide the kind of value-added which it is accustomed too. There is a great opportunity to become a market leader in this sector and this will probably be sufficient to attract future venture capital for this company. The regulatory barriers are very high and the company had to spend considerable efforts and capital to build regulatory consensus around its technology. The environmental technology market is shifting from regulatory drivers and cost-plus to one of economic value-added and efficiencies. This is good for the technology developers, investment community, and, most importantly, for environmental standards and public health.

INTELLECTUAL PROPERTY ASPECTS OF DEFENSE CONVERSION

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1. Introduction

It is a recognized fact in the areas of commerce and business that intellectual property has significant economic value. Therefore, the rights associated with intellectual property are important, valuable business assets which can be sold, assigned, and licensed like any other business asset. As a result, intellectual property rights form the central part of many business transactions. It is important, because of the value inherent in intellectual property rights, that intellectual property be protected as it is developed and employed in products or services. It is also important in the increasingly competitive world market that the holder of intellectual property right maintain awareness of the marketplace in order to aggressively prosecute infringement of its intellectual property rights and, at the same time, ensure that it is not infringing on the rights of others.

Intellectual property includes patents, trademarks, copyrights, trade secrets, semiconductor chip protection, and contracts. While some see intellectual property as only patents, it is obviously a much broader field. In many cases, such as in the commodities and entertainment markets, trademarks and copyrights are extremely powerful economic intellectual property rights.

The World Intellectual Property Organization defines intellectual property as rights related to:

(a) literary, artistic, and scientific work;
(b) performance of performing artists, phonograms, and broadcasts;
(c) inventions in all fields of human endeavor;
(d) scientific discoveries;
(e) industrial design, trademarks, service marks, and commercial names and designations;
(f) protection against unfair competition; and
(g) all other rights resulting from intellectual activity in the industrial, scientific, literary or artistic fields.

This paper will address the legal and commercial aspects of intellectual property. While it is intended to explain intellectual property in the context of defense conversion

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strategies, intellectual property is really a common theme in business. Therefore, the transition and application of intellectual property to products or services, while there may be some particular market variances, is fairly generic. The following sections will discuss patents, copyrights, trademarks, trade secrets, and licensing.

The Semiconductor Chip Protection Act of 1984 protects mask works, the three-dimensional design of a semiconductor chip, if registered in the United States within two years of its first commercialization. Most major industrial countries have enacted similar protection, although separate registration is generally required. While this protection is an important intellectual property right, no further comments are necessary since the owner's rights are analogous to copyrights.

Additionally, the major intellectual property areas of patents, copyrights, trademarks and trade secrets are all solidly based in the evolution of commerce and legal precedent. In essence, patents protect the substance of ideas, trade secrets may protect the substance or the form or both, and copyrights protect only the form in which the ideas are fixed. These rights have changed and expanded over time in order to foster technical and artistic creativity while stimulating economic value. The United States and other countries have developed their national bodies of intellectual property law in concert with international conferences and agreements which attempt to standardize the extra-territorial rights of each country's citizens.

2. Patents

2.1 INTRODUCTION

In the United States, the patent and copyright system is founded in the Constitution, Article 1, Section 8, which states "the Congress shall have the power to promote the progress of science and useful arts by securing for limited times to authors and inventors the exclusive right to their respective writings and discoveries...." The first U.S. patent statute was known as the Patent Act of 1790.

On December 8, 1994, President Clinton signed into law the Uruguay Round Agreements Act, which brings the U.S. law into conformity with the Agreement on Trade Related Aspects of Intellectual Property, one of the agreements resulting from the Uruguay Round of multilateral trade negotiations under the auspices of the General Agreement of Tariffs and Trade (GATT). The major change in U.S. patent law associated with this Act is that the term of any patent resulting from an application filed on or after June 8, 1995, will end 20 years from the earliest relied-on filing date. In the past, the term of a U.S. patent was 17 years from the grant or issuance of the patent and, in some cases, the termination date could be greater than 20 years from the filing date.

Broadly stated, the U.S. patent system provides that, in return for being granted the right to exclude others from making, using, or selling the patented invention for a limited period of time, the inventor must fully disclose the invention. This allows the public to freely use the invention after the patent term expires and means that, during the

life of the patent, improvements and variations can be made, thereby increasing the rate of scientific progress. The following paragraphs will address the types of patents, what is meant by patentable material, the composition of a patent application, and how an invention proceeds from conception to an issued patent.

2.2 TYPES OF PATENTS

Utility Patents: 35 United States Code § 101 provides that:
Whoever invents or discovers any new and useful process, machine, manufacture or composition of matter or any new and useful improvement thereof may obtain a patent therefore....

Patents applications of this type are commonly referred to as "utility patents", as distinguished from either plant or design patents. Utility patents can also be further classified as mechanical, electrical, or chemical and sometimes are referred to as apparatus, machine, or combination patents. With respect to Section 101, "process" refers to a step or series of steps, an operation or series of operations performed on some matter or substance that produces a physical result; "machine" refers to an apparatus that does something; "manufacture" is something made by man; and "composition" refers to chemical compounds and physical mixtures.

Design Patents: 35 U.S.C. §171 provides that:
Whoever invents any new, original and ornamental design for an article of manufacture may obtain a patent therefor....

Design patent applications consist primarily of a drawing and a single formal claim that refers to the drawing itself for a new, original, and ornamental appearance of an article of manufacture. The term of a design patent is 14 years, which is different from the term of a utility and plant patent.

Plant Patents: 35 U.S.C. § 161 provides that:
Whoever invents or discovers and asexually reproduces any distinct and new variety of plant, including cultivated sports, mutants, hybrids, and newly found seedlings, other than a tuber propagated plant or a plant found in an uncultivated state, may obtain a patent therefor ....

Plant patent applications are similar to design applications in that they contain a drawing showing the distinctive characteristics of the plant and a claim referring to the drawing.

Owners of utility and design patents have the right to exclude others from making, using, or selling their inventions; in contrast, plant patent owners are granted the right to exclude others from asexually reproducing the plant or selling or using the plant so reproduced.

Patentability. Novelty and Nonobviousness

To be patentable, the subject matter of a utility patent must be: new, not previously invented or discovered by another or obvious in view of what is previously known; useful, not frivolous or immoral; and within the statutory patent classes of utility, design, and plant.

The requirements of novelty and nonobviousness are embodied in 35 U.S.C. §102 and §103, respectively. Application of these sections in patent examination is a two-step process. Section 102 evaluation is the first step, or the threshold step, in determining the patentability of an invention. It contains a series of tests which, if applicable, can bar issuance of a patent.

Section 102, Conditions for Patentability; Novelty and Loss of Right to Patent, states:
A person shall be entitled to a patent unless

(a) the invention was known or used by others in this country, or patented or described in a printed publication in this or a foreign country, before the invention thereof by the applicant for patent, or
(b) the invention was patented or described in a printed publication in this or a foreign country or in public use or on sale in this country, more than one year prior to the date of the application for patent in the U.S., or
(c) he has abandoned the invention, or
(d) the invention was first patented or caused to be patented or was the subject of an inventor's certificate, by the applicant or his legal representatives or assigns in a foreign country prior to the date of the application for patent in this country on an application for patent or inventor's certificate filed more than twelve months before the filing of the application in the U.S., or
(e) the invention was described in a patent granted on an application for patent by another filed in the U.S. before the invention thereof by the applicant for patent, or on an international application by another who has fulfilled the requirements of paragraphs (1), (2) and (4) of Section 371 (c) of this title before the invention thereof by the applicant for patent, or
(f) he did not himself invent the subject matter sought to be patented, or
(g) before the applicant's invention thereof the invention was made in this country by another who had not abandoned, suppresses, or concealed it. In determining priority of invention there shall be considered not only the respective date of conception and reduction to practice of the invention, but also the reasonable diligence of one who was first to conceive and last to reduce to practice, from a time prior to conception by the other.

Section 103, the second step, does not come into play unless one can meet the threshold requirements of Section 102. Section 103 requires that the claimed invention as a whole also has to have been nonobvious at the time the invention was made to a person having ordinary skill in the art to which the subject matter of the invention pertains.

Several court decisions relating to nonobviousness under Section 103 have caused the PTO to provide the following nonobviousness standard to PTO examiners (MPEP, Rev. 6, October 1987):

Office policy has consistently been to follow *Graham v John Deere Co,* 383 US 1, 148 USPQ 459 (1966), in the consideration and determination of obviousness under 35 U.S.C. § 103. The three factual inquirers enunciated therein as a background for determining obviousness are briefly as follows:

1. Determination of the scope and contents of the prior art;
2. Ascertaining the differences between the prior art and the claims in issue; and
3. Resolving the level of ordinary skill in the pertinent art.

2.3 PATENT APPLICATION

A United States patent application consists of a specification, which is a written description of the invention and its technological environment, and drawings, when the nature of the invention makes them necessary for understanding the claimed subject matter. 35 U.S.C. § 112 states that the specification shall contain a written description of the invention in a manner such as to enable any person skilled in the art to practice the invention. Accordingly, the specification or drawings, or both, must fully demonstrate how to make and use the invention, and must describe the best mode contemplated by the inventor for carrying out the invention. The specification must conclude with one or more claims particularly pointing out and distinctly claiming the subject matter which the applicant claims as his invention. A claim is a one sentence statement which accurately and precisely defines the property according to the invention.

35 U.S.C. § 111 specifies that an application for patent shall include:

- a specification as prescribed in 35 U.S.C. §112;
- a drawing as prescribed in 35 U.S.C. § 113;
- an oath by the applicant as prescribed in 35 U.S.C. § 115; and
- the fee required by law.

The preferred format for the specification is as follows:

- Title of the Invention
- Cross-Reference to Related Application(s), if any
- Background of the Invention
- Field of the Invention
- Description of the Prior Art
- Summary of the Invention
- Brief Description of the Drawing
- Description of the Preferred Embodiment(s)

- Claim(s)
- Abstract of the Disclosure

2.4 PATENT CLAIMS

Patent claims are the most critical component of the application from a business or economic perspective. Patent claims serve two general purposes. First, they should be carefully crafted to define the invention for the purpose of determining patentability. In this context, the claims define or establish the boundaries of what the applicant is seeking to patent and answer the question of whether, in fact, the invention is new and nonobvious. It is vital that the claims distinguish the subject invention from the prior art. The second purpose relates to the issue of infringement, where the claims are used to determine whether or not an infringement has occurred. In this use, the claims are reviewed to define the bounds of the patent and then to determine whether a specific claim or claims are being infringed.

2.5 THE PATENTING PROCESS

The patenting process consists fundamentally of creating the invention, reducing the invention to practice, preparing the patent application, and prosecuting the application with the Patent and Trademark Office (PTO) until the patent issues.

Since U.S. patent law is based on the first-to-invent rule, it is absolutely vital for the inventor(s) to document conception and reduction to practice in the event that the time of invention is ever called into question. It is said that conception always determines inventorship while actual reduction to practice may determine the date of invention. This is because conception is the formulation in the mind of the inventor of a definite and permanent idea of the complete and operative invention as it is thereafter to be applied in practice. Thus conception is in the mind of the true inventor. Actual reduction to practice occurs when the inventive concept that is claimed is embodied in physical form and demonstrated to be workable for its intended purpose. Actual reduction to practice is an important milestone in the patenting process and can be carried out by others in addition to the inventor(s). Therefore, reduction to practice comes after conception and is a factual input in determining the first-to-invent. While each such determination is accomplished on a case-by-case basis, factors such as diligence in proceeding from conception to reduction to practice, date of filing the patent application, and the concept of constructive reduction to practice (i.e., date of filing becomes date of reduction to practice) all influence the outcome.

Assuming the successful outcome of prior art searches, reviews of statutory bars and issues of inventorship, and other appropriate considerations, the next step in the patenting process is the preparation and filing of the patent application. A patent application includes a complete description of the invention, claims defining the invention (analogous to the description of land defining property metes, bounds and rights in a deed to real estate), a drawing in each instance where the nature of the

invention requires explanation by a drawing, an oath or declaration which specifies, among other things, that the applicant is the original inventor, and a filing fee.

The application then enters the examination process in the PTO. An examiner studies the application and a search is made through all relevant prior U.S. patents and also through patents of foreign countries and publications to find out if the invention is new and nonobvious to a person of ordinary skill in the art to which the invention pertains. The examiner then makes a decision, in view of the study and the results of the search, as to the patentability of the claimed invention and to other formal matters of the application. This decision is communicated to the applicant as the process enters what is known as the "office action phase." In this phase, depending on the initial patentability decision by the examiner, the applicant may accept the examiner's initial decision, ask for reconsideration or reexamination, or further appeal the examiner's decision(s). The various responses that an applicant may take during the patent prosecution process are governed by the Patent Statute, 35 U. S. C., and by the rules promulgated in Title 37 of the Code of Federal Regulations.

In general, most office actions center around the allowing of the claims, as proposed and amended, and obviousness based on prior art Assuming the office action phase results in the allowance of a claim or set of claims agreeable to both parties, the applicant is sent a Notice of Allowance and the patent is granted upon the payment of the issue fee.

3. Copyrights

Copyright, or the legal recognition of authors' rights to own, control and copy their works, probably got its origin around the time of Gutenberg's invention of the printing press in the late 15th century. In the United States, the first copyright act was passed in 1790, after the Constitution gave Congress the power to grant authors the exclusive right to their writings.

As with other intellectual property rights, international copyright law has evolved at various conferences over the years. The United States adheres to the Universal Copyright Convention, the Paris Revision effective July 10, 1974. The most recent U.S. Legislation is the Copyright Act of 1988.

Copyright law protects all original works of authorship at the instant when the author creates the work in a tangible means of expression. The Copyright Act, 17 U.S.C. § 101 et. seq., specifies that works of authorship include the following categories: literary works; musical works, including any accompanying words; dramatic works, including any accompanying music; pantomimes and choreographic works; pictorial, graphic and sculptural works; motion pictures and other audiovisual works; sound recordings; and architectural work.

A copyright holder is granted certain exclusive rights in and to that work. 17 U.S.C. § 106 grants to the copyright holder the right to prevent and seek redress for certain unauthorized uses of a copyrighted work which violate the holder's exclusive rights. Specifically, the owner has the exclusive right to: reproduce the copyrighted work;

prepare derivative works based on the copyrighted work; distribute copies or phonorecords of the copyrighted work to the public; perform the copyrighted work publicly, in the case of literary, musical, dramatic and choreographic works, pantomimes, and audiovisual works; and display the copyrighted work publicly, in the case of literary, musical, dramatic, and choreographic works, pantomimes, and pictorial, graphic or sculptural works.

While the copyright comes to life upon the creation of an original work fixed in a tangible means of expression, there are certain benefits that are obtained by registration in the Copyright Office at the Library of Congress. Registration not only establishes a public record of the claim, it also allows the copyright holder to file infringement suits in U.S. federal courts. Registered copyright holders can recover statutory damages and attorney's fees for infringement after registration, and registration certificates can also be used to prevent importation of infringing works.

The term of a copyright is the author's life plus 50 years, or if a work made for hire, 75 years from the publication or 100 years from the creation of the work, whichever is less.

There are two other important aspects of copyright law: "work made for hire" and "fair use."

In "work made for hire" cases, the copyright generally becomes the property of the person or entity for which the work was made, normally an employer. However, copyright ownership issues often require an examination of the facts relating to the creation of the work. Normally, copyright ownership is vested in the employer when the work is created by an employee within the scope of employment. Copyright ownership for works created by consultants and others often depend on the relationship between the commissioner of the work and the author or creator, including any contractual terms and conditions.

"Fair use", a common law doctrine now codified in 17 U.S.C. § 107, provides that certain uses of a copyright protected work, which might otherwise be considered to be infringing, will be considered to be fair use and shall not result in infringement liabilities. Such uses include use of the copyrighted work for scholarship or research, teaching, news reporting, comment, and criticism. While fair use is an equitable rule to be applied on a case-by-case basis, 17 U.S.C. §107 sets out four non-exclusive factors to consider in determining whether a particular use is "fair use." These include: (i) the purpose and character of the use, (ii) the nature of the copyrighted work, (iii) the amount and substantiality of the portion used in relation to the copyrighted work as a whole, and (iv) the effect of the use upon the potential market for, or value of, the copyrighted work.

In summary, while copyright law does not prevent others from making competitive products, it does prevent them from copying another's copyrighted work and including any portion of that work in their product. Copyright law extends to source and object code as well as to the structure, sequence, organization, and user interface of computer programs.

4. Trade Secrets

Trade secrets are a combination of information that an individual or company uses in business which gives that individual or company an advantage over its competition. It is that something different that makes its products or services unique.

Trade secrets are governed by common law and state law - unlike patents, trademarks and copyrights which are covered by federal statutes and international agreements. The development of trade secret law dates back to the days of Guilds and has evolved as inventors have been forced to decide between obtaining a patent or maintaining their invention as a trade secret. In the United States, trade secret law is founded on a series of cases having to do with employees stealing their employers' secrets. There has been movement in the United States towards a systematic and predictable treatment of trade secrets in all states, i.e., a "Uniform Trades Secrets Act."

Trade secrets derive their economic value from their secrecy, so that the trade secret holder can obtain economic advantage from using something no one else has. A trade secret can consist of any information, such as formulas, patterns, software, compilations, devices or processes, methods, business information, etc.

Importantly, the user/holder of a trade secret must take reasonable efforts to protect its secrecy. Unlike patents, trademarks and copyrights, which provide legal exclusivity and monopoly, trade secrets exist because the competition either does not know they exist or does not know their composition.

Reasonable protection efforts include having employees execute confidentiality agreements; limiting employee access to trade secret information; reviewing written articles, papers, public disclosures and speeches to assure that the secret is not revealed; and requiring that non-disclosure agreements be signed before discussing technical details with others.

Unlike other forms of intellectual property, trade secrets have no term. They are trade secrets so long as they are kept confidential. Trade secrets can be lost through disclosure, either inadvertently or through corporate espionage, independent discovery, or reverse engineering.

5. Trademarks

A trademark is a name, word, phrase or design used to identify a product as coming from a certain source and which indicates to the consumer that the product is of a certain quality that has come to be associated with that mark. The primary purpose of a trademark is to differentiate a company's product from that of its competitor.

The United States Constitution did not specifically grant to Congress the authority to legislate on trademarks as it did for patents and copyrights. The Trademark Act of 1946, known as the Lanham Act, as revised and amended, provides for the registration of trademarks with the Patent and Trademark Office. In 1988, the trademark law was modified to permit registration of marks intended to be used by the applicant. Prior to

1988, a trademark right was created only upon the commercial use of the mark. The 1988 revision provides that registration would be issued provided that the actual use was verified within a limited period of time.

Federal trademark registration gives the owner certain legal rights such as presumption of ownership, right to sue in federal court, right to claim treble damages for willful infringement, and the right to claim protection in foreign countries.

The term of federal registration is indefinite, provided filing and renewal fees are paid, and only registrants can use the symbol "Registered in U.S. Patent Office."

There are several kinds of marks: (i) a trademark is a word, name, phrase, symbol, device or combination thereof, used by a manufacturer or merchant to identify his goods and distinguish them from others; (ii) a service mark is used in the sale or advertising of a service to identify the service and distinguish it from those offered by others; (iii) certification marks are used to describe products or services of persons other than the owner of the mark by certifying their regional or other origin, material, mode of manufacture, quality, accuracy or other characteristics, or that the work or labor on the goods or services was performed by members of a union or other organization; and (iv) a collective mark is used by members of a cooperative, association, union or other collective group or organization to identify the source of goods or services.

Strong, recognizable trademarks are valuable commercial assets and can be significant marketing attractions. Therefore, selection of a trademark is an important undertaking. Trademarks cannot be used to protect generic names that describe a category or type of product marketed by more that one company. The best trademark is one that is completely arbitrary and has no descriptive connotation at all, such as Xerox or Exxon.

Trademarks can be lost if the mark becomes generic as a result of widespread misuse. Thus, too much publicity can actually lead to the loss of the trademark if the mark comes to be used generically to refer to a category of products instead of being used to identify a specific product from a particular manufacturer. It is important, therefore, to use the trademark as an adjective when referring to the marked product.

6. Licensing

The intent of this section is to shift from a focus on the legal aspects of intellectual property to a discussion on one contractual method to transition intellectual property into products and/or services for the marketplace.

In general, there are three methods to transfer intellectual property rights. The owner can sell all or part of his rights to another, the owner can assign all or part of his rights to another, or the owner can license all or part of his rights to a licensee. In the case of a sale or assignment, normally the ownership in the intellectual property is transferred to the purchaser or assignee. In the case of a license, the licensor grants rights in the intellectual property without transferring ownership.

Licenses can be exclusive, meaning that there is only one licensee with the intellectual property rights; nonexclusive, meaning that there may be more than one

licensee; or there may be variations such as an exclusive or non-exclusive license which has territorial or field of use limitations. Licenses can also be classified by subject matter such as technology, publishing and entertainment, and trademark and merchandising licenses.

Since a license is a contract between two or more parties, it can take any form agreeable to the parties so long as it is legally sufficient. Notwithstanding, there are certain fundamental requirements that any effective license should satisfy. These are: the licensor must own the rights which are the subject matter of the license; there must be legal protection for the intellectual property about to be transferred, i.e., valid patent(s) or patent application(s); the agreement must specify what intellectual property rights are being licensed; and the agreement must state what rights, if any, are being retained.

Each license agreement should be crafted to the specific facts associated with that particular arrangement; however, some general comments can be made to demonstrate what areas should be covered and what issues should be addressed. The following is a sampling of representative components of a license agreement. It is not complete, but will give the reader an idea of the level of information required and what areas should be addressed. As always, competent legal or licensing personnel should draft any license agreement.

License Sections/Articles	Content
Preamble	Date, parties, intellectual property
Definitions	Anything that needs to be defined, such as patent rights, licensed product, licensed process, net sales price, territory, field of use, etc.
Grant	What is granted, term of grant, what is not granted
Due Diligence	Milestones, sales goals, march-in rights
Royalties	Up-front payments, progress payments, royalty rate(s) calculation formula, minimum payments
Reports and Records	Frequency, format, contents, access to records
Patent Prosecution	Who files for domestic or foreign patents and who is responsible for the maintenance fees
Infringement	Notice of infringement, who can bring infringement action, who can take what action in the event this intellectual property is found to infringe on another
Product Liability	Indemnification, insurance
Export Controls	Who is responsible to seek export licenses, if any are required
Non-Use of Names	Limits licensee's use of licensor's name
Assignment	Yes, no, or maybe
Disputes	Arbitration, legal recourse
Termination	What acts trigger termination

Payments, Notices and Other Provisions	How, when, and where to make payments; provide notice; points of contact
Miscellaneous	Entire agreement statement, how to mark product(s), governing Law

As stated, this is not an all inclusive list, but it does indicate that the licensing process is not complete until the terms and conditions agreed upon at the end of negotiations are put into writing.

7. Summary

The intellectual property issues surrounding the economic exploitation of technology are generally independent of the question of whether the technology holder is a defense laboratory, defense contractor or commercial company. The fundamental aspects of identifying the intellectual property, protecting it as it is developed, following the proper legal steps to establish ownership rights, and assessing the market value or potential are not questions of what type of entity develops the intellectual property. Granted, a commercial company is better suited to the transition from idea to commercial product development and marketplace entry; however, these actions are business-driven and supported by the intellectual property, not controlled by it. The basic intellectual property questions which must be answered are: is the creation something which can be protected as intellectual property?; who owns the resulting intellectual property?; and what do we do with it?

Defense conversion is therefore a business and market challenge, not an intellectual property challenge. To make defense conversion work, defense laboratories must make their technologies available for licensing to commercial companies, and defense contractors should develop strategic relationships with commercial companies already established in the markets for which the defense contractors' technology is applicable. The greatest probability of business success exists when the introducer of a new product embodying intellectual property is already successful and recognized in that marketplace.

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MEASUREMENT AND EVALUATION OF TECHNOLOGY TRANSFER FROM U.S. DUAL-USE AND TECHNOLOGY PROGRAMS

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Abstract. *Gauging the impact of federal technology transfer and dual-use technology concerns policy makers. The simplest measures indicate increasing levels of technology transfer for the past decade but nothing about economic impact. Most technology transfer is transferred knowledge, and measuring its economic value is an old problem. However, dual-use activities can be observed to see if real unified civilian/military production is created. Technology transfer measurement suffers from the lack of specific models of how technologies are commercialized. There arc ways around such problems through a mechanism specific approach utilizing intermediate data and surveys to create indicators of the economic benefit of technology transfer. Dual-use activities may require an alternative approach.*

1. Introduction

Academics and Government policy makers have long sought a systematic way to detect, measure and evaluate the effects of U.S. federal programs which transfer technologies to and engage in, cooperative R&D with the private sector for purposes of dual-use technology development and general competitiveness. This need has steadily intensified during the current era of federal technology transfer programs begun in 1980 with the passage of the Bayh-Dole and Stevenson-Wydler Acts. These two acts authorized and encouraged technology transfer from federal laboratories to industry and other nonfederal entities, particularly through the licensing (exclusive or otherwise) of government inventions to the private sector. Amendments to the Stevenson-Wydler Act passed in 1986 and 1989 provided further encouragement to technology transfer activities as well as authorization for cooperative research and development programs (CRADAs) between federal laboratories and nonfederal entities (mostly private firms). Finally, the 1993 Defense Authorization Act created the Technology Reinvestment Project (TRP) operated by the Pentagon's Advanced Research Projects Agency (ARPA). The TRP provides

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technology development funds to private sector firms for development of products with dual use (i.e., in both the military and civilian sectors). Also in 1993, the Clinton Administration renamed the Pentagon's Defense Advanced Research Projects Agency, removing "Defense," and reverting to its original name, ARPA. This move was thought to be symbolic of an increase in dual-use R&D activities.

Although these legislative endeavors marked new directions in federal policy, they were based on nearly a century of federal technology cooperation with the private sector. These precursors of current federal technology cooperation include still-ongoing programs to support important sectors of the U. S. economy. In addition to well known public/private cooperation in **defense,** close cooperation has occurred in three other sectors: **agriculture** (beginning with the 1887 Hatch Agricultural Experiment Station Act, and now focused on the Agricultural Research Service, the Cooperative Research Service, and the Economic Research Service); **aeronautics** (through the National Advisory Committee on Aeronautics [NASA], and its successor organization, NASA); and **health** (primarily through the National Institutes of Health).

This paper focuses on the measurement and evaluation of federal dual-use and technology transfer activities. Dual-use activities span a wide spectrum of R&D activities from basic research to product development. Likewise, "technology transfer" is a political rubric which covers not a singular activity, but many different mechanisms for interchange among federal agencies, laboratories and their partners. The Federal Laboratory Consortium has identified eleven technology transfer mechanisms, and, more recently, an interagency working group operating under the aegis of the Interagency Committee on Federal Technology Transfer (chaired by the Commerce Department) has identified a more succinct list of the most important ways by which federal technology transfer occurs. These mechanisms vary in importance from agency to agency, but provide a good categorization of the lion's share of today's federal technology transfer. They are:

- licensing
- cooperative research and development (including CRADAs & Space Act Agreements)
- technical assistance
- reimbursable work for nonfederal partners
- use of facilities exchange programs, and
- collegial interchange and conferences.

Some would add the formation of new, spin-off companies to this list of mechanisms, while others consider that activity to be subsumed into one or more of the other mechanisms, primarily licensing.

Some technology transfer events involve only a single mechanism, while others may span two or more. For example, a collegial interchange may lead scientists from a firm and a lab to design a cooperative R&D project resulting in a CRADA. From that experience, the firm might license some intellectual property from the laboratory. Once a

relationship is developed between a firm and a laboratory, that relationship may come to encompass many technology transfer mechanisms.

Technology transfer is differentiated from most other federal technology programs (such as the TRP) in that the only thing transferred outward (and sometimes inward) is knowledge, expertise and technology. In most other technology cooperation programs, including dual-use programs, federal funds, often matched by the recipient, are granted for the purpose of technology assistance or development, but without concomitant transfer of federal technology.

2. Does Technology Transfer Work?

Many in government, both on Capitol Hill and in the Executive Branch, are asking whether increased technology transfer activities and increased spending on dual-use and other technology programs has had a significant impact on the economy, and whether that impact was high relative to the federal dollars spent. The question is important but difficult, perhaps impossible, to answer fully.

With regard to technology transfer programs, there is evidence that the Bayh-Dole and Stevenson-Wydler legislation seems to have produced the desired result. The number of both cooperative research and development agreements (CRADAs), license agreements, and royalties therefrom are increasing steadily as can be seen in Figures 1 and 2. Some academic studies also support the conclusion of preliminary success, with one major survey of large R&D intensive firms concluding, *inter alia,* "...the tech transfer legislation has "worked" in the sense that companies are increasingly tapping the knowledge, expertise and facilities in federal labs [1] (although many companies favor informal or collegial relationships with federal labs over the formal licensing and cooperative R&D programs established by the legislation).

Notwithstanding the demonstrated increase in activity, the data in Figures 1 and 2 say little about the economic or social impact of technology transfer activity since 1980. To probe the economic impacts of technology transfer and dual-use programs requires more sophisticated collection, organization, and interpretation of data on such programs.

2.1 ADMINISTRATION AND CONGRESSIONAL INTEREST IN MEASUREMENT AND EVALUATION

There is increasing interest in and support for measurement and evaluation of federal technology activities. The Clinton campaign advocated evaluation of technology programs in its campaign technology policy statement [2]. Shortly after the inauguration, the importance attributed to evaluation of technology programs was reaffirmed in 'Technology for America's Economic Growth, A New direction to Build Economic Strength [3]. In that document, the Administration stated that "...every federal technology program, including those of longstanding, will be evaluated against pre-established criteria to determine if they should remain part of a national program."

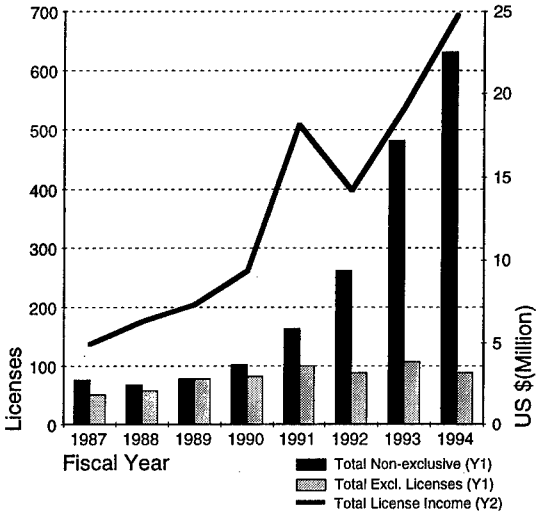


Figure 1. Federal Laboratory Licensing Activity
(Data: OMB - 1991 "bump" represents a one-time AIDS test payment.)

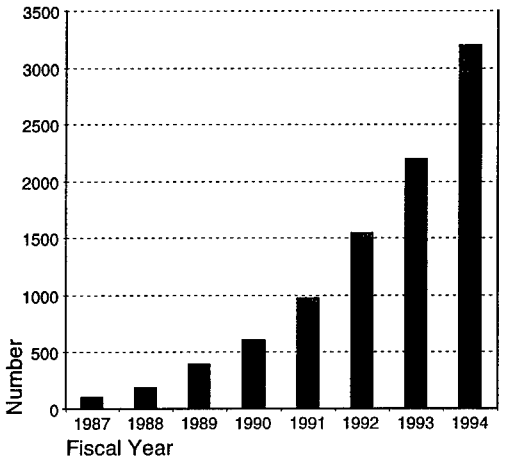


Figure 2. Federal Laboratory Active CRADAs
(Data: OMB - 1994 is estimated.)

In addition to the Administration, the 103rd Congress became increasingly interested in evaluation of technology programs (and of other government programs, as well). Bills governing technology as well as other programs began to incorporate evaluation requirements. In what may become landmark legislation, the Government Performance and Results Act (GPRA) initially required that a number of pilot programs measure performance against established criteria and mandated the use of quantifiable goals and objectives. A number of technology agencies and research programs are among the pilots established to date.

As the 104th Congress opened with new Republican majorities in both houses, the tenor of Congressional opinion about technology programs changed. Once enjoying modest bipartisan support, many technology programs are now coming under intense scrutiny, particularly during the appropriations process [4]. For some Republican Congressmen, the opposition to these programs is ideological. Others, however, are skeptical of the ability of government-run technology programs to create a positive return to the economy, and still others doubt whether technology programs and technology transfer activities (whether they "work" or not) are the most effective way for the federal government to provide assistance to private sector technology development.

2.2 MEASUREMENT AND EVALUATION OF KNOWLEDGE IN TECHNOLOGY TRANSFER PROGRAMS

Knowledge is the coin of technology transfer. Knowledge may be embedded in formal intellectual property documents, such as licenses; may reside in scientists and engineers from the public and private sectors who interact; may be created by cooperative R&D programs; may be embedded in transferred materials, processes and prototypes; and may move in many other ways Because the medium of technology transfer is some form of knowledge, to measure the economic value of technology transfer is to measure the economic value of knowledge. This is an old conundrum. Economists and others have struggled with the problems of defining and measuring the economic value of knowledge for many years without particularly satisfying results. Economic analyses which require dollar valuations of knowledge are often forced to employ surrogates, sometimes crude surrogates, to produce that value. The use of such surrogates reduces the outcome to a (sometimes misleading) approximation.

Over the past decade a number of studies have attempted to find ways to detect economic benefits resulting from federally-funded basic research [5]. In addition, a few private firms have undertaken efforts to determine the impact of and returns from corporate R&D activities and internal technology transfer. While these latter two categories of investigation look at phenomena which are different from technology transfer, they nonetheless use techniques and produce a body of knowledge which students of technology transfer can draw upon. Like these investigators, technology transfer evaluators are trying to find a way to attach an economic value to knowledge. However, students of technology transfer have a decided advantage -- they focus on the interface between the R&D organization (in this case, federal laboratories) and the commercial

sector which must transform knowledge into economic value. At this interface (i.e., the point of transfer of knowledge between organizations), one can use metrics which are not generally available in evaluations of basic research and are sometimes absent from internal corporate technology transfer.

2.3 MEASUREMENT AND EVALUATION OF FEDERAL TECHNOLOGY TRANSFER PROGRAMS

In the past two years, the Executive Branch has begun a number of activities to establish measurement and evaluation (M&E) systems for federal technology transfer programs At present, an interagency working group is developing an information system with a set of definitions for data elements which describe technology transfer activities in most federal R&D agencies. This data set may lead to the creation of a virtual interagency database which will permit, for the first time, identification and analysis of the activities under the Stevenson-Wydler and Bayh-Dole Acts on a government-wide basis. The data elements which have been defined by the working group are activity measures (sometimes referred to as input measures). These measures, taken at the technology transfer interface, will provide only inferential evidence of economic impacts, but constitute an essential beginning. Without comprehensive data on technology transfer events, it will be extremely difficult to design, collect and interpret impact measures.

2.4 MEASUREMENT AND EVALUATION IN AN IDEAL WORLD

What would constitute ideal measures of success for federal technology transfer and other technology programs? Federal policy makers in both the Executive and Legislative Branches want metrics which give them information about the kinds of technology programs that have been the most effective in contributing to the economy and to the social well-being (e.g., health) of the nation. They want this information in real time to help them make decisions about investments of marginal dollars in future technology programs. They also want information (both numeric and anecdotal) about the economic contributions of technology projects of the recent past in order to provide political support for continuing investment.

Is it possible to provide policy makers with these kinds of metrics of technology transfer? Unfortunately, the answer has more negatives than positives. It is possible (and even easy) to collect anecdotal information about successful technology programs. In fact, the very successful events will tend to stand out and be used by their sponsors to market their programs. For this reason, systems which constitute collections of anecdotal information should be carefully balanced to include stories of not-so-successful programs and events. The latter are also valuable as evidence of what may not work.

Success measures of dual-use activities are similar to those for technology transfer. ARPA has expressed a requirement that metrics should be observable, indicative, and timely. Unfortunately these criteria are often mutually exclusive. For example, most of ARPA's activities do not become observable for a considerable time after R&D has

ended, and this makes timely measurement difficult, if not impossible. While retrospective studies of dual-use and other technology programs are possible, the time lags inherent in the technology commercialization process will normally mean lengthy gaps between events and visible economic benefits. Furthermore, retrospective studies tend to be resource intensive and costly, so it is unlikely that a sufficient number will be funded.

Regardless of the studies undertaken, it is unlikely that researchers will discover many significant new ways to link inputs and economic benefits using mathematical relationships. Any hope of finding mathematical models describing the economic impacts of federal technology transfer is unlikely to be realized, given the complexity and unpredictability of the many actors and events which make up the technology transfer process.

However, ongoing work on metrics and the development of databases on federal technology transfer events may permit analysts to create indicators which will serve as surrogates for actual impact data. These indicators would be a combination of activity measures and impact data derived from retrospective studies. Although they would be expensive to create and only approximate, such indicators would nonetheless provide policy makers with considerably more information than they have at present.

3. Dual-use Technology Development And Defense Conversion Programs

The term defense conversion has fallen out of political favor in the United States, and the current political debate is focusing on dual-use technology activities. Although many billion-dollar defense conversion programs (such as personnel assistance and community support) continue, this paper also focuses on dual-use technology activities. Dual-use programs are both new phenomena and old hat. Many defense activities are inherently dual-use, and have been undertaken for many years without focused programs and official fanfare. One has only to think of semiconductors, microelectronics, and computers to see that fields which began with a defense stimulus have grown to the point where the civilian markets are now larger than those in the defense sector.

Current dual-use activities are concentrated in a few areas of the defense budget. The most important are:

- The technology transfer activities of the Department of Defense laboratories and Energy Department weapons laboratories make important contributions to dual-use technologies. The technology transfer activities of these laboratories constitute an important fraction of all federal technology transfer. The cooperative R&D activities of the DOE Defense Programs laboratories (the weapons labs) are based on an appropriated investment of approximately $250 million per year. No good data yet exist on the amounts expended by DoD laboratories on cooperative R&D and other

technology transfer activities, but it is probably somewhat less than the DOE weapons laboratories.

- Tech base research (under DoD budget codes 6.1 and 6.2) in the armed services and defense agencies has wide applications to the civilian economy and is an important element of federal dual-use activities. One DoD official has estimated that 90% of defense basic research (6.1) and 50% of exploratory development (6.2) has dual-use potential. This is potentially a very significant contribution to both the military and civilian economy. These two research categories totaled $4.3 billion [6] in 1995 of which the dual-use portion would be $2.6 billion under the above formula.
- A number of current programs have been redesignated, redesigned or recently created to meet civilian as well as defense goals. The most visible example is the Technology Reinvestment Project (TRP) managed by a multi-agency group led by ARPA. In the TRP, technology transfer may occur from firms in the civilian sector to the Pentagon, since in many areas, civilian technology development is now outpacing military technology development. In addition, the TRP contributes to defense conversion by funding manufacturing extension centers which could help lower tier defense contractors prepare themselves to compete in civilian markets. The TRP was authorized and funded in the 1993 DoD Authorization and Appropriations Acts, and funding reached a half billion dollars before it was reduced by the new Republican majority in the Congress. The TRP is opposed by many in the Republican majority and its future is uncertain.
- A number of other defense R&D programs (all carried out by ARPA) have been designated as dual-use by the Office of Management and Budget. These include the electronics and materials initiative, computing systems and communication technologies, federal support for Sematech (to end after 1996), advanced simulation, and refocused Small Business Innovation Research (SBIR) programs. The size of these ARPA R&D programs (in the 1995 federal budget) was almost $1.4 billion.

4. Problems in Evaluation of Benefits From Technology Programs

There are serious problems associated with trying to measure and evaluate technology programs. Data that one would like are unavailable, proprietary, or too expensive to gather. However, even if the necessary data can be captured, there are still theoretical problems which impede the development of working M&E systems. These conceptual problems have to be understood and resolved before such a system can produce value for policy makers. This section discusses these problems and how they can be mitigated.

4.1 NON-ECONOMIC BENEFITS FROM TECHNOLOGY PROGRAMS

Federal technology programs have many goals in addition to improvement of the nation's economy, and many benefits from federal programs lie outside the sphere of economics. Technology programs can, and often do, contribute to improved health care, to

environmental protection and restoration, and to greater efficiency at all levels of government. The full value of these social benefits is sometimes difficult to express in economic terms since the results often include things which are not traded in markets and for which no real "prices" exist. That is not to say that evaluation of non-economic benefits is not possible. Indeed, a number of techniques are in use, beginning with a simple, though systematic, collection of anecdotal evidence. However, methods of evaluation used for such non-economic benefit are beyond the scope of this paper.

4.2 ECONOMIC BENEFITS FROM TECHNOLOGY PROGRAMS - THE LACK OF MODELS

There are no widely accepted models to explain the path by which technologies from government labs, or other sources such as universities, move through firms into commercial products and processes to create value. Unless one has a clear understanding of that path, it is difficult to design a detailed measurement and evaluation system to calculate economic benefit. Many systems designed to estimate economic benefit are implicitly based on the classic linear model of technology flow, i.e., basic research leading to applied research; leading to development and engineering work; leading to product or process design. This model assumes that technologies which are transferred to commercial firms, at whatever stage of research, continue to flow down a more or less "straight-line" path toward commercialization.

However, today's theories of technology commercialization prefer a model which is linear only in the sense that movement is mostly in one direction, but with many feedback loops, and many important non-technology inputs. Such a model introduces a high degree of complexity. 'The Implicit use of the old linear model in technology transfer evaluation avoids the need to describe the complex reality of technology commercialization, but limits the veracity of the evaluation results. Furthermore, no single model, however complex, could describe the very large number of trajectories which technologies follow from their introduction into the commercial arena to commercialization. In fact, a very large number of individual models would be required. In sum, identifying and validating all the possible models which explain the commercialization of transferred technologies would be a task of at least Herculean, and possibly infinite, proportions.

4.3 ECONOMIC BENEFITS FROM TECHNOLOGY TRANSFER - FUDGING THE MODEL PROBLEM

The difficulty in devising proper models to describe how technology transfer creates economic value represent a significant but not insurmountable problem. The usual approach is to ask the recipient to attach a value to the benefit of the transferred technology, implicitly shifting the responsibility for identifying an appropriate model to the receiving end. Recipients are usually asked to state the benefit realized from technology transfer experience (lower costs, new sales, changes in employment levels,

etc.) in concrete terms. Many recipients have been willing to translate these technology transfer benefits into a dollar value. However, even when recipients are carefully instructed as to methodology, they may not be able to determine how the transferred technology should be apportioned among other important factors, and evaluators will therefore be uncertain as to whether recipients were able to perform a credible analysis or simply assigned an arbitrary fraction of the economic outcome to the transferred technology.

4.4 ECONOMIC BENEFITS FROM TECHNOLOGY TRANSFER - A MECHANISM SPECIFIC APPROACH

As discussed in the Introduction, there are many mechanisms through which federal technology and expertise can be transferred to the commercial sector. Each of these mechanisms would require one or more different models and therefore different M&E strategies. The following three examples may help illustrate the point. In the first case, a defense lab engages in a CRADA with a division of a large firm doing research in a specific technical area in which both the lab and the firm are interested. The project is conducted successfully, but the R&D outcome indicates the initial technical approach is wrong. Armed with that knowledge, the firm begins a new internal R&D program which scores a breakthrough in a related area. After several more years of development, the division is spun off into an independent subsidiary which then licenses a complementary technology from another firm and incorporates both technologies into a new production process requiring fewer employees. The new process produces both a military and civilian product through the same process. In the second case, contact is made between a small manufacturing firm and a federal laboratory through a technology intermediary (such as a state technology extension or the National Technology Transfer Center - NTTC). A federal laboratory engineer is dispatched to assist the business in re-engineering a part of its production system. The business modifies its manufacturing process and is able to increase its output while lowering its per unit costs. In the third case, several federal lab scientists leave their employment, start a new company, and secure the license to an invention they made while working at the lab. With financing from their savings and relatives, they fashion a prototype which is successful and attracts critical additional funding from a venture capital fund. They now run a $100 million company with many employees [7].

Each of the above examples would require a different measurement strategy. In fact, in technology transfer activities similar to the first example (dual-use R&D in a generic technology area), the firm might have to employ an extremely complex analysis to isolate the effect of the cooperative R&D. Firms are rarely willing or able to make such complex analyses. However, the second example offers a somewhat easier M&E challenge as the technology transfer inputs are close to the economic results in time and the technology trajectory is relatively straightforward. In the third example, there is some complexity, but analysts often hold all the non-technology transfer inputs constant, on

the assumption (possibly incorrect) that the new start-up firm's success is due entirely to the new technology.

From these examples, it is evident that the complexity of the model required to explain a technology transfer outcome is roughly proportional to the time and distance on the technology trajectory between the technology input and economic results. Thus, when the federal technology input is generic and far from commercialization, devising M&E systems is more difficult than when the federal input is close to the commercialization stage as it is in technical assistance programs. It should come as no surprise that technology transfer M&E systems at the state level concentrate on technical assistance; while relatively few systems offer impact information on other technology transfer mechanisms.

4.5 ECONOMIC BENEFITS FROM TECHNOLOGY TRANSFER - MEASURING THE COSTS

Analysts and policy makers have often wanted to express the benefits of technology transfer in terms of cost-benefit ratios or as a return on investment (ROI). In order to do this, it is necessary to develop a way to capture the costs of federal technology transfer. In contrast to the benefits, the costs of technology transfer are somewhat easier to quantify, and particularly those of the federal laboratories. However, there are conceptual problems on the cost side as well.

In the past, federal R&D was planned and undertaken primarily to fulfill agency missions. The cost of technology transfer was the additional cost of facilitating the transfer; generally a modest figure. However, the recent emphasis on increasing the percentages of laboratory R&D budgets devoted to cooperative activities with industry has meant that criteria for laboratory R&D investments often include a technology transfer element. In the case of the Department of Energy, money has been specifically appropriated to fund CRADAs with industry. Technology transfer from federal lab activities which are specifically designed to support both commercialization as well as public missions and a higher cost, attributable to the technology transfer element. Apportioning this additional cost between the public and commercial goals of the activity may be difficult.

In addition to the public cost of supporting technology transfer, the private sector incurs significant costs to commercialize federal laboratory technologies. Are these private sector costs to be included as part of the overall cost of federal technology transfer activities? If so, even more complexity is added to the equation. Just as firms have problems apportioning the contributions of federal technologies to new products and processes, they often have problems separating the development and commercialization costs of federal technologies from the costs of other product development activities.

4.6 ECONOMIC BENEFITS FROM TECHNOLOGY TRANSFER - MEASUREMENT AND EVALUATION STRATEGIES

As has been noted, few arithmetical relationships are likely to exist between measurable technology transfer inputs and economic benefit. Such relationships that exist will normally be measurable only at the firm level, but some of these measures can be extrapolated to estimate national benefit from particular technology transfer mechanisms. However, by taking a mechanism-by-mechanism approach, it may be possible to create a series of M&E systems which produce at least a good approximation of the economic benefits of the federal technology transfer effort. In most cases, evaluators will have to satisfy themselves with surrogate measures for outcomes which themselves are difficult, if not impossible, to capture in quantifiable terms A summary of possible approaches to deriving indicators of economic benefit for each of the technology transfer mechanisms identified by the Interagency Working Group follows below (arranged in declining order of the author's perceived ease of measurement).

New company formation: While not a mechanism in and of itself, new company formation based on federal laboratory technologies constitutes a unique opportunity to capture economic impact information. Many standard economic indicators such as sales, profits, and capital investment are available. In most cases, the transferred technology was the sine qua non of the new company, and thus, one can be comfortable in attributing the company's entire economic performance to it. (Although other factors, such as the enthusiasm of the entrepreneurs and the quality of management are also critical.) Organizations which have a high rate of new company formation from their R&D activities (MIT is a good example) often measure their contribution to the economy by summing the economic activity (i.e., sales, employment, exports) of their spin-off firms. The costs to the federal government of new spin-off firms from laboratories are probably easy to calculate as long as one can decide on which elements to include. For example, was the R&D which led to the spin-off funded with an eye toward commercialization, or was it purely mission R&D which generated a fortunate commercial outcome?

Licensing: Royalty payment on licenses of technology is one of the few data elements in technology transfer where there is a relatively straightforward mathematical link to economic benefit Most license agreements require periodic royalty payments based on a percentage of sales. The royalty percentage may be a somewhat arbitrary indicator of the contribution of the licensed technology to eventual sales, but it is one of the few technology transfer indicators which is determined through market activity. Using well known macroeconomic relationships, one can use royalty percentages and income to derive sales volume, and then to calculate other economic impact data, including employment. (One is more confident of such calculations when they are done on an industry-specific basis.) The costs of federal laboratory licensing activities are usually very low, normally consisting of the operating expenses of the licensing offices.

Cooperative R&D (including CRADAs): Information reported by private sector partners in cooperative R&D (from surveys, or under requirements of a CRADA

agreement) can provide evidence of economic outcomes, particularly to individual firms. Firms can be asked to provide data on, inter alia. changes in costs, sales, investments or other factors resulting from a cooperative R&D project. Alternatively, they can be asked simply to estimate the total economic benefit to them from the project (fudging the model problem). Invention disclosures and patents by companies as a result of cooperative R&D are also useful indicators since they are evidence of commercially valuable knowledge. The technology transfer authorizing legislation envisioned that laboratories would undertake CRADAs which supported mission goals as well as commercialization. With the exception of some DOE laboratories which have appropriated funds for CRADAs, most federal labs pay for their share of CRADA R&D from their program funds. These costs are relatively easy to calculate, although some definitional problems exist.

Technical Assistance: Most technical assistance which is provided by federal laboratories is undertaken to solve technology-related problems in the recipient firm, most of which are small and medium-sized companies located in the state or region of the laboratory. Technical assistance is often mediated by state technical extension programs or regional/national organizations such as the NTTC. Once again, the principal source of data on impacts lies in the assisted firm. Most publicly funded technical assistance programs are provided gratis to the recipient~~ with the only requirement that the recipient provide data on how the assistance impacted the firm. These data usually try to capture phenomena such as cost reductions and sales increases, and frequently include employment changes as well. However, a number of efforts to measure job creation/retention have shown that jobs data are frequently biased toward "success." The costs of technical assistance consist primarily of the opportunity costs of the laboratory personnel who perform the assistance activity.

Use of Facilities and Reimbursable Work for Others: Many federal laboratories have technical facilities which are unique. These are often made available to private firms, with the firm normally paying some portion of the facility's operating cost. Most of these facilities are in Department of Energy and Department of Defense laboratories as well as in NASA field centers. They are often facilities which no single firm is likely to build because of their technical complexity and/or cost. Likewise, reimbursable work for others is normally undertaken because the laboratories have unique scientific and technical skills in addition to their physical facilities which make them the only source for some highly specialized R& D. The outcomes of these two technology transfer mechanisms are almost always some form of knowledge, occasionally embedded in a material or process. Any intellectual property generated usually belongs to the firm, so impacts will not be reflected in licensing income to the laboratory. The fact that a firm is willing to spend scarce R&D dollars outside its corporate boundaries is, in itself, a positive indicator of the value of the federal laboratory's ability to contribute to the firm's technical progress. Once again, firms can be asked to estimate the value of such outputs from facilities use and laboratory research in dollar terms; and some may be able to do so. The costs of these efforts are almost always expressed in the dollar fees paid, and are well known to both sides. In the event of free facilities usage (less common), one would have to calculate the

opportunity cost of the use of the facility. The question of whether to include depreciation has frequently complicated the calculation of such costs.

Collegial Interchange, Conferences and Exchange Programs: Collegial interchange which takes place at conferences and other less formal meetings as well as exchange programs which bring industry and laboratory scientists together through more formal mechanisms are important in fostering person-to-person contact, the primary channel through which technology transfers.

The informal interchange mechanisms are often said to be, in the aggregate, the most important form of technology transfer between federal labs and industry. More formal exchange programs have the potential for considerable value, but the level of such activity is low compared to other forms of scientific contacts. Furthermore, informal interchanges are often precursors of other, more formal, mechanisms of technology transfer.

Random sample surveys could elicit the opinion of firms about the value of specific interchanges which impacted the firm. Some dollar value for the contacts might be inferred, particularly in terms of cost savings. However, this is clearly the most difficult type of technology transfer to measure with quantifiable data. The cost of these interchanges would also be more difficult to identify, although it is probably low.

Dual-use Technology Development Activities. As noted above, much of the dual-use activity of the past occurred without a major strategy to promote it. Therefore, not much effort was expended to collect data or develop a systematic way to gauge the impacts of the program. Some past dual-use activities (aerospace, microelectronics, etc.) have been so visible in creating significant civilian applications for new technologies alongside the military ones, that the question of a systematic evaluation effort is largely moot. Evaluations of some dual-use programs face difficulties beyond those of technology transfer. Much of the R&D activity currently identified as "dual-use" is in the basic and exploratory development stage. Evaluation of these "early-stage" of research projects involve the well known difficulties with the evaluation of basic research discussed earlier. Furthermore, ARPA has always felt that the practical results (military or civilian) from its activities were likely to be many years down the road and for that reason has not established a system (other than collecting anecdotes) to gauge the impacts of dual-use activities.

Evaluation of programs such as the TRP pose fewer theoretical problems. The TRP has laid out a three stage process to track its grants: (1) During the grant period -- Firms and consortia which apply for TRP grants submit technical and business plans. One can monitor activity to see whether what was proposed is actually being carried out. (2) After the grant period -- One can monitor the continuing progress in technology and product development to see whether the project's technical and business goals are being achieved. (3) Post-project impacts -- One could utilize the same techniques suggested for technology transfer evaluation to gauge the economic impacts of TRP projects and other dual-use activities. However, additional and perhaps more important results must be evaluated where dual-use is concerned. The most important impact of a dual-use program

is whether the products and processes created are actually produced in a unified facility and marketed to both civilian and military buyers.

5. An "Indicator" Approach to Measuring the Economic Impacts of Technology Transfer

What approach might one suggest for a system which could signal the likely economic impacts of federal technology transfer in a way that would benefit policy makers? As noted above, technology transfer is a fragmented activity consisting of a number of mechanisms, each requiring a different M&E approach. In virtually every case, economic impacts will lag the events being evaluated by a period of months or, more likely years. Thus, studies or surveys to ascertain economic outcomes will not produce information about the efficacy of technology transfer programs for some time after the individual technology transfer events have been terminated. This may be acceptable for academic studies, but it will not be adequate for policy makers. Are there alternatives which can provide timely information to government managers?

When economists and other analysts need to gauge likely future events, they often employ "indicators." In this context, "indicators" are intermediate measures which have a known historical relationship with some future outcome which one wishes to estimate. Well known examples can be found in the Commerce Department's Index of Leading Economic Indicators. Among these indicators are building permits. Building permits themselves are pieces of paper of no economic value, but it is known from past experience that a certain amount of construction having a certain value will normally result after a known lag time. These known historical relationships give an intermediate metric considerable value for predicting future economic events.

Could indicators be employed in technology transfer measurement and evaluation to provide information which policy makers could use? It may be possible to discern continuing relationships between certain types of technology transfer events and economic impacts which can be detected through a broadened program of analysis and data collection. Such an analysis would be a three part effort, beginning with a series of extensive, and therefore expensive, case studies of technology transfer events. These studies would attempt to identify the elements in each case which appeared to be related to positive economic impacts. Common elements of "successful" technology transfer events could then be established as intermediate measures to define and collect.

Following the case study phase, a second, larger effort would be launched to gather those "success indicators" from a much larger number of technology transfer partners, either by surveys or required reporting from partners. The larger sample size of the second phase would permit analysts to verify the utility of the indicators and to examine whether there are identifiable subsets of any technology transfer mechanism which seem to be more economically productive than others. For example, one could compare the economic impacts of cooperative R&D in the life sciences with those in materials. Finally, an operational system would be established to collect the best "success

indicators" from laboratories and their technology transfer partners on a comprehensive scale.

What would such indicators look like? They would differ from mechanism to mechanism. For example, in the case of licensing, the number of license agreements and the royalty percentages could be studied retrospectively to see what percentage of licensing agreements produce revenue and how much, on the average, they produce. Using these data, one could estimate an average return on each federal laboratory license agreement. If such studies included other factors such as technology type and the degree of license exclusivity, more precision could be built into the indicators.

The impacts of new spin-off companies will also be relatively easy to show using indicators. It would be conceptually simple to develop periodic studies of laboratory spin-offs and gauge their economic performance. Again, average economic impact data for spin-off firms could be developed. Since the number of federal laboratory spin-off firms is still relatively low (compared to MIT, for example), one would have to be careful in making extrapolations from a small sample.

In the case of technical assistance, carefully performed surveys could produce (and some have produced) average returns for technical assistance programs in terms of reduced costs, increased output and other observable factors at assisted firms. It may be possible for the firms to attach dollar values to the results of assistance rendered which could be averaged over the entire program.

More complex problems arise with collegial interchange. It will be very difficult to characterize the impact of this mechanism with any numeric measurement system. In all likelihood, policy makers will have to satisfy themselves with survey information that these interchanges are considered valuable to both sides without attempting to fix a dollar value for these events. For the most part, these informal interchanges occur naturally (i.e., without special programs to facilitate them) and have a very low cost, so almost any sort of return will be worthwhile.

In the case of cooperative R&D, a relatively new, expensive, and important mechanism, indicators are less obvious. To develop them will require a full implementation of the three-steps outlined above, i.e., case studies to identify critical elements of cooperative R&D projects seemingly related to economic outcomes, followed by careful definition of these elements and collection of sample data through surveys and other data gathering techniques. Based on these outcomes, the intermediate measures would be refined and a full scale data collection system implemented.

Dual-use programs potentially involve a number of technology transfer mechanisms ranging from cooperative R&D and licensing from defense laboratories to product development under TRP. Each of these dual-use activities could employ the indicators used for similar technology transfer activities. However, dual-use activities have additional measurement requirements not shared by technology transfer programs. They must create either a product that is produced in a single facility and marketed to both the civilian and military sectors, or they must further develop a military oriented technology for civilian use (or vice versa). These unique dual-use requirements are probably not suitable for an indicators approach, and will have to be studied retrospectively.

Implementation of a series of such systems would not be a trivial undertaking, and would probably have to be done on a government-wide basis to be cost effective. However, it offers the possibility of producing a systematic source of data on technology transfer activities which would be available to policy makers in real "political time." The alternative to such a system will be to continue to perform ad hoc surveys of technology transfer partners to ascertain their evaluation of the economic worth of specific events. These surveys are useful as snapshots of activity at specific times, but do not provide a dynamic picture of federal laboratory technology transfer's contribution to the U.S. economy.

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TOTAL QUALITY MANAGEMENT AND SYSTEMATIC INNOVATION IN DEFENSE CONVERSION

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1. New Management Methods

Defense conversion presents a number of major challenges. A non-military use must be found for a technology that has most likely been focused in whole or in part on customers as compared to the single or relatively small umber of customers as is often the case for the military applications.

There is also likely to be much more competition. Not only does defense conversion require a refocusing of technology, it also requires a refocusing of management to adopt new approaches to management which are heavily customer focused and produce high quality products at competitively low prices. The focus of this paper is to highlight these new management methods referred to most often as Total Quality (TQ) or Total Quality Management (TQM).

During most of the 20th century organizations used a style of management that was based on the work of Frederick Taylor. In his system, engineers determined the best way to do a job and managers tried to convince employees with a carrot or a stick to do the job the way the engineers had set it up. This approach produced a moderately high quality at a relatively high cost.

In the 1980's, it became clear that organizations who were stuck in the command and control approach of Taylor could not survive. The new paradigm for management was explained by several authors. Kaoru/Ihikawa [1,2] showed that all employees could use basic improvement tools. W. Edwards Deming [3], showed the importance of understanding variation. Joseph M. Juran [4], explained the new role for management; Armand V. Feigenbaum [5] showed the new role for engineers. Katsuya Hosotani [6] explained the new processes step by step.

The auto industry was the first to wake up in the United States. Ford Motor Company lost over one billion dollars in 1980 and 1981. Foreign competition was producing cars of higher quality and at lower costs. A total refocus of management from CEO Don Peterson to the lowest level worker was undertaken. All were taught the philosophy of customer focus and continuous improvement, and the tools to accomplish these. Also suppliers were required to adopt the same philosophy and tools. Costs

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dropped by 10% per year from 1982 to 1985, and by 1985 Ford made over a billion dollars in profit.

Customer focus was highlighted in the Ford Taurus. Customers were asked to choose among the parts available the one they liked the best. Soon Taurus became the best selling american car.

Other companies made similar transformations with the new management philosophy and tools.

By 1984, Xerox realized that Japanese copier companies were making copiers at a higher quality than Xerox and selling them in the United States at prices lower than Xerox could produce them. Their willingness and ability to change was a survival issue. Again a total effort by everyone from the chairman on down and major suppliers as well led to a dramatic reduction in cost and improvement in Quality. Xerox became competitive again and won the Malcolm Baldrige National Quality Award in 1989.

In 1988, Intel, the computer chip maker, was losing the market share to the Japanese. The Japanese were getting faster and faster at copying Intel's technology and producing it at a higher quality and lower cost. Intel's top management was afraid that they would be out of business in ten years. In 1988, I had the opportunity to go to Japan with Intel's top 45 managers and explain the systems and tools that the Japanese were using. Intel was a fast learner. The very next year Intel won the Fortune Magazine New Product of the Year Award using a design system they had learned in Japan.

Similar turn arounds took place at Hewlett Packard, Motorola and Philips. Giants like AT&T, IBM, and Digital have also benefitted from the new paradigm. The new management philosophy and tools spread in the United States into health care, government and education industries. Although some organizations have not made the transition to the new management approach, one can only wonder how long they can survive in the old paradigm. Organizations involved in defense conversion must adopt the new management paradigm if they hope to succeed.

1. Tools and Processes for a New Management Paradigm

Total Quality Management is based on the belief that the people who are closest to the job best understand what is wrong and how to fix it. Management has the responsibility at all levels to work on the systems in which goods or services are produced.

An understanding of variation is important to the success of Total Quality. One desirable is to work toward minimal variations rather than adopt some acceptable level of quality. Ford learned this lesson dramatically in the mid 1980's. They sub-contracted the production of some automobile engines to a Japanese company. Although all of Ford's parts were meeting specification, the variation between parts in the Japanese engines was so small that the Ford technician thought at first that his measurement instrument was broken. But the Japanese engines with minimal variation ran quieter, were more reliable, and were asked for by customers. Continuous improvement had become essential.

So the first phase in total quality requires systematically putting all employees to work reducing variation using simple but powerful tools referred to as the seven quality control tools. These tools are used to maintain good quality if it exists and to continuously improve it if it doesn't. Motorola, for example, started with defects or mistakes that were measured in terms of percentages. As they continuously improved they raised the bar of performance to six sigma i.e., less than 3.4 mistakes or defects per one million opportunities.

The continuous improvement methodology uses a process that follows the plan-do-check-act cycle. The situation is analyzed and the improvement is planned (Plan). The improvement is tried (Do). Then data is gathered to see how the new approach works (Check or study) and the improvement is either implemented or a decision is made to try something else (Act). This process of continuous improvement makes it possible to reduce variations and lower defects to near zero.

The processes that produce good results are standardized and documented. The documented processes are followed. If the process is changed the documentation is changed. If an organization lacks this standardization, then improvements tend to slip. Without standardization, variation is increased rather than reduced.

Standardization was given a major boost in the early 1990's when ISO 9000 became widely accepted as a basic minimum that companies needed to do to sell products in the European Union. Because it required a documentation of key processes and provided a regular audit to see that processes were followed as documented, it was a major boost to standardization. AT&T initially undertook ISO compliance as a way to keep and grow business in Europe. When AT&T realized how ISO improved its own processes, it began to encourage all its suppliers to become ISO certified. In 1995, AT&T discovered that the ISO-certified suppliers had half as many defects as non-ISO-certified suppliers. This led AT&T to giving preference to suppliers that were ISO certified.

2. Team Work

Teamwork is critical to effective continuous improvement and standardization. Individuals can support the team by taking responsibility for the success of the team following through on commitments, contributing to discussions, actively listening to others, getting your message across clearly, giving useful feedback, and accepting feedback easily.

In getting the team off to a good start, you need to agree on a purpose, identify people who will be effected by the work of the team (stake holders), identify limits and expectations of the team's work, and agree on roles and responsibilities, ground rules, and logistics of when and where to meet.

The work of the team is accomplished by creating work plans, having productive meetings, using data, making good decisions, evaluating potential solutions, implementing changes, and documenting its work.

A team must know when its work is done: it has accomplished its purpose; took steps to maintain the gains; completed documentation of actions, results, and ideas for future improvements; evaluated the work and shared results with others; recognized everyone's contributions; and celebrated achievements.

Successful teams also must master potential problems: 1, the area of conflict - some people fight over everything; 2, power - the boss is on the team and people don't speak openly; 3, correct use of experts - who speak clearly and don't dominate; 4, focus - people stay on the subject; 5, participation - all participate in an equal fashion; 6, follow-through - everyone does his or her assignments.

3. Organization-Wide Planning

Once most employees have mastered the first phase of work improvement, then the organization is ready to move into organization-wide planning. This to is a plan-do-check-act process as indicated in Figure 1.

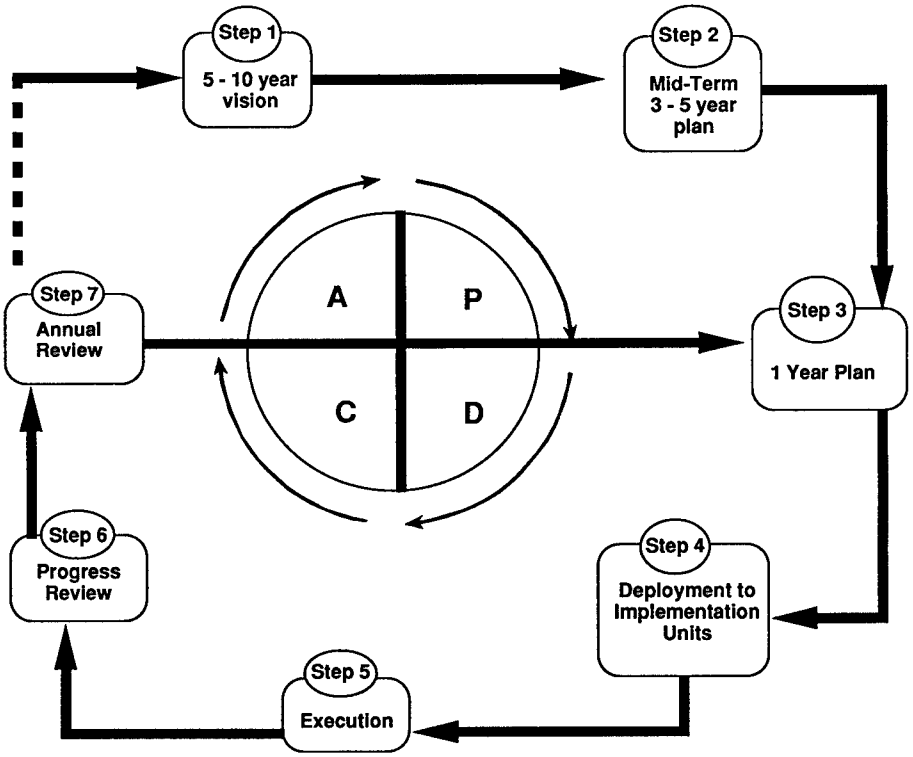


Figure 1. PDCA Chart

The complexity and scope of defense conversion makes it more essential than ever to use a thorough and effective planning system. Under the new paradigm planning involves all managers in the organization, not just the top people. Plans at all levels are aligned by a process of catch ball. This means that plans are communicated and conflicts between plans are resolved. Plans are documented. They are not just a once-a-year project put on the shelf to collect dust. Also, each manager monitors his or her plan on a monthly basis and studies successes and problems to make the changes in behavior that will help assure the plan will be met and exceeded.

Step 1: 5-10 Year Plan. The strategic plan is important for defense conversion. When one surveys the markets to check competing products it is important to design not to compete with the existing product but with the products competition will be producing 3-5 years from now. The lines of evolution as part of systematic innovation (or TRIZ) [Ref. 8] are a key to examining how technologies will evolve.

One of the lines of evolution is the S curve. Products develop very quickly at first, then the number of changes slow indicating the need for a major break-through in the product. Another line of evolution is the mono-poly cycle. Products diverge then get grouped together. An example is the knife. Two knives are combined to form scissors. Different size knives are made for different functions. Eventually these get combined into a Swiss army knife.

Another line of evolution is increasing dynamism. An example is in bicycles when they shifted from a rigid direct drive to flexible chain. Uneven development of parts shows where the weak link is in the system and where the next product break-through needs to come. Other lines of evaluations have included the conversion from macro to micro and automation.

A sound understanding of customer values is also important for strategic planning. A customer may be able to articulate what they want today or tomorrow, but they cannot tell you what will be exciting products 3-5 years from now. To define these products one must find the values that underlay today's requirements. Then these must be pushed up against what is possible to come up with next year's exciting quality.

For example, people want convenience in using the telephone information services, but you need to have a paper and pencil to write down the number. Today you can push "1" on some information services and the phone will automatically dial the number requested for a nominal fee. Really exciting quality might be to provide the service at no extra fee!

Step 2: 3-5 Year Plan. Once the vision is established, then the 3-5 year project plan must be developed. The purpose of this is to do detailed up-front planning. This step, if done properly, will dramatically reduce the cost of defense conversion and enhance its likelihood of success. The bible on project planning is called PMBOK which is short for Project Management Body of Knowledge.

Step 3: One-Year Plan. The one year plan includes the targets, means, and measures that each manager will work on that year. Typically each manager has six to eight target areas. Half of these are related to the manager's participation in the strategic plan and

half are related to the critical processes of the person's regular job. All must be measurable with monthly numerical targets.

Step 4: Deployment of Plan. All workers are expected to be involved in the continuous improvement and standardization of their activities. Each employee should support his or her bosses activity. The means of each boss often become the targets for subordinates. Even in the case of self-directed teams in Quality Control Circles, strong efforts are made to understand and support the initiatives of the organization.

Step 5: Execution of Plan. During the year the plan is to be carried out by each manager. Key inhibitors to progress are controlled with standardization and improved with continuous improvement as outlined in phase one (that is one reason why knowledge and skill in daily improvement is a prerequisite to phase two).

Step 6: Monthly Review of Plan. A check sheet can be used to gather data on frequency. This can be portrayed on a pareto chart listing the causes from the most prominent to least frequent in a bar-chart format. This can provide a guide for action. Such a methodology for regular checking will assure continuously improving quality and reduction cost.

Step 7: Annual Review. These monthly reviews are folded together into an annual review. The annual review lists the successes and failures and analyses from the various monthly reports.

The annual review also focuses heavily on the planning process. What contributed to effective planning? What detracted from effective planning?

Also part of the new paradigm for planning is the President's Annual Review. The President meets with a sampling of groups that had planning success as well as those who had problems. It is an example of seeing how things are going in the work place.

In summary, phase two makes it possible for organizations to take the continuous improvement and standardization capability of phase one and apply them to a focused improvement area. Hewlett Packard, for example, used this methodology to reduce its time to market and gain advantage in their laser technology products. For more detail see author's book on Hoskin Planning [9].

4. Cross-Functional Management and Quality Function Deployment

Phase three takes the processes of phase one and two and applies them to multiple areas. The most frequent areas of focus are quality, cost, delivery and employee morale. The most widely used application in the United States is Quality Function Deployment (QFO).

Quality Function Deployment has four states. State one, gathers the voice of the customer, puts their words accurately understood by producing organization and analyzes it versus the capability and strategic plans of the organizations. State two, identifies the area of priority break-through that will result in dramatic growth in market share for the producer. State three, represents the break-through to new technology. This is the area that has seen the largest growth in the last few years with the discovery of the Russian

TRIZ approach to incentive problem-solving (see below). State four, represents the production of the new product and new technology at the highest possible quality standards.

The following is one of the classic QFD examples. In the early 1980's International Harvester and Komatsu ended a partnering relationship. Since International Harvester had owned all the patents, Komatsu had to develop eleven new heavy equipment models in the short period of twenty-four months.

Komatsu engineers went out to the field to observe the actual use of the equipment. They observed the discomfort and toil of the operator. As they studied this it became clear that two improvement areas might be the comfort of the driver in the cab and reducing the effort to shift the vehicle, since it was constantly going back and forth.

In the case of the cab, Komatsu engineers reworked the window structure so there was a clearer view in all directions. They put in air conditioning that would stand up in a dusty environment. They made a seat that was comfortable to sit in for long periods of time. In the case of the shifting they looked into electronic shifting. They considered twelve different approaches. After considerable testing, they chose the one that would be the most reliable and easy to use.

When Komatsu introduced its new line of heavy trucks, it was met with great enthusiasm. Because of its ease of use it led to higher productivity and driver preference. Soon Komatsu became a dominant force in the heavy truck business, a position it maintained for over a decade. For more details see author's book *Better Designs in Half the Time* [10].

5. Systematic Innovation

As was mentioned in phase three, achieving a technology break-through is the key to both new product design and also in solving some of the most difficult problems. The Russian process TRIZ, the Theory of Inventive Problem Solving, is emerging.

TRIZ has developed over a fifty-year period from 1945 to 1995 under the leadership of Altshuller. Altshuller worked for many years in the Russian patent office. He began to classify patents from simple modifications to major innovations. As he studied the most innovative patents, he began to identify the principles that led to the innovation. He also began to develop a series of algorithms for solving the most difficult problems.

One of the key focuses of TRIZ is identifying and solving the basic contradiction at the root of the problem. This is different from the approach of trying to find a good trade-off. TRIZ is a systematic way of solving the contradiction. TRIZ is also useful in reducing unneeded functions in a product, thus reducing its cost and improving its reliability. A brief introduction to basic TRIZ follows.

Systematic Innovation (SI) starts with a thorough analysis of a problem or perceived opportunity:

- Why is it a problem or opportunity?
- For whom?
- Under what circumstances?
- Is there a contradiction in the problem?

Contradictions, rather than being a problem, are very important and useful in SI. Here are two examples:

(1) Airplanes are required to have wheels, to maneuver on the ground, but to not have wheels to be streamlined in the air. In SI, the requirement that something have two opposite properties is called a "physical contradiction." For this class of contradiction, SI recommends separating the properties of the system in time, which leads to the idea of landing gear that can be present on the ground and absent in flight.

(2) A razor is required to be sharp to cut hair, but the sharper it gets, the more likely it is to cut the skin. An SI analysis would lead to phrasing this contradiction as: When improving one parameter causes another to degrade, we have a "technical contradiction." Conventional engineering frequently tries to compromise the solution when a technical contradiction arises; that is, a trade-off is made based on how much good will result versus how much harm. SI uses the contradiction as a springboard for breakthrough - to remove the contradiction, rather than compromise the design, by accepting the harm with the good. To facilitate this work, the SI tools include a special matrix. (After presenting this tool, we'll tell you the solution to the razor example.)

The SI tools include the Contradiction Matrix, a 39x39 matrix of characteristics of general technical systems that could be in conflict. Figure 2 is an excerpt of the matrix; it's only partial, constructed for an example, as the full matrix would be too large to show here.

The row elements are the characteristics to be improved, and the columns are the characteristics that could be adversely affected. The numbers at the intersection guide the user to some of the 40 principles that might be of help in resolving the contradiction. (The shaded cells mean there is no conflict or contradiction; strength does not contradict strength, for example.)

Each cell of the matrix contains up to five of the 40 principles of problem solving that are possible solutions to the contradiction. The problem-solving team reads the recommended principles, and the case studies that illustrate them, then uses advanced analogy to generate solutions to their problem.

→ / ↓	Characteristic which is Deteriorating	14	21	32	39
Characteristic to be Improved		Strength	Power	Convenience to Manufacture	Capacity
14	Strength		10, 26, 35, 28	11,3,10,32	29, 35,10,14
21	Power	26,10,28		26, 10, 34	28, 35, 34
32	Convenience to Manufacture	1, 3, 10, 32	27, 12, 1, 24		35, 1, 10, 28
39	Capacity	29, 28, 10, 18	35, 20, 10	35, 28, 2, 24	

Figure 2. Contradiction Matrix

Now back to the razor example. One of the recommended principles was "Localization of Quality" which states that different parts of the system should be optimized to do specific functions. In the case of the razor, the product team decided that they should make the blade very sharp to optimize cutting, and then design the blade holder to push the skin aside and position the skin properly to cut the hair without cutting the skin; thus, the razor can cut very close without harming the skin. Many different designs are now on the market that apply this principle.

This is a type of advanced problem solving that requires the taking of different views. One looks at the system level, the supersystem, and any subsystem of the problem. The reason for this is that what looks like a technical contradiction at one level may look like a physical contradiction at another level. Having several views enriches the set of available solutions and leads to the generation of better options.

SI can also be used to forecast technological change. The technology forecasting methods of SI multiply your ability to understand where your designs are going, and where your competitors are going, so you can plan development investments now to get the right products to market at the right time. This is a good way to leap-frog the competition, rather than just catch up.

You can also use these same methods to predict where your suppliers' technologies are headed and avoid the problems of having great products that require unavailable parts and processes. In like manner, predicting your customers' technologies will help prevent being in the wrong market at the wrong time.

The U.S. Air Force is an enthusiastic user of SI's technology forecasting methods. The Air University is engaged in a future forecasting project for the year 2025. They recently began to apply SI's technology forecasting tools to creating concepts for Air Force systems in the year 2025. Within two hours of first seeing examples of the SI

methods, 13 cross-disciplinary teams (including other services, civilians, and non-U.S. Military) had applied the techniques to four different technology areas and developed scenarios that have accelerated their research.

This approach was developed largely by Russian Jews, who taught it to each other in a closed society in a mentoring format. It is only now being organized in a systematic way so that it can be taught widely to engineers. For more details see GOAL/QPC Research Report on Systematic Innovation [11].

In summary, the paradigm of management has shifted toward the end of this century, making it possible for high quality, low-cost innovative products. Those who want to succeed at technology conversion need to adopt these new paradigms to compete successfully.

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CONVERTING DEFENSE R&D IN RUSSIA: PROBLEMS AND PROMISE

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Abstract. *The economic, political, and social changes underway in the former Soviet Union are of unprecedented scale and importance. They already have created a world without division along political systems, without two main opposing super-powers, in difference of what lasted for seven decades. Initiated in Russia by Michael Gorbachev almost 10 years ago, these changes after the failed anti-Gorbachev's coup in 1991 accelerated dramatically, and led to dissolution of the Soviet Union with its political, social and economic structures, and started the wild "russian" version of a transition to a market economy society, accompanied by overwhelming crisis and severe hardships, comparable only to the war years in Russian history. According to the State Committee of Statistics in May 1995 about 45 million Russian people lived in families, whose average per capita income was below the poverty line. Stratification of Russian society deepened and the richest 10% of the population received one third of the total income, and earned 13.3 times, what the poorest 10% earned.*

All of this creates a new social situation, pregnant with possible gross social unrest and explosions. As is mandatory to overcome the present crisis in the post-Soviet society and to make the transition to normal free market economy society irreversible, all post-soviet industry, which was heavily militarized, must undergo a conversion of an unprecedented scale. This in fact calls for the complete restructuring of Russia's economic and social life. In turn, the latter mandates significant changes in the scientific establishment and its place in the post-Soviet society.

The general problems facing post-soviet science are exemplified by a particular Defense related domain- namely pulsed power (PP). In its potential for civil application and its survival as an area of scientific research, PP conversion can be used as a test case for all Defense related science in the former Soviet Union.

The analysis of the general problems and promise of Defense R&D conversion, and PP test case study are presented in this report with tentative recommendations based on the analysis.

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1. Post-Soviet Science in Transition

1.1 ORGANIZATIONAL STRUCTURE OF SOVIET SCIENCE AND R&D

With the end of World War II at the dawn of the new era of atomic weapons and space carriers, the importance of Defense related science was recognized all over the world. In the Soviet Union, respective science and R&D received a status of the highest priority, practically without any funding limitations. This tendency shaped all organizations and a rigid structure for soviet scientific and technological development, under the guidance of Communist Party Politbureau, with the main emphasis put on the Defense. As a consequence, the civilian sector of Soviet science was heavily crippled and underfunded. The Soviet organizational structure for scientific and technological development are presented in Figs. 1, 2. [1] The main portion of government funds for R&D was distributed by Military Industrial Complex (MIC) through its ministries. The list of these ministries follows. The Soviet Academy of Sciences (SAS) distributed its portion of funds to its research facilities few hundred of All Union and republican institutes and controlled and regulated the collaboration of these institutes with MIC and other ministries. SAS was also the only agency in charge of funding international scientific collaboration and fundamental research in the Soviet Union.

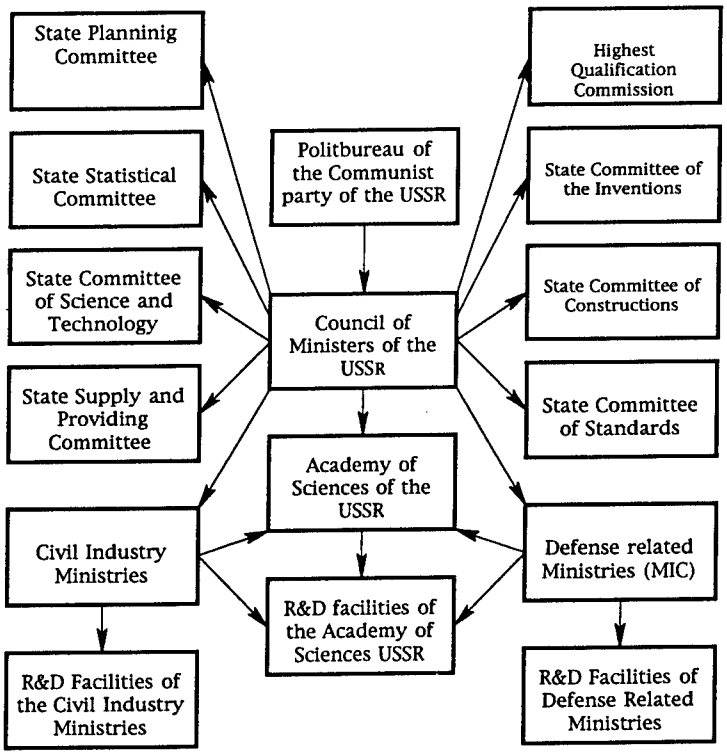


Figure 1. Soviet Organizational Structure for Science and Research and Design Development

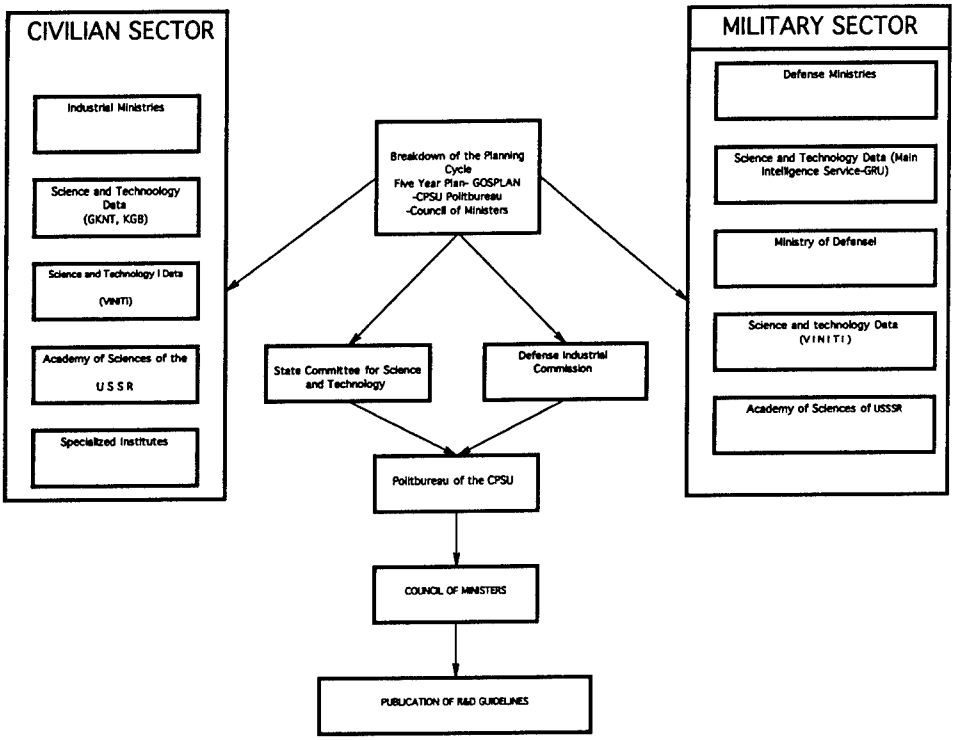


Figure 2. Formulation of Guidelines for Scientific and Technical R&D in the USSR

The famous Military Industrial Complex (MIC) of the USSR, which funded nearly 70% of all soviet science, was represented by the following ministries of:

a. Defense
b. Heavy Machine Building Industry (Mintyazhmash)
c. Defense Industry (Minoboronprom)
d. General Machine Building (Minobschemash)
e. Medium Machine Building (Minsredmash)
f. Electronics Industry (Minelectroprom)
g. Radio Industry (Minradioprom)
h. Aviation Industry (Minaviaprom)
i. Shipbuilding Industry (Minsudprom)
j. Communications Industry (Minsvyaz'prom)

Besides these ministries, MIC included several State Committees under the auspices of the government, such as the State Committee for Atomic Energy, the State Committee for Science and Technology, etc.

In 1986, an estimated total of 12 million people (i.e. researchers, designers, technicians, and workers) worked in the Soviet scientific establishments in close to 5,100 research, design and production facilities and R&D institutes, operating under the auspices of various government ministries, the Soviet Academy of Sciences (SAS) and universities [2,3].

In average, these facilities drew up to 70% of their aggregate funding from the MIC. For instance in 1990 SAS and MIC funding for basic and applied sciences and R&D were near 2 billion and 40 billion rubles respectively, spawning military applications from high technology R&D.

With the collapse of the Soviet Union, the structure of scientific management has already undergone some changes. The post-soviet organizational structure in the transitional period, for scientific and technological development, is illustrated in Fig. 3.

Replacing the previous State Committee on Science and Technology, the new Ministry of Science and Technical Policy was created, with the Department of Fundamental Studies. Now the Russian Academy of Sciences is funded through this Ministry, and not directly from the Government as in the past. The RAS is no longer in charge of financing fundamental studies, which is also under the auspices of the same ministry (the new Fund for Fundamental Studies was organized), though the main priority of the latter is in applied studies. The Ministry allocates the funds under the specified programs, approved by the Government. These programs also include the financing of the National Laboratories of Russia: Joint Institute of Nuclear Research, Kurchatov Institute , Protvino Accelerator Center, etc.

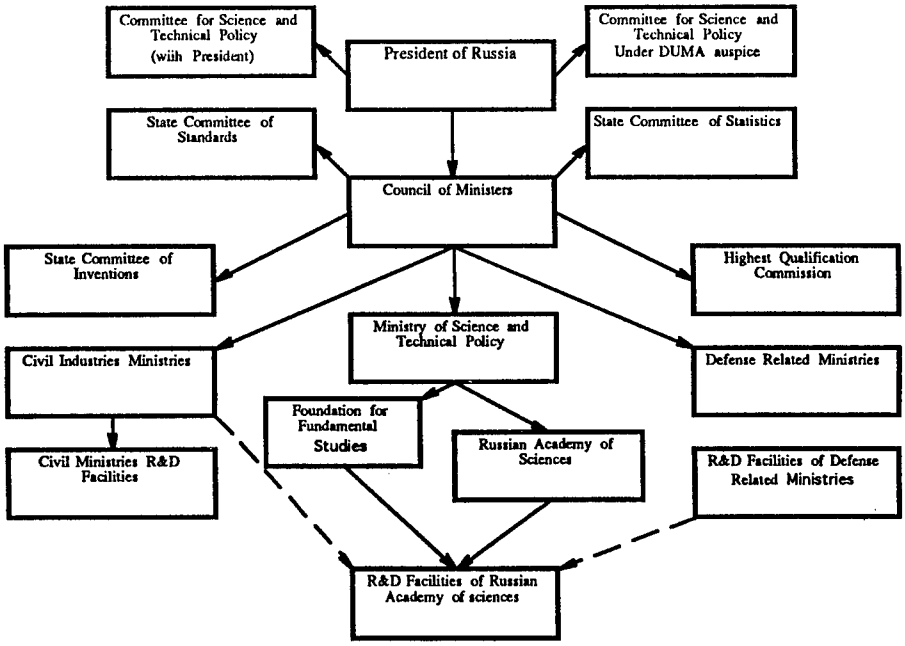


Figure 3. Organizational Structure of Russian Science and R&D During the Transition Period

It seems that this transitional structure of management of Russian science suffers from the same problem as before- an over concentration of power in one agency. This is seen in Ministry of Science and Technical Policy, though it gives more independence for RAS institutes than before, and stimulates the centrifugal tendencies inside the RAS community. The lower status of the RAS in the new structure of Russian scientific policy and management, compared with its former position, creates rising tensions at the top of the scientific administration.

The former powerful Minsredmash (with the State Committee on Atomic Energy) changed its name and became the Ministry of Russian Atomic Energy and Industry.

It is still unclear what the real functions of the Duma Council for Science, Culture and Education are, besides formal authorization of a pre-prepared science budget (in the Council of Ministers) and various related papers on procedures. It analyzes and gives its opinion on the requests for science and R&D funding submitted to the Council of Ministers. There is also a Council for Science in the President's Administration. Its functions are also unclear, except that it aid in securing some equilibrium between the RAS and the Ministry of Science. There are very clear indications about ongoing struggle between Ministry of Science and the Praesidium of Russian Academy of Science, for the right to control science and R&D funds [4]. The last meeting of this Council in May with the participation of President, Prime Minister and RAS president (but strangely without the minister of Science and Technical Policy) discussed the problem of overconcentration of power with this Ministry.

Finally, the new structure of Russian science management could be expected within ten years. It will be more compatible with the future Russian economy.

2.2 WELL-BEING LEVEL AND SOCIAL POSITION OF SCIENTIFIC COMMUNITY

It is noteworthy that in the Soviet Union , although average salaries in the scientific community were somewhat lower than those of skilled workers, scientists still were considered to be part of the middle class, comparable in status with other, such as those in construction and mining. The narrow range of salaries over the diversity of professions eliminated social stratification of living standards (which generally were low), but at the same time deprived the most enterprising and creative members of the society of incentives to improve both the quantity and quality of their job. On the other hand, membership in the well paid upper and top echelons of the scientific community (professors, directors of R&D facilities, members of Academy of Sciences, and especially those involved in the top secret nuclear and missile Defense R&D) conferred long lived prestige on the profession of scientist, guaranteeing that science would attract future generations of students.

The following is a table illustrating the average salaries of typical representatives of the scientific community, and of engineers and workers with various ministries in the middle of the 80s for comparison. The salaries are given in dollars, with the exchange rate of 1$ = 0.5 rubles, which roughly corresponds to the respective prices of staples at the inner markets of USSR and USA in those years.

Some factors affected the salary determinations. The salary of scientists who worked with the Medium Machinery Ministry, especially at the top secret Defense facilities (Arzamas- 16, Chelyabinsk-70, Tomsk-7, etc), were typically 1.5-2 times higher in average than for other enterprises. Besides, they got additional benefits, such as better housing, better child care, and health care, discounts on food, admission to special resorts, and access to limited resources (cars, western goods, etc.). The bonuses for special assignments in some cases could reach (for instance an outstanding role in the new weapon design) the equivalent of several years salaries [5].

TABLE 1. Average monthly salaries (in dollars 1$ = 0.5 rubles) of various personnel in the 80s.

Position	Salary	Position	D	E	MB	CG	Ag
Technician	120-160	Worker (HQ)	800	800	600	400	300
Grad. Student	200-250	Engineer	400	400	300	300	240
Engineer	200-240	Sen. Engineer	600	600	400	320	280
Jr. Scientist	240-300	Teacher	280-360	280-360	280-360	280-360	280-360
Sr. Scientist	500-560	Physician	280-360	280-360	280-360	280-360	280-360
Laboratory Head	600-800	Municipal Clerk	240-280	240-280	240-280	240-280	240-280
Professor, Chair	1000-1600	Head of Department of Enterprise	800-1200	600-1000	480-800	480-800	480-800
Chief Eng. of R.&D facility	1000-1600	Chief Engineer of Enterprise	1000-2000	800-1600	600-800	600-800	600-800
Director of R&D	1400-2000	Director of Enterprise	1000-2000	800-1000	600-800	600-800	600-800

D: Defense Ministry
E: Energy Production (coal miners, oil, gas workers)
MB: Machine Building
CG: Consumer Goods Enterprises
Ag: Agriculture

The most prominent feature of the Russian perestroika became huge, uncontrolled inflation, related to the deeply militarized and subsidized economy, and the poor state of its civil sector. Starting in 1990, consumer prices have risen far more rapidly than salaries. In 1990 and 1991, they rose approximately 30-50 percent per year. But at the beginning of 1992 after the federal law on price liberalization was adopted, prices

multiplied 100 times overnight. By the end of 1994, the cost of many commodities, including such staples as bread and butter had risen by 5 to 10 thousand, while the average salaries rose at most only 1 to 2 thousand.

When the perestroika cuts in Defense oriented science began, they already reached 30% by the fall of 1990 [6]. As early as 1988, the Russian parliament issued a draft conversion program in which civil R&D planned an increase from 28% share of the total Defense R&D budget to 45% in 1995 [7]. Sharp cuts of the Defense budget resulted in a considerable decrease on the well being of the scientific community, and a loss of scientists. There is no published data about the outcome of this program, but an estimation of the cuts in the Defense R&D funds roughly corresponds to the fact that nearly two to two and a half million people (including half a million scientists) left R&D to try a new domain of activity or became unemployed. According to data from the Russian Federal Statistics Bureau, the total number of employed scientists decreased by 27% between 1990-1993, 24% - from RAS, 30% -from ministries, and nearly 12%- from universities. The real budget of RAS in 1994 was less than 15-20% of that of 1990 [9].

The Ministries and RAS have adjusted their budgets upward in rubles in response to the economic crisis, but those higher numbers in reality represent a purchasing power several times below that of the 1990 budget. Prices of technical materials have increased even much more dramatically- and are becoming higher than international prices which stimulates a further decline in the local high tech industry output.

Sharp cuts in the funding of PP from Defense resulted in the dropping of many programs, including basic investigations, and especially those using unique, big scale installations, which could not find any civil applications.

Many Institutes have difficulty obtaining necessary resources and materials. Through its monopolistic hold of economy, the Soviet regime concentrated a particular industry in various geographic areas, making industry and its customers dependent upon one another for the delivery of parts needed for R&D. There was no free market for the purchase of scientific equipment and materials; all supplies were strictly controlled by the State Committee for Supply. Dissolution of the USSR put an end to this Committee. Together with new state borders and price inflation, it brought havoc.

Russian science is still controlled by the state agencies, though they changed the structure and nomenclature. There are still no other substantial sources for funding science, except from the state budget and contracts with state enterprises. The new Russian business is absolutely disinterested in scientific investments, looking for fast and short range enrichments through middleman activities, raw material trade, stock exchange gambling, etc. The claims from private entrepreneurs about their interest in supporting R&D are usually a tactical trick to get some exemptions from the state taxation under the umbrella of a non-profit scientific facility.

All these factors resulted in a dramatic drop of the scientists well-being, and the prestige of the science as a domain of social activity. Table 2 illustrates the position of scientists and related personnel in the post-Soviet society.

This table is partially based on the existing system of personnel grades (total 18 grades), introduced for all state-owned enterprises, science, and R&D establishments. Accordingly to this system, the laborants and technicians in R& D facilities have grades from 4 to 8, (which corresponds to the monthly salary of 10-20$, taking for the rate of ruble/dollar exchange of 1:5000), the engineers have grades from 6 to 11, ($15-$25), research scientists have grades from 9 to 16 ($20-50).

In any given situation, many scientists apply their skills in new, private companies, doing business unrelated to their previous scientific activity. For example many research institutes house commercial companies organized by its employees. These employees are primarily involved in the business and have little to do with the main activity of the research facility.

The probability of privatization of scientific R&D facilities is very low at least at present time. The current debate on this issue in the science is somewhat similar to the debate over the economy as a whole, where the struggle between the executive and legislative branches is in fact a struggle for control over former state property. The latter process in Russia is heavily infested by the criminal activity of mafia. Luckily for the sciences they are currently outside of mafia interest (except may be for R&D, which are involved with fissile materials).

TABLE 2. Average monthly salaries, May 1995 in dollars (1$= 5000 rubles)

Workers and Staff	Salary
Managers of joint stock enterprises (oil, gas, metallurgy)	$400-1000
Top managers of the state enterprises (average over near 28000)	$200
Managers of state communal energy and water distribution enterprises, administration of regional centers	$150-400
Army officers (from Lieutenant to General)	$100-300
Staff and workers at state owned enterprises	$50-100
State owned municipal trade	$40-80
State salaries of PP scientists (from graduate student to chief scientist)	$10-100
Physicians in hospitals	$10-50
Teachers in high schools	$ 10-50

The upper administration scientific bodies are reluctant torelinguish control of scientific property. Entities that began as scientific spin-offs do not own property either. The RAS and the ministries have therefore received little competition from the free market in science and R&D.

Converting Defense research to commercial purposes is not as simple as it might appear.

A great disparity separates the technology of the post-Soviet civil and defense sectors. Before the latter could be applied (for instance, to ecology or the technology of materials), industry must undergo considerable modernization. Such a step requires investments involving substantial financial risk which few civil enterprises can afford. Thus, post- Soviet R&D establishments find it easier to link with the businesses and R&D Laboratories in the West and with the Russian MIC.

It is noteworthy, that the inflation in Russia makes East-West collaboration less appealing for the West and each year. Hopefully, to do the science in Russia is still cheaper than in the West, and a relatively modest contract of 100 thousand dollars could support productive research in Russia by a team of several scientists for a year. Potential Western partners are wary of investing in the former Soviet Union, that promises results only in the future, especially in technology. The reasons are many: there are no mature local or federal laws regulating business; the ruble is chronically unstable, though recently it demonstrated some stability; inflation seems a permanent phenomenon; the investors' potential russian partners-most notably in the scientific world-lack business experience and knowledge about the free market economy.

Of special interest is the transitional situation in the Russian Universities system, which during former soviet time was under the auspices of the ministry of higher education. It could be illustrated by the structure of research and funding at Tomsk Polytechnical University. This University is the oldest higher educational facility in Siberia, and one of the main Universities in the Russia, providing scientific staff for Russian science together with Moscow, Petersburg, and Novosibirsk Universities. TPU now has two main sources of financing.[8]: the state budget and contracts with MIC ministries and other agencies. The dynamics of the funding ratio follow the cuts in the Defense funding, which is clearly seen in the Table 3.

TABLE 3. Dynamics of the State and Contracts ratio in TPU funding by years:

Years Percentage	1990 %	1991 %	1992 %	1993 %	1994 %
State Budget	18	46	68	68	60
Contracts with MIC and other aencies	82	54	32	32	40

The support from the state budget is provided mainly from the State Committee for Higher Education. Its present low status compares to that of the former Ministry of Higher Education, almost 91%, including 52% for education processes and management, and 45% for science and R&D under assigned special scientific-technical programs. The Soros fund and some other agencies are responsible for the rest.

2.3 MAIN PROBLEMS FACING POST-SOVIET SCIENCE AND R&D

In the existing situation post-soviet Defense related science and R&D face few options:

- At the very least, it ought to maintain sufficient Defense technology capability and sustain the general health of advanced scientific research and education. This option depends heavily upon a commitment by the Russian Government, and will be realized only if the latter will provide minimal sustaining funding. Certainly this funding will still not be adequate for preserving the former structure and volume of Defense R&D.
- At the same time, most Defense-related institutes and laboratories ought to be reoriented to a civil economy, beginning by using its pool of technologies and already existing structures.

Failing to adopt these two strategies, the former Defense related science and R&D could become extinct or be so dramatically reduced that it could bring irreversible damage to future Russian science per se. However, several obstacles and dangers stand in the way of sustaining and reorienting Defense science R&D.

There is a huge disparity between the highly developed Defense science, R&D infrastructure and the inefficient outdated civil infrastructure. The civil economy is simply not equipped to exploit sophisticated Defense spin-off technologies. This disparity is aggravated by the fact that the vertical integration of services and the horizontal integration of ministries and related enterprises have been severed. The resulting decline in profits and available resources, aggravated by non payments from the customer's side has deprived the civil economy of the funds needed to modernize effectively and apply Defense spin-off technologies.

Because most who left science were young, the average age in the post-soviet scientific establishment has increased, which presents a potential threat for the continuous process of passing expertise to the next generation. Having dramatically less funding and prestige, Russian science and R&D attract few newcomers. For instance, in 1994, the Institute of High Current Electronics at Tomsk hired only one new scientist (even though RAS guaranteed salaries for graduates from Universities), whereas in previous years it employed 3- 5 graduates each year. This could be the most serious danger facing Russian PP. Moreover, the highly hazardous technology inherent in the chemical and nuclear enterprises in many former secret cities like Chelyabinsk-75, Tomsk-7, Krasnoyarsk-26, etc will continue to exist in face of the declining expertise for maintenance.

Scientists who emigrate present the potential danger of transferring sensitive technology to unstable regions and promote proliferation of nuclear weapons to third world countries [10]. This danger is aggravated with attempts (luckily rare), of smuggling of fissile materials [10]. By early 1993, some were already convinced that the loss of scientists had begun to take on "a dangerous character , approaching a critical level... which is perilous to the recuperation of the Russian scientific pool" [11]. The RAS has already begun to feel the effects of this brain drain; in 1993 it could recruit only a third of the young scientists it interested in 1990 in its research and development establishments [12].

The hardships of Russian science have begun to trigger social stresses in scientific communities, resulting in demonstrations, strikes and other expressions of displeasure, many of them occurring in former top secret cities such as Arzamas-16 [13]. The main motto of the numerous meetings of the scientific community in various Russian cities is "poor science today- poor society forever". Thus, as the post-soviet Russia seeks to transform its economic, social and political order, the answers to several key questions are critical to the survival of the Russian science:

- How should a new scientific base be constructed for preserving our security interests while addressing emerging new social priorities?
- What are the options for post-Soviet science and R&D on the transitional road to civil orientation?
- How to preserve intellectual potential in the transitional period and lay foundation a for its future development?
- What should be the role of state agencies in supporting science during prolonged periods of transition?
- What should be the role of the private sector in Russia in this process?
- What could be the participation of West?

There are no ready answers to these questions of paramount importance. The Russian Government has not yet produced a strategy for confronting the main problems facing the post-Soviet scientific community. With massive budget cuts and runaway inflation, and complete control by higher administrative bodies, R&D establishments have had to find their own survival strategies.

The general problems facing post-Soviet science and R&D are characteristic of a particular Defense oriented domain-pulsed power plasma physics and electronics , which will be referred to elsewhere in the text as Pulsed Power (PP). In its potential for civil applications, problems of conversion, and finally its survival as an area of scientific research, PP can be used as a case study for examining the larger main issue of conversion.

3. Post-Soviet Pulsed Power

3.1 WHAT IS PULSED POWER (PP)?

Pulsed Power deals with the processes of transforming mechanical, electrical or other types of energy into electromagnetic energy, storing this energy, compressing it in time, and delivering in short electromagnetic pulses. These pulses could be used in the production production of intense vacuum, gaseous, liquid and solid state body discharges, the generation of directed energy flows (X-rays and neutron fluxes, charged particle and laser beams, microwaves), pulsed magnetic fields, electromagnetic waves and shockwaves, the acceleration of macroscopic bodies, etc. To provide this output various PP devices are being used: step-up high voltage transformers, capacitive and inductive stores, high voltage pulsed diodes, rail guns, plasma-focus and Z-pinches, explosive magnetic flux compressing chemical generators, etc. The typical schematic of the energy flow in the PP device is illustrated in Fig. 4.

The conventional PP device includes : primary storage, usually of DC or millisecond time scale, which could be a capacitor battery, pulsed transformer, mechanical- rotor, or explosive charge, using chemical energy; several stages of voltage enhancement via energy flow compression in time, compiled of forming lines and various commutators-switches, which open the route for energy flow at prescribed moments of time to get the needed power compression; load of the device, to which the generated high voltage pulse is applied to produce the previously listed types of directed energy and radiation.

PP is identified by certain characteristics:

- High peak power output (10^9-10^{14} W and higher), with low average power
- High density energy input (1-10^6 J/cm^2) at the load (target) location
- Low energy particles (10^5-10^7 eV) in short pulse duration (10^{-9}-10^{-6} s) beams

These characteristics can provide extremely high pulsed pressure and temperature, intensity of electromagnetic pulse, x-rays and neutron fluxes, which are in principal unattainable by any other technology and in certain aspects could simulate the ambient conditions in atomic explosion. This is why mostPP applications were and still are in Defense, but some are in the fundamental plasma physics and civil technology domains.

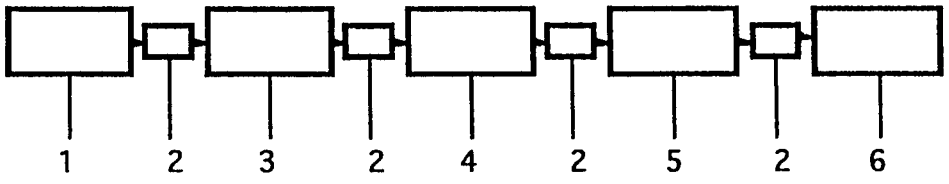


Figure 4. Scheme of Pulsed Power Device: 1 - slow energy storage (Marx generator, pulsed transformer); 2 - switches (pressurized gas, liquid dielectric, solid state, vacuum); 3 - intermediate storage (fast capacitive or inductive); 4 - pulse forming line with distributed inductance and capacity; 5 - compression and transport line; 6 - load (diode, Z-pinch, gas discharge chamber, etc.)

3.2 MILITARY APPLICATION OF PP

Although the relationship between PP and weapons, and especially with nuclear Defense is important, it is not always straightforward. It can be divided into four domains [14]:

- Contribution to underground nuclear tests (via investigation of inertial confinement fusion of imploded DT pellet) Expected neutron, x-ray and ERM pulse yield during the implosion of the fusion pellet would be lower than in the regular underground tests, but still it could to some extent substitute for the regular full scale testing of the weapons (already stored or of new design). Such an approach in the characterization of stored nuclear weapon performance and of newly designed weapon is reasonable, especially in the context of future total ban on the nuclear tests.
- Contribution to weapons programs (investigations of directed energy flows' interaction with targets)
- Providing above ground radiation sources (testing military hardware and electronics in ambient conditions simulating nuclear explosion)
- Providing development and maintenance skills compatible with weapon designs

3.3 POTENTIAL CIVILIAN APPLICATIONS OF PP

Over the past ten years, the promise for a civilian application of PP attracted increased attention in Russia, especially in the fields of technology, medicine and ecology. But still there are few examples of PP applications with a market potential, such as clean up technology [15], material, and modification technology. [16] To select candidates for civil application we could ask the following specific questions [17]:

a. Is the candidate's approach and its underlying concept scientifically valid?
b. Does the candidate have major advantages over existing concepts and approaches?
c. Is there a need or a market for the candidate's approach ?
d. Does experimental data support the feasibility of the candidate's technology?
e. Is there evidence that consumers would prefer the candidate's approach?
f. Is there an industry or large enterprise that would be willing to commercialize the candidate?
g. Is there a company, group or agency that would be willing to invest in this application?
h. What steps must be taken to perform the complete economic assessment?

The following Table 4 illustrates the analysis of some promising PP applications in the civil domain in Russia along the lines of these questions. The columns 1 thousand eight identify the above questions, letter "y" and "n" mean for yes and no respectively. The letters D, A, S and M, indicating what is needed to make PP approach ready for a market, represent as follows D- design of improved commercial pilot device; S- search for a company willing to invest money; A- advertisement; M- marketing

TABLE 4. Potential civil applications of PP

Application	1	2	3	4	5	6	7	8	Status	PP type	Ref
Photo Lithography	y	n	y	y	y	y	y		MAD	Z-pinch	18
Metal forming	y	?	y	?	y	y	y		MAD	Pulsed B-field	19
Laser welding	y	n	y	y	y	y	y		MAD	Pulsed Laser	20
Removing scale from tubings	y	y	y	?	y	?	y		AMS	Shock waves	21
Rock fracturing, drilling	y	y	y	y	y	y	y		DS	Shock waves	22
Production of nanoscale powder	y	y	y	y	?	y	y		DAM	Wire electro expl-on	23
Epoxy resin curing	y	y	y	y	?	y	y		MSA	Pulsed electron beam	24
Sterilization of medical instruments	y	n	y	?	y	?	?		DSAM	X-rays, pulsed electron beam	25
Sludge water cleaning	y	y	y	y	y	y	y		DSAM	Pulsed dis-rge, electron beam	26
Concrete waste reprocessing	y	y	y	y	?	y	y		DSAM	Pulsed dis-rge	27

3.4 SCOPE AND GEOGRAPHY OF POST-SOVIET PP

Near the end of the Soviet era near 70% of the studies conducted by PP facilities were funded by the MIC and Soviet Academy of sciences through the programs focused on the technology of storing, transforming and transporting energy, novel methods of generating directed energy flows, development of new materials, interaction of energy flows with solid objects, inertial confinement fusion, and equation of state. By 1991, the Academy of science budgeted an estimated 25 million dollars for PP programs. MIC funding for PP totaled about 120 million dollars.

Although there are Laboratories doing PP work in former Soviet republics, such as Ukraine (Kharkov), Uzbekistan (Tashkent), most PP facilities are in Russia. The main research institutes are found in Moscow, Tomsk, Yekaterinburg, Arzamas-16, Chelyabinsk-70, Novosibirsk, Sankt-Petersburg, Dubna, shown in the map in Fig. 5.

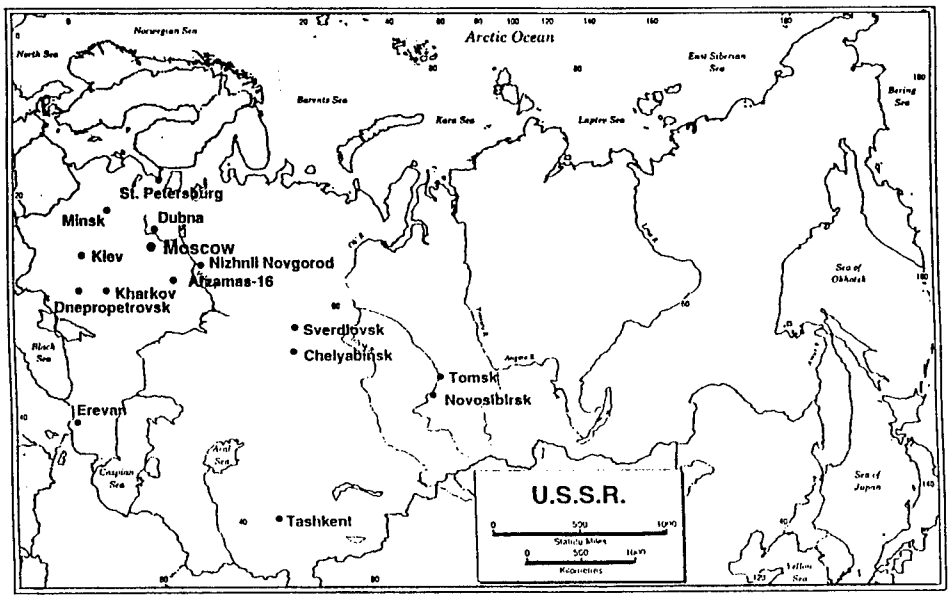


Figure 5. Pulsed Power Sites in the Former Soviet Union

A Majority of these institutes are located near the main science and Defense centers in the European and Siberian sections of Russia and the Ukraine. The profiles of establishments engaged in PP and their studies, illustrated in the following Table 5, are only tentatively complete: they were compiled from the author's personal knowledge, by identifying the institutes fields of activity through the presentations of their scientists at regular PP meetings in Russia and abroad, publications in their respective journals, and personal visits to these institutes and discussions.

TABLE 5. The list of main Russian PP Institutes and Laboratories

Federal Scientific Centers

Name and Location	Ministry	Domain of PP activity	Main PP Installations
1. Kurchatov Institute Atomic Energy, Moscow	RAS	ND, PPH, IPB, ICF, ECT, PPD, MW, TMF, PH	Angara-1 (PP generator, I of TW; Stend-300 (PP storage, 10 TW)
2. Institute of Experimental Physics, Arzamas-16 (Kremlev)	MAI	ND, PPH, ICF, ECT, IPB, MW, PPD, EMC, PPL, PH	MC-1 (magnetic explosive generator, 150 MA); LIU-30, (electron linear inductive accelerator, 30 MV, 50 kA); ISKRA-100 TW laser
3. Institute of Technical Physics, Chelyabinsk-70	MAI	ND, PPH, IPB, MW, PPD, MW, EMC, MPA	IGUR, EMIR (X-RAY 1 TW electron beam generators)
4. Trinity Corporation, Troitsk, Moscow	MAI	TMF, PPH, IPB, PPL, PPD, ICF, PH	Angara-5-1 (10 TW generator; T-14 tokomak)

PP Institutes of Russian Academy of Sciences

Name and Location	Ministry	Domain of PP activity	Main PP Installations
5. Institute of High Temperature, Moscow	RAS	PPH, IPB, EMC, PH, MPA	5 MJ rail gun, 1 MJ storage fast facility
6. Institute of Radio-Technology	RAS	ECT, IPB, MW, PPH, PH	1 MJ electron beam generators
7. Lebedev Institute ICF, Moscow	RAS	IPB, MW, PPL, ICF, MF, PPD, PH	Delfin Laser 0.1 TW; Electron beam generators
8. Institute of High Current Electronics Tomsk	RAS	PPH, IPB, MW, ECT PPD, PPL, PH	1-10 MJ generators, GI-8, Gamma, SNOP-3; 10 kJ CO_2 Laser
9. Institute of Optics of Atmosphere, Tomsk	RAS	PPH, PPL, PPD	0.1 -1 MJ storages for Lasers
10. Institute of Nuclear Physics, Novosibirsk	RAS	PPH, IPB, ECT, PH	GOL (1 MJ electron-beam plasma heating installation; 1 MJ U-1, U-2 generators
11. Institute of hydrodynamics, Novosibirsk	RAS	PPH, MPA, EMC	Explosive chamber for 5 kG TNT, 1 MJ rail gun
12. Institute of Applied Physics, Nizhnii Novgorod	RAS	MW, PPH, IPB	1 MJ storages for MW
13. Institute of Electgrophysics, Ekaterinburg	RAS	MW, PPL, PPH, ECT, IPB, PPD, ECT, EMC	1 MJ VIRA electron accelerators for X-rays

PP Institutes of the Ministries

Name and Location	Ministry	Domain of PP activity	Main PP Installations
14. Research Institute of Electrophysics, Sankt-Petersburg	MAI	PPH, IPB, PPD, ECT	1 MJ electron beam accelerators
16. Joint Institute of Nuclear Researches, Dubna, Moscow	MAI	PPD, IPB, PPH, PH	600 MeV synchrotron, 10 GeV phasotron
17. Research Institute of Nuclear Physics, Tomsk	SCHE	PPH, PPD, MW, IPB, ECT	0, 1 TW electron generators; 20 MW research water reactor; 1 GeV electron synchrotron
18. Research Institute of High Voltage Technology, Tomsk	SCHE	PPH, ECT, PPD	1 MJ storage, pulsed facilities for solid dielectrics tests
19. Research Institute of Introscopy, Tomsk	SCHE	PPH, IPB, PPD	Pulsed Betatrons, 30 MeV

RAS	Russian Academy of Science
MAI	Ministry of Atomic Energy and Industry
SCHE	State Committee for Higher Education
ND	Nuclear Defense
PPH	Pulsed Power Hardware
TMF	Tokamak Magnetic Fusion
IPB	Intense Particle Beams
PH	Plasma Heating
ICF	Inertial Confinement Fusion
PPL	Pulsed Power Lasers
ECT	Energy Compression and Transport
MW	Microwaves
PPD	Pulsed Power Diagnostics
EMC	Explosive Magnetic Compression
MPA	Macro Particle Accelerators

4. PP Survival Tactics

4.1. INTRODUCTION TO THE CASE STUDY

Few of serious problems faced by PP during the period of transition are unique to it; most are common to scientific facilities throughout. For a more specific illustration, see Table 6 the scientists salaries in dollars (using the respective official exchange rate) in the Joint Institute of Nuclear Researches (JINR) at Dubna, Moscow region. This institute was for more than 40 years and still is a Leading International Center under the auspices of the former Ministry of Medium Machinery, and now is one of the National Russian Nuclear Centers [28].

4.2. SCIENCE POLICY AND CONVERSION

PP facilities, similar to other research institutes throughout Russia have tried a few different approaches:

- **Reducing staff through hiring freezes, forcing older scientists to retire, or merging laboratories and consolidating personnel.** Initially, when the economic crisis first affected the scientific world, directors (following the socialist ideal of full employment) preferred not to fire personnel and compensated for funding cuts by freezing salaries and reducing benefits. But it was not sufficient. Finally, the PP community lost nearly 25-30% of its member .
- **Identifying civil applications for PP research.**
  PP is most likely to find commercial applicaations in ecology and material technology, as it is clear from the Table 4. The large demand for the environmental remediation of chemical, nuclear, and other types of pollution promises a large potential demand for PP applications.

TABLE 6. Average monthly salaries in dollars (1$= 5000 rubles) of the staff

(May 1995)

Position	Salary	Position	Salary
Director	220	Mechanic	45-50
Head of Department	110-120	Engineer	35
Head of Sector	100-130	Clerk	25
Top Scientist	130	Senior Scientist	85
Leading Scientist	100	Junior Scientist	40
		Graduate Student	10

When comparing this data with Table 1, we need to account for the fact, that the real value of the dollar in the inner Russian market fell 2-3 times from the rate it held in the 80s. The 1980's situation in other and not as specialized PP research facilities is only worse.

Taking PP conversion as a case-study we will examine several issues, including: How the inadequately funded PP Institutes are coping with their problems, how government administrators help PP Institutes undergo conversion, and the international community and foreign government's assistance to PP R&D

Unfortunately, large scale ecological programs require high levels of funding. This necessarily includes state funding, which will not be forthcoming in the near future. This is why big scale PP applications are still more likely to be found in new directions within MIC and related R&D establishments. Considering the existing conditions, it is unlikely that large numbers of commercial spin-off wills soon be formed or that the commercial world will be a large part of the near future of PP research in Russia. The success of PP conversion ultimately depends on the future market for Hi-Tech products; for the next five to ten years, these products will be more marketable in the West. A similar process has occurred in China and other third world countries; during their transition to a free market economy they aimed too their high-tech industries to commodities marketable in the West. Russia has certain advantages over those countries, since it possesses certain technologies the West does not, mainly in Defense related R&D. Approaches taken by various PP scientific facilities in the past few years include the organization of small scientific cooperatives within institutes specializing in high-tech which have market demand both in Russia and abroad. The various small companies already existed under the umbrella of research facilities. Most of these companies devote themselves primarily to the commercial activities of which the institute is ignorant of, such as computers trading and other commodities.

For example, the High Current Electronics Institute at Tomsk houses cooperatives engaged in commercial activities of two types. The first is logging and trade with the Japanese; the second is the fabrication of new products, using a novel technology, patented by the head of cooperative, for plasma coating dielectrics and metal parts (glass, ceramics, stainless steel). Cooperatives of the first type, organized in 1990, barter local timber for far east brand computers from Japan and Taiwan. The second cooperative tries to find markets inside the Tomsk region by addressing the local demand. How these cooperatives affect the host institute is difficult to ascess. There have been positive results of the timber- barter cooperative activity, when the latter has provided the institute with a relatively good PC and participated in delivering consumer products from China to the Institute for selling there accelerator.

Another approach is to separate the entire staff of the Laboratory from the Institute to form an independent company (R&D Center). The company in this case still rents the space and equipment and buys energy from the institute. Such an approach works for laboratories, which have some new products for which there are potential customers. For example, the ion-beam laboratory of the institute of Nuclear Physics (INP) at Tomsk, which contracted with MIC up to 1988 on studying the modification of the materials under the action of pulsed ion beams, formed in 1990 a joint-stock company with its own bank account. By the end of 1992 several other laboratories from INP had followed suit and started companies of their own. During this process nearly a quarter of the staff left.

Another example of a spin-off is commercial the company Vacuum Marketing, in Moscow, formed as a spin-off from the Research Center of Surface Studies (director prof. V. Rakhovsky). The company produces high vacuum pumps with ultra-low emissivity coating on the inner walls to minimize evaporation and energy loss [30]. The

very large market for these unique energy and cost saving pumps provides the company with a constant flow of customers.

For sure, the absence of laws regulating the privatization of scientific equipment from large PP facilities now in hard times does not stimulate spin-off activities. An April 1993 decree of the Russian Parliament on RAS property brought privatization of the latter property to a halt [31]. However, small cooperatives, acting inside the institutes of RAS could be a promising mode for gradual privatization in the future.

A final approach is the organizing of spin-off companies under the auspices of the Federal Centers. This approach could be most suitable to the former secret cities, which have a large concentration of high technology and fundamental studies. The combined population of these cities more than a million people complicates the problem. As a rule, they own no real estate, and cannot relocate for new jobs without relinquishing their apartments - an invitation to catastrophe for the Russian family. The new companies could operate under the auspices of Defense related ministries, and at first would need state funding a new commercial products would not be likely to generate enough revenue [32]. Several such companies are under the auspices of Federal Nuclear Center at Chelyabinsk- 70. The latter entered the market with many new technologies for such purposes as munitions destruction and processing explosives for fertilizer, radioactive waste clean-up and vitrification, and nuclear material storage [33].

4.3. WESTERN INVOLVEMENT

From the moment Russia began its course of political and economic restructuring, the West declared its commitment to help the country reach its aims, including the issues of Defense oriented science and R&D conversion. Of special concern were the issues of strengthening the security of the existing fissile materials, curtailing and finally ending further fissile material production, disposal of its wastes, and the increase of the "transparency" of the management on fissile materials and warheads. These were related to the fact that in the former USSR an adequate material control system was never developed because of the "...pervasive central system of regulating the movements of its citizens and monitoring suspicious activities" [10]. In the meetings of Russian and USA presidents (Gorbachev-Bush, Eltsin-Clinton) total of 1.4 billion dollars for these goals and Russian Defense related science and R&D conversion, were promised. The following is the tentative list of Western initiatives taken for support of Russian and FSU Defense conversion:

a. Collaboration was initiated under the Nunn-Lugar program by DOD with its first stage - "Trust-1". The total sum allocated for both stages (including Trust-2 as the second) was defined as $300 M. Finally after many administrative difficulties from both sides, based on a lack of trust, the program had some definite success: USA safeguarding equipment was demonstrated in action at several Russian facilities handling a large quantity of weapons including usable plutonium and uranium fuel at Podol'sk and Electgrosdtal' (Moscow region).

Nearly 20 million dollars total are to be spent in Russia in this field in coming year.

b. Beside this collaboration on the government to government level the interaction took place on the Lab to Lab level with more success, including direct cooperation of Los Alamos National Laboratory, the Institute of Experimental physics in the Arzamas-16 and Kurchatov Institute, and funding from the USA to Russian scientists for their time and equipment. During the same time, the money allocated for Trust-2 stage was never released due to certain developments.

c. Collaboration, supervised under the funding of the International Science and Technology Center.[34]with Russian Defense related facilities and Federal Nuclear Centers. The governments of the FSU, US, Japan and the European Community established this Center to develop alternative work for weapon scientists and engineers. Each country contributed $25 millions to the Center. The Russian Defense related scientific institutes and other facilities, including PP community, were urged to submit respective proposals for funding. The scientific expertise of these proposals were reviewed by the National Laboratories of the participating countries. After two years, of real money finally was released by the Center for several Russian programs (for instance-study on Compact Torus - along project submitted by Kurchatov Institute).

d. Collaboration under the auspices of NATO Science Programme and Cooperation Partners with priority areas including Defense industry conversion. Under this program several PP Centers in Russia (Institute of High current electronics, Kurchatov Institute) collaborated in a fundamental study with the National laboratory at Palaseau (France) and the Institute of Nuclear Physics at Karlsruhe (Germany).

e. Direct Contracts of Russian PP facilities with National USA Laboratories (Sandia, Los Alamos, Livermore, Naval Research) under the DOE for civil applied or Defense related studies. These contracts support similar programs, which are financed by DOE in the named national laboratories . In this case the transparency of the Russian work is provided by the control on the results and their availability in USA Laboratories. For example, the PP division of Sandia, involved in the study of the Plasma Opening Switches technology, supports related study in Russia from 150 to 300 $k per year (Tomsk, Institute of High Current electronics, Institute of Electrophysics, Moscow, Kurchatov Institute, Troitsk, Arzamas-16) [35]. Similar level of contracts are placed and already in action between various PP institutes in Russia (Tomsk, Ekaterinburg, Pulsed Power Moscow) and Technology Divisions in Sandia [36] and Los Alamos [37]. In fact the support from the USA provides an average $200 per researcher per month, which is three times higher than the average level of their salary.

f. Western companies as marketers of new Russian products in the West, or middle men for organizing the contact of Western customers with their perspective Russian partners. Kiser Research, Inc. in Washington [38], and 21 Century

Integrated technology in Lubbock, Texas [39] are two companies, currently working with the PP institutes in Tomsk and Ekaterinburg, both marketing novel PP accelerators. One of the latter was bought by the Department of Electrical Engineering at the University of New Mexico for a study of microwave generation. The Russians installed and provided personnel training and maintenance for one year. The contract considerably improved the University research program and saved it a considerable amount of money. 21 Century Integrated Technology has organized several such contracts, selling compact accelerators of electrons to US and Great Britain university laboratories, involved in the Defense related microwave studies.

g. Organizing international non-profit and for profit companies made up of both Russian and foreign PP specialists. Two examples will suffice: World Laboratory (WL) was created by Trinity Corporation in Troitsk with the support of RAS Praesidium [40]. The main goal of the WL is to market Russian PP designs and products throughout the former Soviet union and abroad at 5 to 10 percent commission for its services. Ecopulse Inc., at Springfield, is an instrumental in organizing and supervising contacts of Russian PP laboratories with USA customers (usually- with USA National laboratories) [41].

4.4. PRIVATE FOREIGN INVESTMENTS

The Soros International Science Foundation in its three years activity spent nearly 100 million dollars on scientists in the FSU. First, in distributing 10 thousand grants of $500 per year for individual researchers, and in 1993 and 1994 conferring more than 4000 long-term grants totaling more than 60 million dollars [42]. In 1994-95 several hundred of outstanding Russian professors got Soros three years fellowships (6-9 thousand dollars per year), which could secure their normal work at universities and a decent standard of living. Nevertheless, the Soros initiative has met with mixed reactions from the Russian media and science administration. The latter would prefer to get funding for the large joint scientific programs related to RAS and respective scientific goals, and to oversee the distribution of these funds, which is not in the policy of the Soros Foundation. The RAS is also concerned that institutes are redirecting their efforts to programs and tasks of secondary significance at the expense of programs approved by RAS and Ministries [43], which finally will do no good for Russian science.

Inviting leading Russian scientists to the West, even for temporary assignment, has also met with mixed reactions from the RAS. Unable to pay its scientists adequately, the RAS has appealed to scientists' patriotism to keep them home. It prefers to use its western funding inside Russia, not for sending scientists abroad. Even with any ideological motives the RAS might harbor, science in Russia is still more cost effective than abroad, and a given sum could support a significantly larger number of scientists.

5. Policy Recommendations

From the variety of conversion approaches already tested in Russia several general policy recommendations can be formulated.

- The funding for Civil sciences cannot be cut any deeper than the overall cuts in the budget.
- The Russian government should set the priorities in fundamental, applied civil and Defense sciences (on the basis on the new Defense doctrine), redirecting much of the funds formerly devoted to Defense toward other fields, and not simply cutting the Defense budget.
- The decision must be made about which research facilities in its strategic program should be federally funded, which should be regionally funded, and which should be privatized.
- The management of Russian science should be modified, including policy regarding the property of research institutes. Once the government has defined the main strategies, scientists should have the right to use their privatization vouchers, or adequate official rights toward organizing companies within their institutes. This could bring new, talented managers into administrative positions in science. These policies should be very specific and should exclude the Russian Federal Centers that are committed to national Defense and fundamental programs. It would eventually result in enough personnel being involved in the scientific activity to correspond with the number needed by a developed society with a free market economy.
- The Federal Scientific Centers must be preserved and used as the main intellectual pools of national science, as well as the cutting edge of national Defense studies.
- The funding of science must be from a variety of independent sources without rigid centralization from only one Ministry, or only from RAS, the centralized approach already proved during many decades to be inefficient.
- The government could create an administrative body to be a civil counterpart to the US Defense Advanced Research Projects Agency[44]. This new federal agency would direct the civil application of Defense science and oversee the competition among R&D facilities, direct the distribution of funds and advanced technologies to the civil sector through a system of federal grants.
- The main avenue for Russian Defense related conversion should be small cooperatives, starting within larger institutes. Given the large discrepancy between Russian civil and Defense related technologies, large scale commercial spin-offs are unlikely in the near future. Nor is the Russian commercial world likely to pay in the near future for Defense conversions of big Defense facilities. The most likely customers for high-tech spin-offs in the next five-ten years are western countries.
- Lab-to-Lab contacts between Russian and their West Defense related laboratories are and will be a very essential part for the survival of Russian facilities for the coming five to ten years. Such collaboration is beneficial not only for the promotion of knowledge and survival , but also for enhancing the climate of openness and trust.

- The collaboration under international programs, such as those active under the auspices of ISTC, NATO, etc., could be broader and deeper and involve more scientists than previously active in Defense fission and fusion study.
- Western administration should offer incentives (favored tax status, loans, federal protection of investments, etc to encourage commercial and non-commercial companies to organize joint R&D ventures with Russian facilities to produce and market Defense spin-off goods.
- Despite the concerns of the Russian administration, foreign investments in the form of personal grants, long term group grants have proven useful for the support of scientists. These grants are especially valuable for theoretical studies. Concerns remain that these grants distract scientists from mainstream research. These concerns must be taken into consideration and analyzed.
- Better support of students an international exchange and visiting scholar program by both Western and Russian authorities would help advance the integration of Russian science into the world's scientific community.

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CONVERSION AT A RUSSIAN SHIPYARD IN ESTONIA

A Mixed Record of Success

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ABSTRACT. *Conventional microeconomic approaches to evaluating Defense conversion almost invariably conclude that conversion is a failure. The case of Shipyard No. 7, a Russian military shipyard in Tallinn, Estonia, is no exception. The situation confronting the shipyard in the early 1990's was not, however, only a matter of conversion: there was a transfer of ownership as the Russian military withdrew from Estonia, during a period of economic transition within Estonia as a nation. The fate of the shipyard must be understood in the context of overcapacity in the shipbuilding and ship repairing industry in the Baltic region and throughout the world.*

However, a conversion project at Shipyard No. 7 achieved some tangible results, including the attraction of a number of Estonian, Russian and Western business representatives to a conference in June 1993, followed by the placement of some orders from Western companies. The project was part of a successful exchange between Swedish and Estonian students and their academic supervisors. This approach was used as a model for a study of the conversion of an electronics factory in Pskov, Russia and a Russian military shipyard in St. Petersburg.

More importantly, the conversion project achieved some remarkable, if more intangible results. The project was based on cooperation between Estonians Swedes, ethnic Russians living in Estonia and Russian nationals, mostly from St. Petersburg, with the support of people from a number of other countries in Europe. At a time when there were considerable tensions in Central and Eastern Europe associated with the Russian presence, the spirit of cooperation was a real achievement. Even if the conversion itself could not be considered a complete economic success, the conversion project certainly did achieve positive results.

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1. Background

The conversion of Shipyard No. 7 in Tallinn, Estonia, was not intended as a purely economic exercise. Rather, it was an experiment in cooperation between Swedish, Estonian and Russian technical specialists, along with the virtually entirely ethnic Russian workforce at a Russian military shipyard. The objectives were (1) to gain mutual understanding of the prospects for commercial development at the shipyard; (2) to promote business opportunities using the shipyard's facilities and experience; and (3) to develop an approach that might be applicable to other predominantly military enterprises in Eastern Europe and the former Soviet Union.

The Shipyard No. 7 project was an outgrowth of voluntary activities by scientists and engineers in the peace movement in the 1980's. Two conferences on "Ways Out of the Arms Race", in Hamburg in 1986, and in London in 1988, led to the formation of the International Network of Engineers and Scientists (INES) for Global Responsibility at a third international conference in Berlin in 1991.

At preparatory meetings for the Berlin conference, in Leningrad (as it still was at the time) and at Balatonfured, Hungary, a small group of engineers agreed to organize a workshop in Berlin on conversion. The Berlin workshop, which brought together two dozen participants from Russia, Eastern and Western Europe and the USA, adopted a common approach in which conversion was seen as a means to scale back military activities while benefitting the civilian economy, social welfare and the quality of the environment. The Swedish participants agreed to investigate the prospects for a conversion project in Eastern Europe.

The Swedish members of INES organized an international conference on conversion in Lund, southern Sweden, in 1992. They presented a plan for a project based on an informally-organized academic exchange between Estonian and Swedish post-graduate students. The Estonian Technical Societies (ETS), a professional engineering organization based in Tallinn, offered institutional support in Estonia, and the Swedes established a new, non-profit organization (Swedish Network of Engineers, Economists and Scientists for Conversion SWENESCO) to jointly manage the project with their ETS partners. Other international participants at the conference acted as informal advisors and observers, most notably Russians from the St. Petersburg area who had participated in the Berlin conference.

Shortly before the Lund conference, a Swedish delegation went to Tallinn to visit six so-called "strategic" Russian factories in and around the Estonian capital. It turned out that most of these "strategic" factories were already producing civilian goods such as domestic appliances; the word "strategic" was used merely to designate these factories as "important", or perhaps sole suppliers in the former Soviet Union.

Although the Swedes and their Estonian hosts were initially denied access to Shipyard No. 7, where the activities were almost entirely military, they were later allowed to make a limited inspection. Founded in 1912 by two Swedish businessmen based in St. Petersburg, the shipyard became an important ship repair facility for the Russian Navy, and also performed some ship construction [1]. The shipyard's activities

were almost entirely conducted for this sole, military client, or in support of housing and other services for the ethnic Russian workers at the shipyard.

In spite of the reluctance of the shipyard's Russian military commanders to entertain such a project, the decision was taken at Lund to "adopt" Shipyard No. 7 as a case study in conversion. Two Swedish students from the Lund Institute of Technology were selected to do research on the potential for conversion at the shipyard and to develop a business plan sketched out by one of their professors. Two Estonian students from the Tallinn Technical University were selected to function as interpreters, to provide practical assistance in Tallinn, and to study Swedish industrial practice at Lund as part of their dissertation research.

The project went ahead under academic supervision in both Sweden and Estonia, and with the support of Swedish volunteers from SWENESCO, Estonians from ETS, and international voluntary advisors drawn from INES. Despite initial reservations on the part of the shipyard, the Swedish and Estonian students and their professors were allowed access. The St. Petersburg Russians were closely involved as advisors and interested observers, Several of the Swedish volunteers were veterans of the shutdown of the Kockums merchant shipyard in Malmo, a successful economic transition that had some elements in common with the situation facing Shipyard No. 7. The participants, advisors and supporters became enthusiastic about rebuilding the historic Hanseatic ties that had once dominated trade in the Baltic region.

2. The Project

The conversion project at Shipyard No. 7 began *after* Estonia formally became independent, but while most Soviet military and trade infrastructures were still in place. The atmosphere in Central and Eastern Europe at this time was tense, in anticipation of the demobilization of Russian forces and the establishment of independent, market economies. The ethnic Russian population, settled in Estonia since 1940, faced hostility from the Estonian population and an uncertain future.

Shortly after a meeting in Moscow at which SWENESCO representatives were present, the top military commanders at Shipyard No. 7 were recalled to Moscow, and the shipyard reverted to Estonian ownership. Although the shipyard became the property of the Estonian military, day-to-day management remained in the hands of the ethnic Russians who ran the workshops. Existing contracts for repairing Russian military ships continued, although the supply of raw materials from Russia became progressively more difficult and costly. The business relationships between the Russian customer and the ethnic Russian workforce endured. However, the downturn in business and general economic pressures forced a reduction of the workforce by almost a quarter between January 1991 and July 1992. The shipyard was subsequently transferred to the Estonian Ministry of Economics, and is known today as Tallinna Meretehas [2] .

The two Swedish students conducted a detailed inventory of the facilities, equipment and human resources at the shipyard, and described its organizational structure and

management. With the assistance of academic and other advisors, the students developed a framework for business development at the shipyard.

The students noted that some conversion had already taken place at the shipyard with the spinoff of the acetylene and oxygen workshop (for gas welding) in 1990. By 1992, this small workshop did roughly half its work for the shipyard and the other half for about 70 other customers in Estonia, and turned a small profit. The rest of the shipyard, however, suffered from costly energy inefficiency, uncertainty about the availability and cost of raw materials, and inexperience in commercial management, pricing and marketing.

In June 1993, a two-part conference was organized in Tallinn to discuss "practical opportunities in Estonia and St Petersburg, including conversion of military industries". One part of the conference was attended by activists from the INES network, covering other peace and environmental issues as well as conversion. The other part of the conference was attended by business and financial representatives, government officials, academics and other researchers. On the last day, the two groups joined forces for a tour of Shipyard No. 7 hosted by the Russian management of the shipyard and the two Swedish students. It was the first time that the shipyard was fully opened to Westerners -- and to Estonians.

The shipyard had been prepared and tidied up for the occasion; the fresh paint and freshly-planted flowers were as conspicuous as the spots of rust on the roads where debris evidently had been recently removed. The conference participants were welcomed with a reception in the shipyard's museum, which contained models of ships that had been built or repaired at the yard. After a tour of the shipyard and a discussion of potential conversion opportunities, Russians from the St Petersburg area described military factories that could benefit from similar projects.

The focus of attention for conversion at the shipyard was on the energy sector, as the metallic hull workshop, pipe, forging, machine tool and gas welding facilities appeared suitable for the design and construction of boilers for domestic and commercial use. The carpentry shop, which was in the process of repairing a Russian minesweeper, also appeared to have small-scale conversion potential. Although the equipment was mostly decades old and the working practices inefficient, the workforce understood the idiosyncracies of their machines and were capable of producing intricate and heavy machinery. One potential project was to manufacture wood chip-fired boilers, which would make use of a plentiful energy source in Estonia, thereby reducing dependency on imported energy from Russia. Another potential project was the reconstruction of historic Swedish ships that might be used to conduct tourists around the Stockholm archipelago; this work could not be done in Sweden or elsewhere in the West as the appropriate facilities did not exist [1].

Representatives of Swedish, Estonian and Finnish companies expressed some interest in the shipyard, but in the end no substantial business resulted. Some small orders were placed, for example by a Swedish department store for display cases from the carpentry workshop, but this was not enough to keep the entire shipyard afloat.

The Swedish students Masters' thesis concluded that the conversion process was as much about transition to Western economic and industrial practice as it was a transition from military to civilian production [3]. The biggest barrier to conversion, they found, stemmed from the shipyard's place in a command economy and its consequent inexperience in commercial operations, cost control, pricing and marketing. These features had direct parallels in other Russian military and civilian companies, as well as some analogy to military manufacturers in post-Cold War Western economies.

3. The Results

The conversion project at Shipyard No. 7 cannot be considered an unqualified success either in economic or in conversion terms. Only one quarter of the workforce employed in 1991 remains in place, and the volume of work remains low and sporadic [21. Yet there is some civilian work under way. Some small repairs are done on fishing and other civilian vessels, and small amounts of non-maritime work are undertaken, such as the manufacture of wooden doors. The shipyard has some business repairing railway wagons. The managing director at the shipyard has plans to sell commercial fishing vessels in Estonia, Latvia and Lithuania although there are no firm orders at present. The shipyard is to be privatized in 1995 or 1996; its ultimate fate has yet to be determined.

Even as an exercise in conversion, the results are mixed. The shipyard is building a new ship for the Estonian frontier guard which is due to be launched this year; effectively still a military function.

The conversion project probably contributed to the ability of the shipyard to adjust to the transition from Russian military installation to Estonian government ownership to privatization. Overcapacity in the ship building and repairing industry in the Baltic has already resulted in the shutdown of a number of shipyards, including almost all ship repair in Sweden. Indeed, there has been a decline in the industry throughout the Western world. The contraction of core business at Shipyard No. 7 is a reflection of commercial reality. The extent to which the conversion project has inhibited or accelerated its contraction is impossible to conclude, but the survival of the shipyard in these circumstances must be considered a success of sorts.

As an academic exercise, the conversion project at Shipyard No. 7 was demonstrably successful. The Swedish and the Estonian students produced dissertations; the Swedish thesis was published in English and Russian and has been widely circulated. Furthermore, the experience at Shipyard No. 7 has served as a model for other conversion projects in Russia [4]. The elements of the model are:

Student exchanges between Sweden and Russia reinforced by research cooperation between university faculties;

Selection of project companies with the assistance of Russian academics with expertise in technology and economics;

Education in commercial management and market economics for host companies through short courses and study visits to Sweden; and

Continuous communication between all participants in the process.

The model has been applied to projects linking the Department of Management and Economics at Linkoping Institute of Technology in Sweden with Almaz, a military shipbuilding company in St. Petersburg; Apparati Dalney Svyazi, a military telecommunications company in Pskov, Electron, a Russian state research institute; and PEKAR, a carburetor manufacturer in St. Petersburg (Refs. 5,6,7,8). The first two of these companies have been predominantly military; the latter two have had both military and civilian business. As the Shipyard No. 7 experience showed, the essential nature of conversion has to do with a transition from a centrally planned economic relationship to a market economy; this is analogous to the position of Western military firms as well as for both military and civilian companies in the former Soviet Union.

Two more projects are under way in Russia, and further projects in Russia are planned with support from SWENESCO. As for Shipyard No. 7, now Tallinna Meretehas, another project is in progress with Swedish students investigating the possibility of producing heat pumps using a Swedish-designed wood-fired boiler [9]. Their Estonian counterparts are studying the district heating plant in Goteborg, Sweden.

4. Discussion

The unusual approach to conversion at Shipyard No. 7 had several notable features. As an outgrowth of the peace movement of the 1980's, the informal cooperation between East and West made it possible to work constructively at a time when both inter-governmental relations and those between Estonians, ethnic Russians in Estonia, and Russian nationals were under strain. The involvement of international advisors, observers and supporters from throughout Western and Eastern Europe and the USA reinforced the cooperative process. Estonian resentment over the presence of Russians was tempered by understanding and a sense of humour; the constructive involvement of the St. Petersburg Russians further underscored the positive intentions.

The Russian military command at the shipyard was prepared to tolerate the presence of students, and over time came to appreciate that Estonians as well as Russians and other international parties that were interested in supporting the future livelihood of the ethnic Russian workforce. The project may have eased the transition to Estonian ownership as the Russian military command was withdrawn. The welcome with which the business representatives and peace activists of all nationalities were received at the shipyard in 1993 was genuine. The Russian seamen at the shipyard watched the tour with bemused interest.

The conversion project at Shipyard No. 7 was relatively inexpensive, drawing upon existing resources in the university systems in both Sweden and Estonia. INES

volunteers paid their own expenses, and industrial participants paid a fee that covered much of the cost of the conference in Tallinn. The financial administration of the project was devolved to the Estonian partners in Tallinn (ETS) to avoid the common problem of overcharging Westerners in the former Soviet Union.

Initial funding for the project was provided by the MacArthur Foundation, an American foundation supporting work in peace and disarmament-related areas, to finance the first academic exchanges. SWENESCO obtained a small grant from the Swedish Ministry of Foreign Affairs to finance part of the conference in Tallinn. In addition, SWENESCO made use of Swedish state work experience grants to employ experienced engineers who were otherwise unemployed. For subsequent work in Russia, SWENESCO received two grants, worth a total of 700,000 Swedish kronor (SEK), from Swedecorp, a Swedish aid organization promoting commercial development between Sweden, Eastern Europe and Russia.

The budget required to support the work of four students for a single SWENESCO conversion project is typically 30,000 SEK [9]. For this, the host company receives a thesis produced under rigorous academic supervision, which includes valuable external assessment and guidance on business development, and is translated into Russian. Although the products are not entirely comparable, the overall budget compares favorably with some Western government assistance programmes that typically go toward employing high-priced consultants, air travel and high-cost accommodation.

It is worth comparing the experience of Shipyard No. 7 with the closures of two other shipyards: a military shipyard in Quincy, Massachusetts, USA, and the Kockums merchant shipyard in Malmo, Sweden, both in the late 1980s.

In the case of the Swedish shipyard, 3000 employees were affected by the planned closure, plus a further estimated 3000 workers in supplier firms [10]. The Swedish government allocated 518 million SEK for industrial regeneration. The government negotiated arrangements with Saab, manufacturing automobiles and aeroengines, a new military submarine builder and a crane manufacturer, who together took over the Kockums site.

State support was given to a local company along with an order to refit and modernize 375 passenger coaches for the Swedish state railway company, and to nearly 60 small enterprises in the area employing a total of 800 people. In addition, the state supported an employment exchange office located at the shipyard, and provided support for training courses for shipyard employees. Some employees accepted state inducements for early retirement. Further backup and support was provided by existing training and social security schemes at local and national level. In the end, the redeployment of the shipyard site and its employees was achieved and has been considered a success. However, the transition involved some conversion from civilian to military production.

In Quincy, Massachusetts, the closure of the military shipyard represented a major potential loss to the local economy, with 6300 jobs at stake [11]. The state commissioned feasibility studies and investigated the possibility of selling the shipyard to private companies or to the workers themselves. Some use was made of the complex of federal and state economic assistance programmes for training and employment.

However, Massachusetts was constrained politically and financially, and with limited public resources and commitment it was impossible to realize the full potential of the shipyard and its workforce.

More recently, the SWENESCO project at the Almaz shipyard in St Petersburg has contributed to some success [5]. Since 1993, the shipyard's production of civilian vessels has grown substantially, including boats for environmental monitoring, catamarans, and yachts; some of these are built to Western standards for export. A venture to produce furniture was less successful, but the shipyard does produce a few miscellaneous non-marine items.

It is impossible, on the basis of just these few examples, to reach more than a tentative conclusion as to the success of different strategies for conversion. The case of the Kockums shipyard, in which a number of existing and special government programmes were employed, appears to be the most successful. However, it required extensive state intervention -- and involved conversion from civilian to military production. In Massachusetts, state intervention was minor in scale and accomplished relatively little. Small-scale state intervention at Almaz to produce folding tables was not successful, but the company now has a thriving civilian shipbuilding business.

SWENESCO experts believe that conversion in the former Soviet Union, although it is very difficult and can only achieve partial economic success, is especially important for economic development as the military manufacturers are relatively well equipped and well endowed with skilled workers (Refs. 1,9). They find that the Russian employees are resourceful and ready to take risks with the simultaneous development of new products and new markets. In the West, they feel, conversion may be more difficult as it is harder to convince capital markets to support risky ventures involving both new products and new markets. State intervention in both East and West faces both political and economic constraints; in the West there appears to be more political resistance to conversion.

5. Conclusion

As an experiment in economic conversion, the experience at Shipyard No. 7 project can be considered a partial success. Some conversion, such as the gas welding supply workshop, was already in progress, and although small in scale, delivered a small profit. The shipyard has been able to stay in the ship repair and construction business, which, in an overcrowded sector, is a mark of success. The shipyard was also able to secure orders for repairing railway wagons and small-scale carpentry work.

The conversion project may not be able to claim exclusive responsibility for the modest achievements at the shipyard, but it is likely that the combination of exposure to Swedish business practices, the cooperation between Swedes, Estonians, ethnic Russians in Estonia, and Russians from St. Petersburg and the external support from INES members helped the shipyard to manage the transition .

The effect that the cooperation had on the wider community, and in turn on political support for the viability of the shipyard, is impossible to measure but can only be a

positive factor. It is significant that the mainly ethnic Russian workforce was not abruptly displaced by Estonians, and that the Estonian government has ordered a border patrol boat from the shipyard. The long-term future of Shipyard No. 7, now Tallinna Merehetas, has yet to bc determined, but cooperation with SWENESCO continues and the company is pursuing a number of lines of current and potential business. The conversion model that was developed for this project has been successfully transferred to other, Russian companies with positive results. It may have wider applicability to military manufacturers in both East and West.

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SOCIAL AND ECONOMIC ASPECTS OF MILITARY CONVERSION IN THE URALS

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ABSTRACT: *Urals economic region has become through centuries of industrial development the stronghold of Russian military-industrial complex (MIC). Two stages of conversion (starting from 1988) have sharply reduced its role in the economy and its technological potential. Total social and economic crisis in the country together with sectoral and spatial peculiarities of Urals' MIC make the process of conversion extremely vulnerable. A programed approach is needed to keep the balance between national and local priorities of the Defense sector. A sketch of such a program is presented in this paper.*

1. Urals as a Second Major Industrial Area in Russia

Urals is the second major industrial area in Russia. The economy of the region was formed according to national (then USSR) priorities ignoring the interests of its population. This resulted in the formation of a huge Defense complex serving national security interests. Only one fact worth mentioning - during World War II (1941 - 1945) Urals region alone provided 40% of the total armoury and ammunition for the Red Army. In the post-war period military oriented industries were expanding greatly.

Hypertrophied density of Defense production has resulted in invalid economic structure in the Urals, militarization of all branches of life, extremely low shares of consumer goods industries, and deterioration of natural environment.

Thus, the search of outcomes from the overall crisis in Russia and particularly its major Defense centers are closely interconnected with the general restructurization of the economy. In order to use conversion more effectively as a tool stimulating structural changes in regional economy, we suggest to conduct a detailed analysis of the conversion features in the region and on that basis to work out the structure of a regional conversion prograrn while taking into account the Russian conversion policy priorities.

Regional conversion is considered by the authors as a specific type of macroconversion (of all-Russian scale), providing the linkage of the latter with microconversion (i.e., reorganization of production capacities within Defense-oriented

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firms). Social and economic aspects of regional conversion appear to be the process of coordination of the federal, regional and group interests on restructuring of the Urals' economy, interindustrial allocation and relocation of resources, and problems of consuming them.

2. Urals' Defense Complex

Nowadays, every fourth Russian Defense enterprise is located in the Urals. By the end of 1990 the volume of Defense production there amounted to 30% of the whole economy (including ancillary industries). The similar indicator for the share of assets was 42% and employment 45%. 1992, the Urals Defense complex itself accounted for 10.3% of the total industrial production and 9.1% of all employees.

One can identify two stages of the regional (as well as national) conversion process. The first one, started at the end of 1988 and finished in the first half of 1991 was characterized by relatively moderate (guidance from Moscow) and, decrease in military expenditures, armament purchases, and R&D allocations. The second stage, starting in mid-1991 was nicknamed 'landslide' due to dramatic reductions of military orders (up to 60-80% annually), cancellation of centralized allocation of material resourses on military purposes, and break-up of cooperative links. In these circumstances, firm administration promotes the survival of existing staff satisfying their prime needs and saving production capacities, manpower, and R&D potential from total destruction. Enterprises have sharply increased civilian production (its share of total output increased from 48% in 1990 to 81% in 1994), though without necessary market research. At the same time, the total production of the Defense complex has been dropping steadily (see Fig. 1), the pace of reduction being higher than in civilian branches.

3. Defense Complex of Sverdlovsk Oblast'

Sverdlovsk oblast' (oblast' is level 1 territorial subdivision in Russia) is the most important part of the Urals' economy, making up 30% of its military production and 25% of military employment. Sverdlovsk oblast' MIC is comprised of some 40 industrial firms and 12 R&D establishments. Apart from this about 50 more civilian enterprises are involved in military production. The level of militarization of the Sverdlovsk oblast' economy is 5% points higher than that in Russia as a whole.

Defense firms there specialize in the most propulsive branches of national industries: aerospace, special metallurgy, ammunition, telecommunications, transport vehicles construction, nuclear and some others. Military R&D establishments in Sverdlovsk oblast' specialize in weapons (including nuclear) design, and automatic control equipment for all types of airplanes, missiles and space labs.

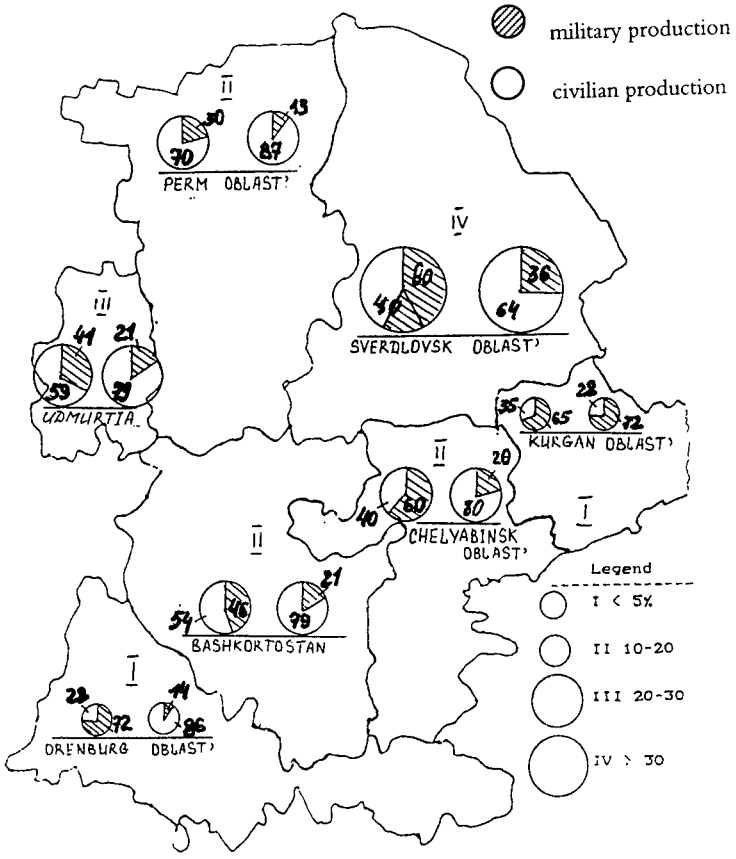


Figure 1. General Structural Indicators for the Urals. The size of the circle corresponds to the share of different Ural's Krritones in overall MIC's production (1991-1994 average). The circle on the left corresponds to 1990 figures while that on the right is for 1994.

On the other hand, there are some factors unfavorable for rapid transformation of the regional economy away from a highly militarized structure to a high-tech civil-oriented one. Among such factors should be named:

- total and long economic crisis;
- lack of business-planning on firm's level;
- uncertainty in Defense ordering policy in Moscow;
- non-payment for fulfilled orders;
- uncertainty in the rules of the so-called "mobilization capacities" use;
- scarce financing conversion programs;
- high labour intensity and low profitability of a number of consumer goods;
- absence of market research traditions.

As a result of sharp conversion, MIC of Sverdlovsk oblast' has shrunk by 36.3% during the period 1991 - 1994 (Fig. 2). Moreover, crucial reorientation of production has taken place within the MIC: only 3% of total output goes for Defense purposes compared with 60% four years earlier. During that period of time, the number employed in a military enterprises fell by 30%. A great number of firms have totally stopped working for Defense, others posess underloaded capacities.

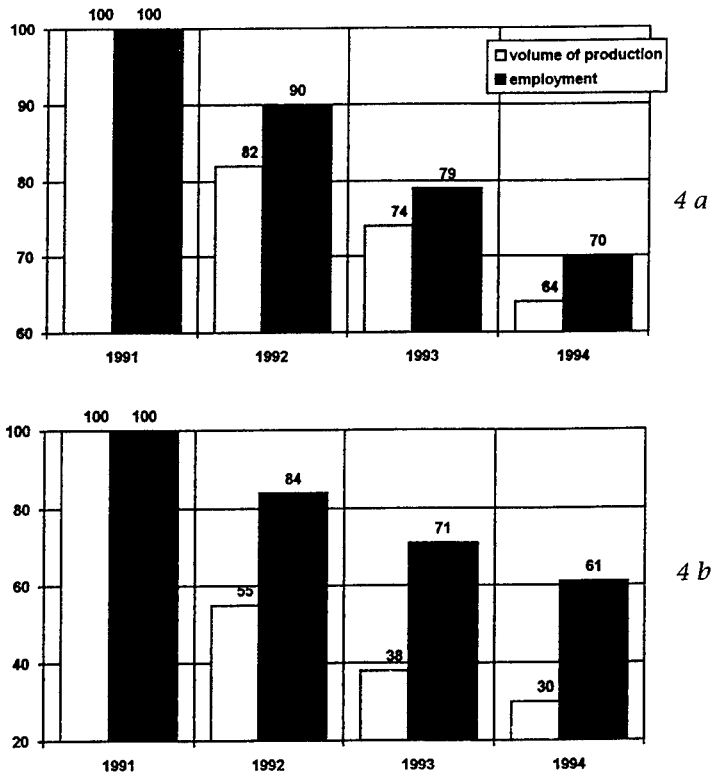


Figure 2. 2a Sverdiovsk Oblast' MIC (1991=100); 2b Sverdiovsk Oblast' Military R&D (1991=100)

4. Privatization in the Defense Complex

Privatization in the Defense complex is targeted at creation of balanced property structure by:

- diminishing state expenses for development and production of weaponry and at the same time - keeping the nation's security;
- stimulating thc new owners to intensify the processes or conversion, structural changes and development of Defense firms;
- attraction of private investments for conversion.

Before 1994 privatization had hardly touched any Defense enterprise, while by January 1, 1995 more than 50% of all enterprises under conversion were in different stages of privatizing (in Russia as a whole - 70%). The share of enterprises that are not allowed to be privatised in Sverdlovsk oblast is 14% points higher than Russian average. Large blocks of shares were left with the state at 11 out of 20 privatized enterprises for a period of three years. At nine other enterprises 'golden' share was issued, that also belongs to the state for a period of three years. Individual privatization concepts were elaborated for selected enterprises.

In spite of the large amount of privatized properties of the state Defense factories, the oblast' budget did not receive much revenue. Nor do privatized enterprises themselves have any substantial resourses for their development. Our analysis has shown that no crucial differences could be observed both in production dynamics and in the financial situation of Defense enterprises between privatized and state-owned ones. High rates of privatization did not lower the speed of decline of Defense and civil production, did not solve non-payment crisis, did not intensify investment activity, and did not improve the management level of the enterprises.

5. Spatial Dimension of Conversion

One of the major limiting factors for conversion in Sverdlovsk oblast' is the situation where in every second district and township Defense enterprise is the chief employer for an area, and in 16 cases - the dominant one. Life in such settlements was a great advantage a decade ago, but not now. Military 'masters' of the cities are often the source of social tension and unemployment. Thus those responsible for the elaboration of conversion policies must take into account substantial spatial differences between three groups of territories:

- the largest industrial centers like Yekaterinburg or Nizhny Taghil with diversified structure and strong R&D potential. Here firms under conversion can more or less easily share their innovative potential with civilian companies;
- small and medium towns with the single Defense factory as a major employer (like Artyomovsky, Bissert', Baranchinsky) experience the most fierce cuts in production volumes and social instability. Those firms are usually low-tech and thus they need not only some financial assistance,but primarily new structural and management decisions;
- finally, the so-called "closed cities" (like Lesnoy and Novouralsk) keep the most sophisticated scientific, manufacturing, intellectual and infrastructural potential involved in nuclear industry.

6. Social Consequences of Conversion

Unsatisfactory orgnization of conversion processes, aggravated by economic crisis in Russia, has initiated a number of social problems affecting Defense enterprises and R&D establishments of Sverdlovsk oblast'.

First, the loss of former social goals has become a serious psychological trial for the majority of employees. In 1993 alone more than half of those layed off from all industries in Sverdlovsk oblast originated from the enterprises under conversion. This initiated tension in the newly-formed labour market. At a number of Defense factories (i.e., electronics), the staff was cut by more then half of its former size in 1991. The proportion of those employed in civilian production inside the MIC has increased from 46 to 56% (though in 1994 at some enterprises the opposite trend was observed). 60% of all lay-offs were self-initiated, the majority of them (87% in 1995) were workers.

Hidden unemployment is sharply increasing. In 1994 more than 30% of employees had to take holidays without pay, another 20% worked on a part-time basis. Hidden unemployment in some industrial centers, was much more then officially reported figures (less than 1%). Due to the specific nature of military production, the staff of the enterprises under conversion have had few chances to find another job of the same speciality. As a result, in Yekaterinburg, in 1994 60% of all persons registered as unemployed originated from the Defense sector. The other dark side of the situation there is that the mean wage-rates reach only 63% of the average for the whole industry, and at a number of Defense factories - only 30-40%. The lowest salary levels are registered in the R&D sector in the major industrial and scientific center of the whole region - Yekaterinburg. Moreover, people are usually waiting for payouts for 2-3 or more months. Top managers, on the contrary, earn now much more than their staff and this inequality increases from year to year.

Lowering of social status, restricted participation in privatization, contradictions between the high professional levels of Defense workers and their new responsibilities during the transitional period - have carried problems of soicial conflict such as strikes, hunger strikes, blocking the entrances to local and regional administrative bodies.

7. Programming Conversion

Regional conversion programs are aimed at elaborating more efficient strategy and tactics of this process, softening transitional concequences, implementing more general industrial policy. Sverdlovsk oblast' was among the pioneers of programming conversion in 1991. However, this first program was too simplified, it did not take into account all ranges of economic, social, regional and other problems.

This time the Administration of Sverdlovsk oblast', Urals scientific and technical conversion center and Institute of economics of the Urals branch of Russian Academy of Sciences have joined their efforts in order to work out a new complex program of military conversion for the years 1995-1997. A team of specialists (among them Yury

Perevalov (DSc), Nickolay Sidelev (CSc), Sergey Yurpalov (CSc), and Vladimir Yatnov (CSc) was formed. The general purpose of this program is selective preservation and development of social, economic, scientific, technical and productive potential of the Defense complex, and its use for promoting the progressive structural changes in regional economy. Particular goals of this program are:

- transformation of regional Defense complex into the effective element of national security system;
- integration of military and civil production processes on the basis of dual use technologies;

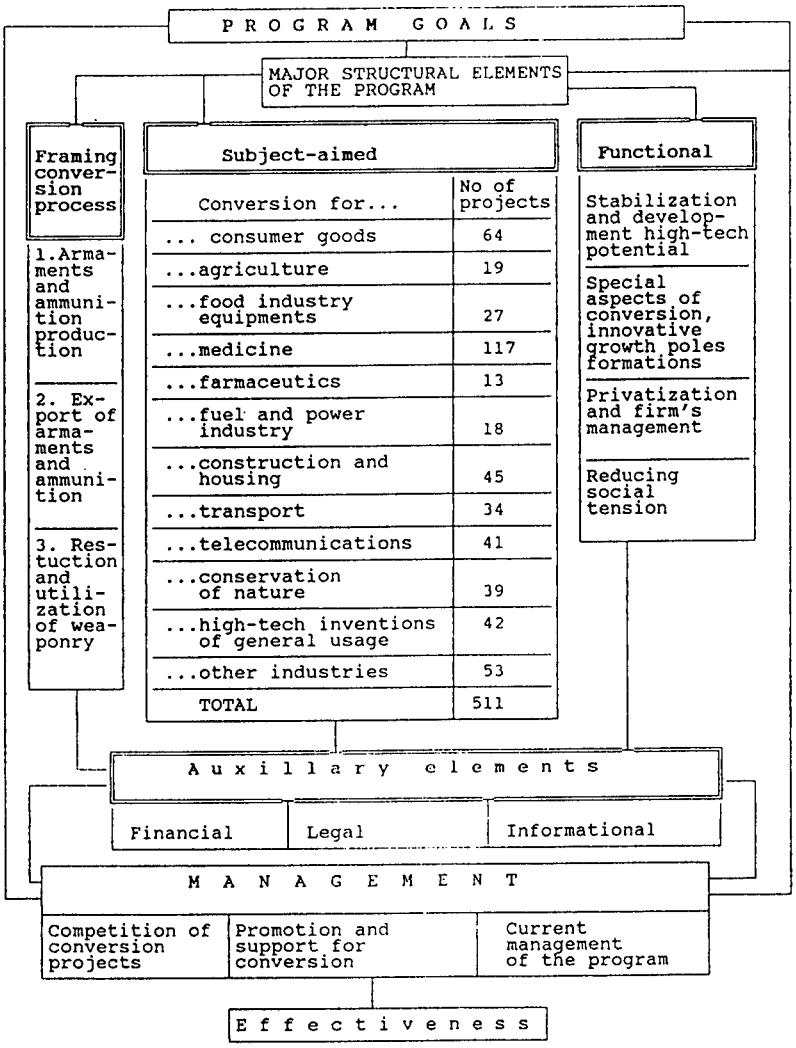


Figure 3. Military Conversion Program for Sverdlovsk Oblast'

- diversification and reorientation of military production facilities for the output of high tech civil and non-food consumer goods, export-oriented and import-substituting products;
- growth poles and technopoles formation;
- softening of social tension through preservation and effective usage of intellectual and labour potential of enterprises and regions.

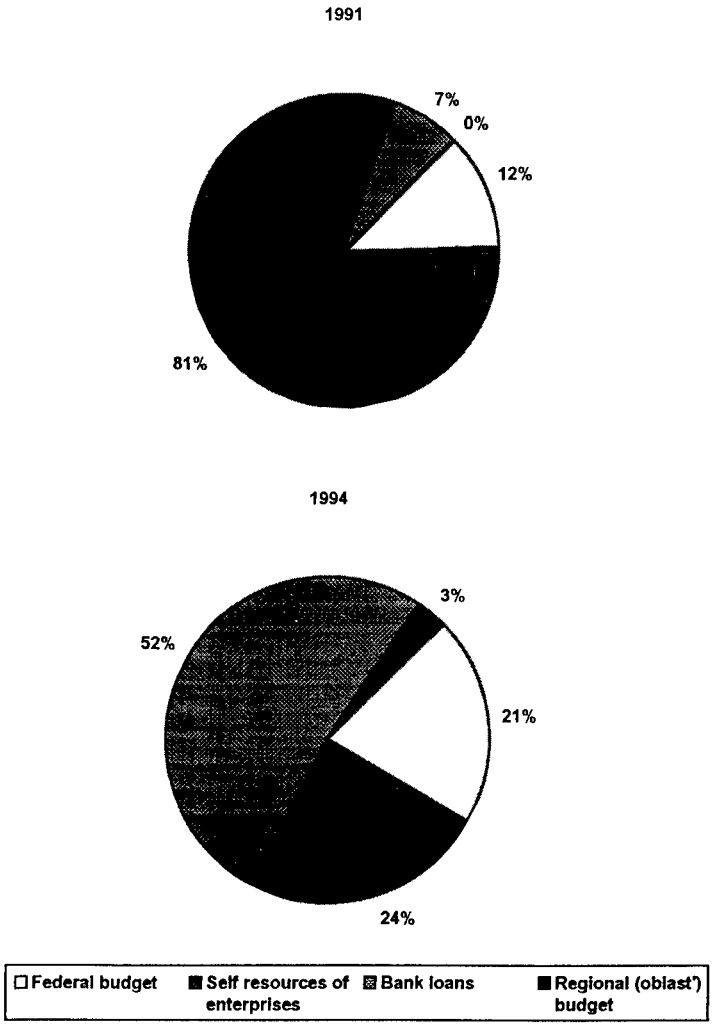


Figure 4. Financial Resources for Conversion oin Sverdiovsk Oblast'

Non-traditional structure of this program is shown on Fig. 3. Its success is determined by the financial resources available. Previous periods of time were characterized by new structure of conversion expenses (see Fig. 4). Neither increased federal funding, nor intensive attraction of bank credits could satisfy the material needs of previous conversion programs. This led to their failure.

Two investment companies were formed in Sverdlovsk oblast' in order to attract additional financial resources for conversion. One of them is called "Convers-Invest". Its co-founders are several Defense enterprises and oblast' Administration. The latter invested 10% of the registered capital. Main functional goals of "Convers-Invest" company are:

- search for investors able to form joint ventures with Defense firms;
- consulting, marketing, legal, informational and other services for Defense firms;
- search for potential buyers of intellectual and high-tech products;
- working out of strategic business plans, investment projects and their expert judgement for enterprises under conversion;
- involvement in privatization process of Defense enterprises;
- purchase and sell out of securities on behalf of the company and at its own expense;
- involvement in secondary securities market formation; and
- elaboration of sample contracts for the dealing on securities market.

The best chances to get access to loans and local financial support have 150 investment projects out of the total 515 on Fig. 3. The start of those most effective projects will allow us to keep more than 30 thousand jobs in Sverdlovsk oblast' in 1995 alone, to solve a lot of urgent problems in the sphere of medicine, ecology, agriculture, food industry, transport, telecommunications, housing infrastructure and power supply.

One of the ways to solve this crucial financial problem is to increase export activity of regional mining complex (thus it is responsible for 75% of all exports) and those Defense firms that are well-known abroad. Service centers to repair and upgrade weaponry for old customers must be set up.

Finally, the new conversion program for Sverdlovsk oblast' is aimed at the establishment of a number of big Defense firms responsible for production of certain types of weapons and high tech products. They are to be formed on the basis of the final stages of production facilities, R&D head offices, large testing establishments. Top on the list are:

- center for aerospace engines production;
- center for military machine-building;
- center for weaponry production;
- centre for nuclear energy;
- center for electronic guidance systems;
- center for telecommunications.

The organizational structure of those centers is under discussion. One possible solution lies in the formation of a giant regional corporation, consisting of several technopoles with some legal and financial privileges to promote hightech production competitive on world markets. The first results of the implementation of these policies could be observed 20 miles to the east of Yekaterinburg - i.e. in 'Technopolis Zarechny", formed around the Beloyarskaya nuclear power station.

At the end of the day, the conversion program discussed above is aimed at keeping the balance between the nationwide specialization of Defense firms and complex structure of regional economy.

THE CONCEPTS OF RUSSIAN AEROSPACE RESEARCH CENTER CONVERSION

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Abstract. *Zhukovsky Central Aerohydrodynamic Institute (TsAGI), a huge aerospace research center, was taken as a collection of problems: conversion of defense science and enterprises; their reconstruction, including capitalization and privatization, intellectual property, social sphere, a new form of relationship with staff, transformation of advanced military technology to civil industries, and cooperation between them; and a new approach to the system of professional education and to the problems of science and defense settlements and towns.*

Detailed consideration of the above, along with conclusions and recommendations, make up the content of this manuscript.

Taking TsAGI as an example, the author attempts to expand his observations of the problems in country and make recommendations to conversion strategies for regional and state-level authorities.

1. Background of Central Aero-Hydrodynamic Institute (TsAGI)

TsAGI was established on December 1, 1918 by Professor Zhukovsky (1847-1921). The Institute in a short time has become a leader in Russian (and Soviet) science and technology, not only in aviation but also in other transportation means. It took part in large-scale national programs.

TsAGI has been a basis for developing the aviation industry of the country; several Design Bureaus have been established (by Tupolev, Sukhoi, Ilushin, Mil', Kamov, and others) and new Research and Development Centers appeared (TsIAM in the aeroengine industry, VIAM in materials science, LII in the flight research area, etc.).

In the 1930's, the Government decided to build a new TsAGI. In 1936-1938, a set of unique aerodynamic test facilities and static strength test buildings were constructed in a settlement that has since been transformed into the city of Zhukovsky, a town of aviation, science, and technology. In addition, an airfield has been prepared built.

In the past-war years TsAGI constructed new-generation test facilities to satisfy the requirements of jet aircraft and supersonic airplanes. In the 1970's and the 1980's the

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Institute created unique facilities, including those for the Buran-Energia programme (analogous with the US Space Shuttle).

2. Present-Day TsAGI

TsAGI is the largest aerospace-research center. The staff in 1986 was 1,4000; now it is less then 8000. The test facilities include:

(a) Over 60 installations for the investigation into problems of aero, gas, and thermodynamics, including some 20 installations for industrial tests, and 23 installations for hypersonic research.
(b) Halls for testing full-size airframes for static strength (2300 sq.m.) and fatigue strength (6400 sq.m.); many stands for studies on specimens; thermal/vacuum strength chambers (one of them has an internal volume of 4500 m^3 and provides temperatures of -170 to +1700C, pressures of 1 atm to 0.0001 atm, and loads of up to 500 tons, so it is unique on the world scale); a reverberation chamber whose volume is 1500 m^3 and with an acoustic pressure level up to 164 dB.
(c) Flight simulators (including four with 6-degrees-of-freedom) and stand for improving performance of control systems.
(d) Water channel (200 meters in length) and setups for full-size marine tests.
(e) Over 10 installations for acoustic tests.

The Institute has also subdivisions specializing in the design of test facilities and measurement equipment, a pilot production plant, and shops in subdivisions for the manufacture of specimens and models, including compressors capable of supplying 300 kg/s of high-pressure air.

The Institute conducts basic research in aerodynamics for all types of flying vehicles (airplanes, helicopters, drones, rockets and spacecraft), structural static and fatigue strength and aeroelasticity, flight dynamics and control systems, hydrodynamics, and aeroacoustics.

Special attention is being paid to research studies including an estimation of the prospects for developments in aviation/spacecraft, and concept definitions for flying machines of the next generation.

Moreover, the Institute, together with Design Bureaus, participates in preparation of specific flying vehicles. We can say that all of the technology in the sky of our country contains our ideas and was created with our immediate participation.

The Institute performs the important function of State expertise. The Institute takes part in the development of the aviation progress program (in particular, the Government in 1992 has approved the Civil Aviation Development Program); formulates recommendations and examines each project (including the preparation for the flight tests); and is responsible for certification of airplanes and helicopters in respect of static and fatigue strengths.

Because of the changes in the national economy (including the drastic reduction in the amount of orders from the defense industry) the Institute funds efforts to transform the highly technological accomplishments into civil industry options for oil/gas producing organizations, for energy-generating plants, for the transportation industry, for agriculture, etc.

It has been four years since the Institute was been given the right to cooperate with aerospace companies and research centers of other countries. Today, Institute cooperates with almost all the leading companies of the USA, France, Great Britain, Germany, China, India, South Korea, and Japan; and has contacts with ONERA, NASA, DLR, NAL and others, with 30-40% of its income from this activity.

The presence of talented scientists, unique test facilities, the experience in preparation of flight vehicles - all these factors determine its leading position in the Russian aerospace and world community.

While this is encouraging information, there have been changes in Russia during the last 7-8 years with consequences to the Institute.

3. Change and the TsAGI

First; seven years ago the Institute had 100% financial support from the Government (60-70% - military budget), with the average salaries of employees that exceeding those in the rest of the country. The Institute received money for development of new facilities, equipment, social amenities, and so on. Now, financial support from the Government has been reduced 20 times (approximately), with military orders reduced about 50 times!

Second; the real salary of employees has been reduced about seven times (in comparison with a reduction of 3-4 times within the country).

Third; a majority of the 40% of employees who have left the Institute are younger than 40 years old; thus, the average age of the staff is more than 50 years. There is real danger of losing the scientific school of TsAGI. Simultaneously, 10-20% of many former kinds possibilities of investigations have been lost.

Fourth; the Institute has stopped developing new facilities, practically ceased maintaining existing installations and buildings, some of which are in need of immediate repair and renovations. Equipments of facilities need replacement. The volume of testing has decreased by 15-20 times. Some of the experimental facilities have not been used for some years. However, some of the wind tunnels are effectively being used by foreign companies.

Fifth; Theoretical have also been reduced, but the Institute successfully uses the huge storage of knowledge, experience, and know-how elaborated earlier.

Sixth; the Institute conserved the old system of property (state's property), old structure, old relation with employees, but did not solve the problem with intellectual property.

Seventh; the Institute, with town forming functions partially solving the problem of social sphere included 40% of the houses, hospitals, palaces, sport complexes and others

of the town of Zhukovsky (with more than 100 thousand people). The Institute now possesses about 15% of them.

Finally, The debts of Institute for electricity, heat, etc., exceeded its computations for 4-5 months.

4. Solving the Problems

Let us consider one way to solve the indicated problems:

By reducing the number of employees through the dismissal of 2000-3000 people in two categories, i.e., with age for retiring, and nonprofessionals.

Some comments needed on the second category:

a. In the former Soviet Union we had no unemployment (officially).
b. In Soviet Union from the 1930s up to 1970s artificial secret colonies and settlements had been built, such as science towns, defense, etc. (industry, resource, nuclear). The best brains from a huge country were relegated to these settlements, where tremendous financial support was provided to construct unique facilities for research, testing, and production.

   Unfortunately, the authorities did not think of the establishment of professional education in these settlements (exceptions had occurred, but rarely). As a result, the second and third generations of citizens had inadequate education, but continued to work at the same enterprises as their parents. Simultaneously, a second generation of talented specialists from throughout the country continued to arrive for work. Invisible, but very difficult, social problems, led to tension inside the enterprises (between employees). Thus, by rough estimations, about 20-30% of employees are unnecessary!
c. We need to begin the maintenance of hundreds of buildings, installations, offices, and others. Some of installations and buildings are very old, with offices per one employee exceeding 40 square meters - a very expensive pleasure! We also need to economize electricity, heat, water, and others.
d. Reconstruction of the institute's scheme of governing is needed, separating part of property which is not attractive to the Government that has no intention (possibility) to support property, and using it for other purposes, e.g., to produce goods, for innovation activities, for rent, etc. The simplest solution is to sell.

   Usual scheme. that our Government uses - transformation of property, is not convenient in this case. "Commercialization" of science is not simple. Basic researches need for Government support, investments, Government control. Where is the boundary between state interests and zone of market economy, when real results of investigations and development concern state and market? One need to elaborate some schemes of reconstructions for different type of enterprise.

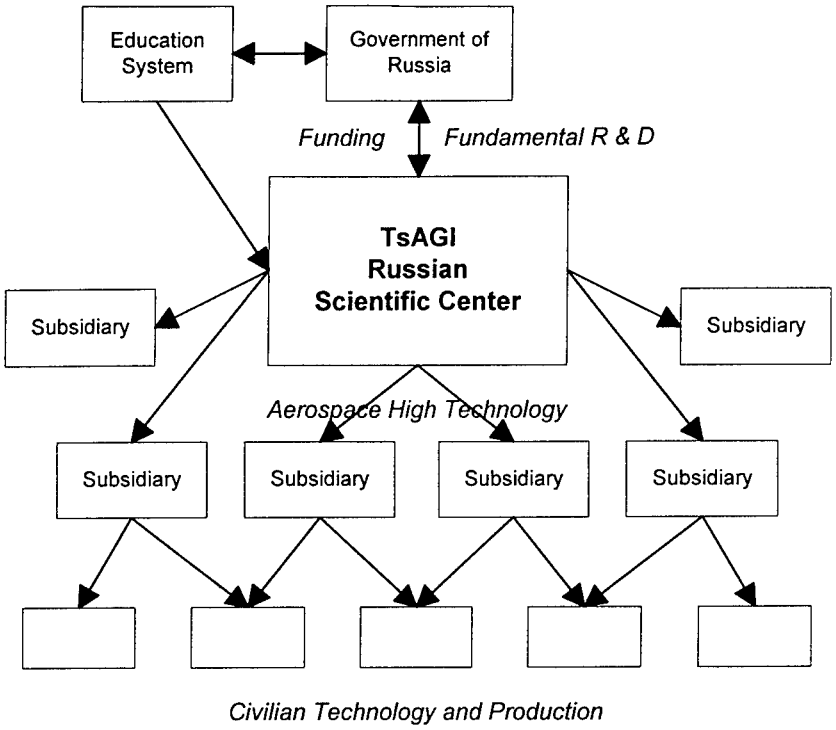


Figure 1. Proposed Structure

e. By changing the relationship with staff, using scheme of contracts with employees in order to conserve intellectual property. Tragical situation in Russia is bounded not only with seven hasty retreat of scientists and engineers to western countries and involvement them to other activities in our country, but ~vith unprecedented theft of intellectual property.

f. To have active policy in cooperation with civil industry of Russia. Our scientific and defense centers possess plenty of high technologies. Their main feature (besides well-known) is universal application. Formerly one of high technologies mentioned: technology for testing of hypersonic vehicles - thermostrength-vacuum chamber and its transformation for electrometallurgy, for porcelain, for drying of wood and so on.

Approach: applying high-technology to conserve resources, increase productivity, automate with information systems and promote ecological safety

Example: hypersonic research

- Temp = -170 to 1750 deg C, P = 1 to 0.0001 atm, F = 500 tons
- Furnaces for metallurgy
- Furnaces for porcelain and ceramics
- Chamber for drying wood

Directions of Activity:

- High quality fabrication, testing and machine-builing techniques
- Energy, oil and gas industries
- Alternative energy sources
- Agriculture and timber industries
- Medical diagnostic equipment
- Enviromental monitoring & ecology
- Metallurgy, porcelain and camera industries

Figure 2. Defense Conversion

We met some difficulties when we tried to penetrate to civil market withour technologies, products and goods. We (i.e. scientific and defense enterprises) were competitors with civil companies. Moreover, ·ve did not know civil market, civil science, technology, experience, condition of exploration of our products. We did not know anything. Only limited number of our high technology enterprises achieved success in this area of activity, gradually the number of successful venture is increasing.

There are two big difficulties for such activities:

a. absence of initial capital (money) for development new products, mounting of new equipment and initial production, and national banks, unwilling to invest money for a long time (year and more);
b. habit of science and defense enterprises to issue products by small series and misunderstanding the importance to reduce consumptions in every step of development and production.

Thus, cooperation (instead of competition) is inevitable process in our economy, cooperation between science and defense enterprises and civii ~ith exchange knowledge, technologies, experience to mutual benefit.

5. Problems of Science and Defense Industries and Ways of Solution [1]

TsAGI is typical example of problems of scientific and defense centers, plants, etc. Problems had arisen after hard reduction of state support, especially military order and understanding, that our science and defense industry were oversized in order to confront whole world. Our country had scientists and defense industry, that could be compared by its possibilities with all western countries .

Former Soviet Union was separated on two equal parts (on population point of view): Russia and other 14 countries. But disposition of 80% of science and defense enterprises in Russia means additional reduction of their budget.

As a result of new policy of government, from the beginning of the vear 1992, military and science order was reduced in many times. It was inevitable, but elemental motion to market economy and democracy had to add state science and industrial policy. Now our science and defense areas of economy practically destroyed, excluding rare islands of felicitous enterprises. Their experience ought to study and recommend to others, which is not so successful.

As to science and industrial policy, on the state level (Government level) we have to provide the solution ofthree problems:

- reorganization of enterprises;
- regional reforms; state programs of selective support to the leading science and defense institutions (see comments below), and, at first, acceptance of specialedicts, acts, decrees, supplying reconstruction of enterprises and regional reforms.

Reorganization of enterprises means list of actions, which were recommended in chapter I (concerning TsAGI):

- reconstruction of property, including separation of state's, stock's and private's property (the first must be limited and determined by government possibilities, but not only intentions and willings), including possibility to sell, to use for another purposes withattraction of investors, credits and so on;
- new relation with the staff and solution the problem of intellectual property;
- Lay-off some part of useless employees (this is the most dangerous action in Russia);
- reformation of social sphere of enterprises; new policy with young employees;
- reduction of consumption energy, heat, water, transportation, to maintain installations and equipment, especially old ones, ceasing exploration some part of building; and
- effective and fast transformation of high defense technology (for example aerospace) to civil technology.

Regional reforms must include as a minimum three aspects:

- transformation of science and defense towns as monocultural settlements into technopolices with many areas of activities, probably with conservation of leading role of former activity (the Market and Government will determine this necessity);
- integration these towns with region (formerly, they had been isolated from region and subordinated directly to branch ministries in Moscow. Zhukovsky city in Moscow region with TsAGI as the enterprise with town forming functions is classic example of similar town. In total, Russia has about 70-100 such kinds of settlements. Integration means close cooperation with regional enterprises and involvement in regional program of development;
- integration of regional science and defense enterprises (Examples of similar integration in South-East part of Moscow region are shown on Figures 3 - 5); and
- gradual reformation of professional education system.

Our national system of high education has achievements, because of plenty talented scientists well-known around the world. Acknowledgement of these successes does not solve new problem of our education system.

During many decades, our talented youth graduated from prestigious colleges and universities in Moscow and limited number of big cities (Leningrad, Kiev, etc.), after graduation relegated to mentioned towns. At that time, regional system of education was weak enough. Now we have possibility to create regional high education system, using world class scientists and engineers, who live in science-defense towns. We know that the best colleges and universities displace not in Washington, New York, London, but in small towns.

Government policy must include some topics:

- issue of edicts, acts, decrees concerning
  (1) reconstruction of science and defense enterprises;
  (2) intellectual property; and
  (3) science and defense towns and others.

- real steps are:
  (1) establishing closed cooperation between civil and science-defense industries;
  (2) gradual transformation of high education system; and
  (3) structural transformation of science and defense industries, coinciding with new national task-to supply wealth of nation.

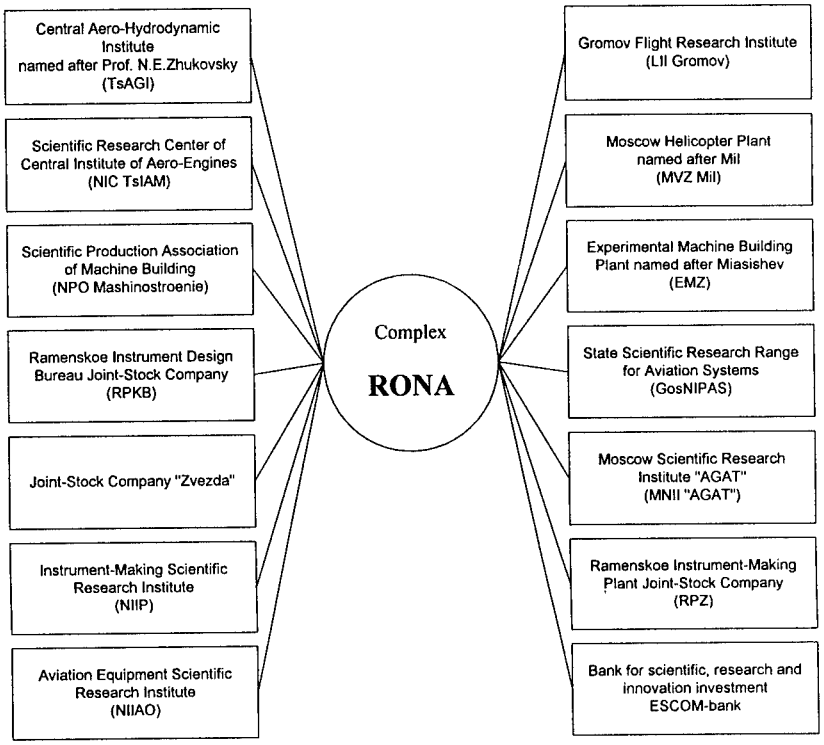


Figure 3. RONA-Complex Founders

1.Region deveplopment:

participation of the defence sector enterprises and research institutes in the development, examination and coordination of scientific and production programs aimed at re-equipment of key economy sectors (enterprises of the fuel/energy production, oil industry, medicine, transport, communications, agriculture, etc.);

consulting and assistance in reorganization and new company founding for defence sector enterprises (strategy of privatization);

region educational system development based on international collaboration with other countries;

regional transport and communication network development;

organization of international relations for small enterprises, consulting and assistance;

development of regional energy system;

assistance in elaboration of regional employment policy, new works creation.

2. Organization of joint production, add-value sale and sale of goods:

marketing and advertizing for goods sailed in Russia;

full delivery assiscance (transport, stock, custom, etc.);

the collaboration with Regional Trade Center

3. Assistance and participation in financial projects:

investment into regional enterprises;

investment into realty asserts and land;

loan and mortage operations;

assistance in obtaining governmental guarantees for investment projects.

Figure 4. Major Fields of Cooperation

- **Employ over 50,000 people**
- **Promote employee education**
- **Transfer technology to civilian industries**
- **Develop of new aircraft, equipment & procedures for flight testing**
- **Perform experiments in flight dinamics, airframe strength and control automation**
- **Develop aircraft maintenance techniques and equipment**
- **Regional projects: housing, agriculture...**

Figure 5. RONA Main Activities

6. Concluding Remarks

Situation with defense conversion in Russia is very difficult. We made many mistakes in this area from 1989, because team of reformer didnot have enough time, experience or political leverage to implement such a concept. Our today's tragedy is "the absence of any consistent policy of reform" [2~. There was no theory or concept of conversion, accepted by Government and our politicians.

Elemental conversion will deteriorate our economy, will conduct us tothe level of backward countries life. It is dangerous way, way of social explosions. Western community experiences the same problems with conversion. We know about solution in aerospace industry of US, GB, France, NASA, ONERA, DRA. But size of their disasters is not comparable with size of Russian's. Simultaneously, we see some achievements in this sphere and feel satisfaction from good news.

On our opinion, in this difficult situation for high technology institutions we need to promote international cooperation between them. Exchange of information, methodology, experience, technology, knowledge, joint investigations, designing development, production, penetrationto civil market help us to overcome temporal difficulties. High technology in economy (and politics also) will save our world!

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CONVERSION OF DEFENSE ELECTRONICS INDUSTRY

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Abstract. *Electronics covers a wide range of technologies most of which known as dual use. Today. civilian markets act as driving forces to reduce the cost of many military systems and equipment, specially those involved in new security requirements.For this reason conversion of defense electronics industry is a major stake for western countries. Public policies are changing fast the way they support this military sector and most companies adapt directly their strategies of diversification to commercial markets challenges. An overview of the french industry shows upon various examples how Defense electronics companies organize their conversion.*

1. The Changing Environment of the Defense Electronics Industry

1.1 A DEFENSE STRATEGIC HIGH TECH SECTOR HIGHLY PROTECTED AMONG MILITARY INDUSTRIES UNTIL THE MID 80'S

1.1.1. A Source of Military Performance

Electronic systems improve the accuracy of weapon systems and they increase the capacity and the speed of communication, control, command and intelligence systems (C3I). Moreover, they allow us to identify and to locate enemy positions forces, while they protect ours with countermeasures. The operational superiority of communications, detection, fire control and navigation systems depends on the wide range of technologies and on the performance required for military applications.

1.1.2 A Growing Share of Defense Budget

Emerging only since World War II, Defense electronics took a growing importance in defense budgets with:

- continuing development of electronics applications in major arms platforms (aircraft, ships, missiles, tanks,...);

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- increasing penetration of electronics technologies in all defense equipment like aero engines, munitions,... known as the pervasive effect of electronics in all military (as civil) products; and
- growing needs for communication and computing technologies, products and networks.

TABLE 1. Electronics portion of Armament

ELECTRONICS SHARE IN ARMAMENT EQUIPMENT (Billions francs)			
	FRANCE	EUROPE	UNITED-STATES
Armament equipment	91	380	1 100
Defence electronics	31	102	400
% Defence electronics / Armament equipment	34	27	36

The share of defense electronics in armament was about 20% in 1975. Ten years later, this share was over 30%, reaching 35 % in the United States' armament production.

Defense electronics has therefore become the most important part of defense budgets, before aerospace.

1.1.3. A Significant Importance in the Whole Electronics Sector for Western Industries

In United States, France and United Kingdom, the share of defense electronics production compared to the whole electronics sector is the most important with, in particular, a high contribution in research and industrial employment and a positive effect on foreign trade balance.

These countries are very sensitive to the performance of the defense electronics sector, but the fading results of their domestic electronics industries compared to others such as Japanese, German or Korean industries have clearly shown the low-level spin-off effects of defense electronics on the whole electronics sector economy.

1.1.4. The Organization of a National Industrial Basis of Companies

Historic development of each national defense electronics industry was based upon independence of technological resources and domestic production and tests. In order to protect military users from a unique source supplier at each step of production, defense authorities encourage competitiveness between companies using redundancy of projects and duplication of R&D. As a result, the industrial base was very fragmented. Defense electronics companies worked as companies fully protected by a national defense policy (see Figure 1).

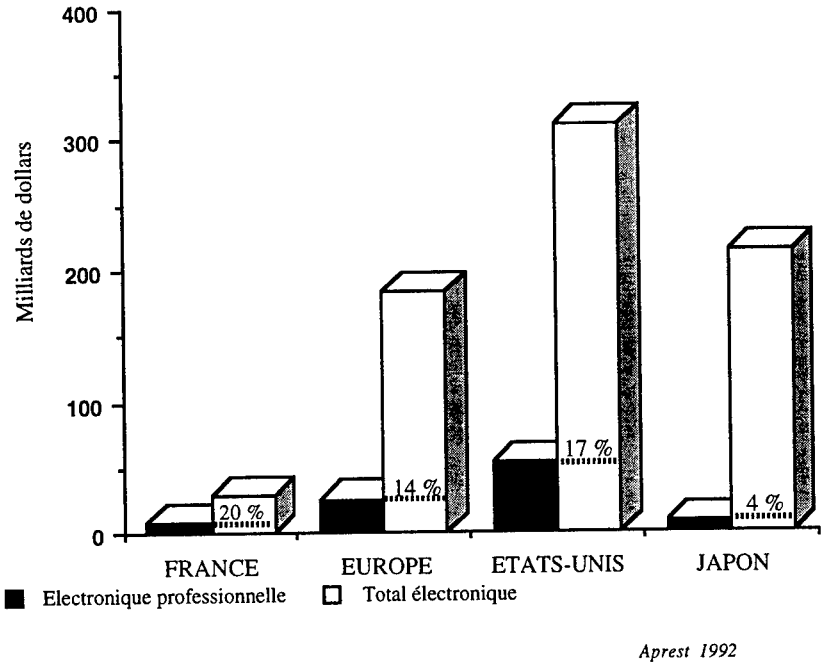


Figure 1. Defense Electronics as Percent of Electronics Sector.

1.2 DEFENSE ELECTRONICS FACES MAJOR CHANGES SINCE 1990

1.2.1. *Cutting Defense Budgets Reduce the Development of Skills in Military Electronics*

The impact of reduction of defense budgets is less important for electronics than for others armament industries. Nevertheless, cancellation in programs and reduction of quantities to be previously produced affect the vision of future activities of defense electronics companies.

Moreover, shrinking margins combined with new competitive pricing of military customers and cuts in some R&D budgets deeply modify relations between defense administrations and their industries. It has become necessary to re-structure the industrial base in order to reach the *critical size* necessary to remain competitive on defense electronics world markets and to be able to finance a growing share of R&D.

1.2.2. A Shift in Defense Requirements

Adapting to new requirements for defense and security involve growing needs for observation and communication equipment. Space technologies and reliable and interoperable systems of information between allies are necessary as continuing processes for monitoring worldwide areas. This situation brings with it new technologies and huge

investments, specially for space systems. On an other side, retrofit of electronic onboard equipment allow lengthening life time of military platforms.

Two main issues modify Defense electronics environment:

- military buyers pressures to reduce the cost of development and production of electronics equipment encourage partnership between companies and more international cooperation for new military programs,
- civil technologies are a driving force in the cost-reducing effort, all the more because many of new Defense applications are dual use based (components and software for communication, navigation, localization, ...computing applications...)

2. Defense Electronics Conversion Topology

Increasing needs to finance R&D when military markets are shrinking oblige defense electronics companies to strong revival strategies.

In addition to in-house efforts designed to:

- rationalize Defense activities like personnel lay-off, organizational revision,...
- enhance cooperation's efficiency between partners, and
- protect financial ratios and increase cash-flow resources;

three ways of specific conversion can be distinguished for defense electronics companies.

2.1 ARMAMENT CONVERSION STRATEGY

As involved in defense production, some electronic companies choose to acquire their main direct customer in order to keep a stronger position on the final market. In that way, they are "Prime" contractors, able to discuss directly with end-user customers and are free to fix profit margins of the business, but they become also fully competitive with armament companies for which electronics constitutes a major stake of competitiveness.

2.2 DEFENSE ELECTRONICS CRITICAL SIZE ACQUISITION STRATEGY

Restructuring defense activities to upgrade electronics, technological skills and to enhance competitiveness in markets is critical to success. Mergers, acquisitions and joint ventures between complementary companies are an easy way to strengthen market share positions.

Consolidation of European defense electronics industry shows many examples of such strategies based on a geographical approach of foreign markets. The "mega-mergers" between the biggest armament companies in the United States offers other examples of

such strategies when regrouping electronics capabilities of the two original defense firms. A third example can be found when large groups acquire small high tech business companies in order to reinforce a narrow and specialized skill.

2.3 DIVERSIFICATION STRATEGY ON CIVIL/COMMERCIAL ACTIVITIES

2.3.1. Diversification on Government-Like Civil Businesses

This first step of diversification on civil activities is an easy access one for defense electronics companies: it concerns mainly requirements defined by large administrative organizations like national infrastructure developments with a high technology content connected with a standardized environment, a sizeable market and a little number of customers base.

The most famous examples of such activities refer to air traffic control systems/ equipments and to radio & TV professional equipment. The development of innovative security networks for transportation control and security, as, on an another side, multimedia are now expanding fast on world markets.

2.3.2. Diversification on Commercial Markets

Commercial markets more often concern equipment produced in quantities and had worldwide marketability (see Figure 2).

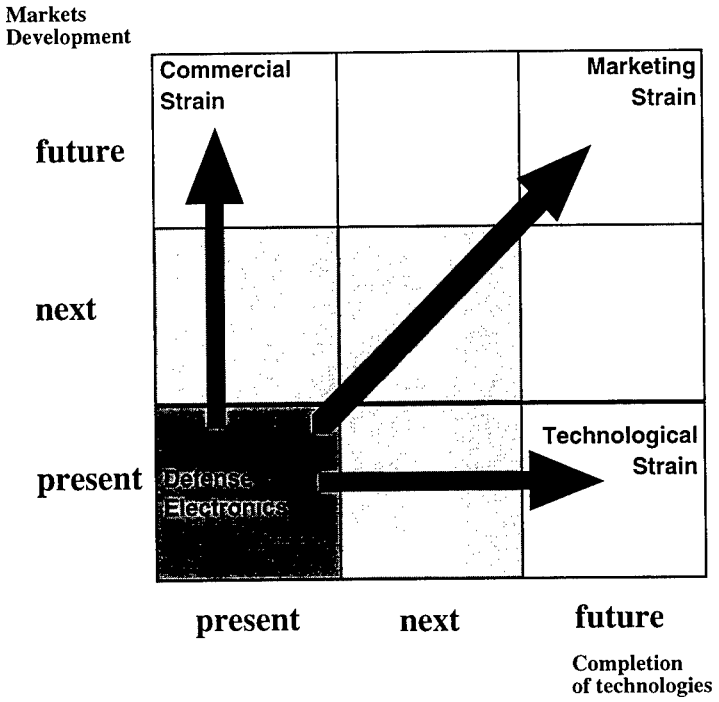


Figure 2. Diversification Strategies on Civil Fields

This kind of diversification strategy is a risky one for defense electronics companies, except those still involved with production and distribution know-how on large electronics markets. Success requires big investment for developing the most advanced technologies, adapting them to new end-users requirements for environment and pricing, and commercializing the products as consumer's ones on a large geographical basis. On the opposite side, these markets are defined as the most promising area of recovery for defense electronics firms in the future.

These trends of defense electronics conversion are universal and they can be observed for each national industry. Nevertheless, the original structure of the industrial base, either in armament or in electronics field, is a major source of difference between nation's industries (see Figure 3).

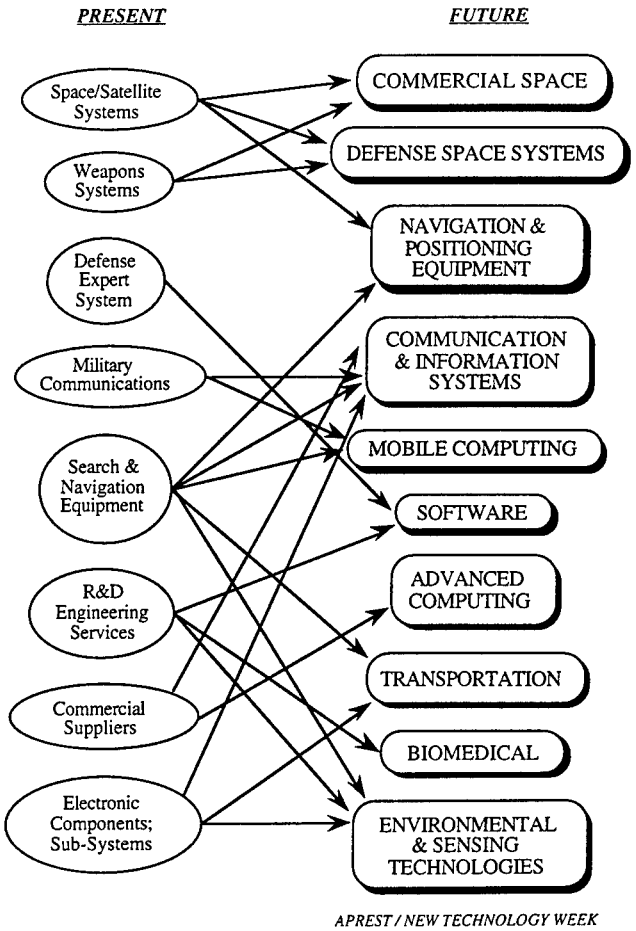


Figure 3. Main Flow of Defense Electronics Conversion.

3. Defense Electronics Conversion: The French Case

Turnover of defense electronics industry is approximately 24 billions Francs in 1994 out of which export sales amount to 40%. Five years ago these figures were respectively 35 billions francs and 70%. French companies were very active to adapt new trends during these last years but the industrial base remains heterogenous with the larger defense company, Thomson-CSF, accounting for 2/3 of the French sector turnover.

Thomson-CSF is the leaderin the European Defense electronics industry. With its constant strategy of external growth it is, by far, the main actor in restructuring this sector.

Development of civil business has been done for many years on air traffic control systems and on radio/TV bases and infrastructure, as natural extensions in synergy of defense activities. Conversion to new and innovative commercial markets seems to be restricted because of company culture, skills and organization. Forecast results of some 500 million France in five years for electronic automotive equipment turnover (out of SGS-Thomson sales for automotive integrated circuits) is indictive of the low-level of involvement of Thomson-CSF in commercial conversion. Nevertheless, technology spin-off between the defense division (CSF part) and the consumer one (TCE, recently renamed as Thomson-Multimedia) with a new definition for the whole Group financial structure constitute a major step in the conversion process.

TABLE 2. Example from Thompson-CSF

CONVERSION/RESTRUCTURATION

THOMSON-CSF' FUSIONS AND ACQUISITIONS IN EUROPE DEFENCE ELECTRONICS AT-MID 1995

Merged companies, subsidiaries fully owned or with a participation

- **United Kingdom :** Ferranti-Thomson sonar systems, MEL Communications, Shorts Missile systems, Pilkington Optronics, Link Miles, Rediffusion, Redifon, Thorn Emi Missiles systems.
- **Holland** : Signaal (HSA).
- **Belgium :** Thomson-CSF Electronics Belgium, Forges de Zeebrugge.
- **Spain** : APEC (radiocommunications) et SAES (activités) sonar.
- **Germany :** recent alliances with DASA in three or four defence fields.

Conversion trends of other French defense electronics companies are mostly related to diversification of activities on the wide range of applications of communication technologies, either for professional networks or commercial products. Company's original experience in commercial fields appears to be of first importance to succeed on future markets.

For five years, a substantial public support is allowed to small defense business firms considered as dual use high tech companies. Many of them are involved in electronics, specially in software design and applications. Partnership between these small and largest companies is strongly promoted by military and civilian administrations to ensure technological capabilities of the national industrial base and to sustain employment (see Figure 4).

	Armament conversion	DE markets/ skills acquisition	Diversification	
			Professional	Consumer
Alcatel Alsthom		→	→	Communication and space systems
Aérospatiale	Software			
CSEE		→	Software	
Dassault Electronique		→	→	Communication Automation
Matra		→	Software →	Communication
Sagem		→	→	Communication multimedia, automotive equip.
SAT		→	Communication	
Sextant Avion.		→	Aerospace equipment	
SFIM		→	automatization and measurement	
Thomson-CSF		→	→	Communication systems multimedia

Figure 4. Conversion Trends of Main Defense Electronics Companies in France.

CIVIL-DEFENSE STRATEGIES IN THE UK

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1. Introduction

Defense conversion as a distinct issue has not figured as conspicuously in UK government policy as it has in some other countries. Some nations in the early 1990's introduced funding schemes explicitly to encourage their defense industries to convert from defense to civil products. The approach in the UK has been instead to leave restructuring to the individual companies and to the market to determine. The US government has made "winning the economic war" part of the mission of the US Department of defense and has funded a substantial program on dual-use technology. In the UK the approach has been to seek benefits for wealth creation from all government-funded research including defense research but not to make wealth creation an explicit or primary objective of defense funding.

It is also the case that for various reasons job losses in the UK defense industry may have been less conspicuous than in other countries. The UK was the first OECD nation to enter the recession and there was rising unemployment in many areas of the economy in the early 1990s. Thus, the job losses in defense were part of a much larger restructuring that has affected many industries during the same period: oil and chemicals, financial services, general manufacturing, telecommunications, construction, computing, retail, transport and aerospace as well as defense. Defense conversion has therefore been seen in the UK as a part of the larger restructuring of the industry produced by the recession and also by the introduction by companies of new business processes into management and manufacturing.

One can also conjecture that the job losses in the UK defense industry may have been less conspicuous for reasons of geography. Most of the defense industry is located in the south of England. This is the high-technology heartland where there are many growth industries, and where defense represents less than 1% of employment in the region. The south of England is geographically compact and communications are very good and hence the job losses can be expected to have had less serious consequences than would have been the case if most of the industry and military installations had been geographically remote from other sources of employment. Where job losses caused most concern has tended to be in these more remote areas such as the dockyards in Davenport and Rosythe.

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In the south of England the closures of military bases have often been welcomed either for providing the opportunity to improve the environment by restoring countryside or because of the scope that closures have created for industrial growth. In the south-east of England good sites for science parks and industrial developments are scarce and some of the defense rundown has provided new sites with good scope for encouraging future growth.

2. Technology Foresight

Because restructuring and national wealth has been seen as part of a larger situation of long term global change, the approach which the UK has adopted to developing an industrial and commercial "strategy" has encompassed all sectors of industry and commerce. The vehicle for developing this "strategy" has been through the UK Technology Foresight program [1]. This program was established by the Government in a Parliamentary White Paper on science, engineering and technology published by the Office of Science and Technology (OST) in May 1993. The objectives of the Technology Foresight program have been to create a national vision, to identify priorities for science and technology, to identify key constraints and to encourage much stronger linkages and networking between different sectors of the economy, including those between defense and civil sectors.

Foresight has been based on 15 industrial/commercial sectors which are listed in Table 1. One of these sectors is Defense and Aerospace, and this recognizes that there has long been a strong civil-defense integration in aerospace.

TABLE 1. The fifteen industrial and commercial sectors which have been the basis for the Technology Foresight studies.

Agriculture, Natural Resources & Environment	Chemicals
Communications	Construction
Defense & Aerospace	Energy
Financial Services	Food & Drink
Health & Life Sciences	IT & Electronics
Leisure & Learning	
Manufacturing, Production & Business Processes	Materials
Retail & Distribution	Transport

3. The Restructuring of the UK Defense and Aerospace Industry

Defense and Aerospace is a sector in which the UK is currently a world leader. The UK's share of OECD exports is higher for Defense and Aerospace (at 11.7%) than it is for any other of the 15 Technology Foresight sectors. Defense and aerospace companies rank highly among the UK's top exporters in the 1993 UK league table of exporters, British Aerospace occupied first position, Rolls-Royce occupied third position and GEC occupied

fourth position. UK defense exports in 1993 totalled £7B giving the UK over 16% of the market, second only to the the US as a defense exporter.

During the 5 year period following the ending of the Cold War the UK defense industry has contracted by about one-third as shown in Table 2. This amounted to a reduction of 180,000 jobs from 595,000 jobs in 1988-89 to 395,000 jobs in 1993-94. During the same period 50,000 jobs were lost in the armed services, a reduction of 16% in the manpower, and about 30,000 civil service jobs were lost, a reduction of 17% in the civilian support.

Of the 425,000 jobs remaining in the defense industry in 1992-93, roughly half were related to the development and production of equipment for the MOD, a quarter were related to equipment for export, and a quarter to non-equipment support.

TABLE 2. Defense Employment (thousands) in UK Companies from 1988 to 1994

	89-90	90-91	91-92	92-93	93-94
Direct	300	275	275	225	210
Indirect	275	260	235	195	185
Total	575	520	515	425	395
% of 88-89	97%	87%	87%	71%	66%

Source: UK Defense Statistics 1995 HMSO

4. De-Industrialization and Conversion

The reductions in the defense and aerospace sector are part of a sustained de-industrialization during the 1980's and early 1990's. In 1993, production (including manufacturing industries, mining and quarrying, and electricity, gas and water utilities) accounted for only 28% of UK GDP, and within this the manufacturing segment represented only 23% of GDP. By comparison both Germany and Japan had about 40% of their GDP coming from industry. It is widely believed that it is their slower de-industrialization that allowed Germany and Japan to sustain a very strong balance of payments position during the period.

As observed in the Technology Foresight report on Manufacturing, Production and Business Processes [2], manufactured products are very important to UK exports. This is demonstrated by the fact that in 1993 almost 30% of UK manufactured output was exported and this accounted for over 60% of all UK exports, whilst the UK service sectors accounted for less than 25%. The UK share of world manufacturing exports has been around 6% since the early 1980's. In contrast Japan, Germany and the US each have a share of 16-20% [3]. This suggests that further rapid de-industrialization might be unhelpful for the UK. Thus, the need to sustain and restore UK manufacturing and production has been a major message from the Technology Foresight studies.

The process of de-industrialization in the UK and other OECD countries is driven in the long term by the massive growth in skilled workers in developing nations

particularly in the Far East and by the global mobility of manufacturing techniques, technology and investment finance. Work and money can now move globally to wherever costs, quality, skills and markets are optimum. For OECD nations to retain industrial employment they therefore need to possess skills, know-how and market access that are less easily mobile. This is one reason that defense and aerospace are particularly important industries for OECD countries because they involve total systems understanding and the expertise to integrate complex systems and subsystems. This provides sustainable high added value based on know-how that is not easily transferable.

Defense and aerospace is also a sector that makes strong use of mechanical engineering skills. In mechanical engineering the UK still has a substantial professional workforce and a strong academic sector. Preserving high added-value jobs that utilize this resource will remain important for at least the next 10 years over which time the skill base will be able to convert steadily to newer disciplines of information engineering and biotechnology.

Because industries based on mechanical engineering are generally facing low growth or decline in the next 20 years within OECD countries, there is little long term macroeconomic benefit in converting from defense to civil products based on mechanical engineering, unless these offer high added value and are defendable through using advanced manufacturing or advanced materials, for example. There are a few growth areas in mechanical engineering, notably robotics, pollution control, advanced materials and aerospace itself. But among the 27 key priority technologies identified in the Technology Foresight Steering Group report [1] the dominant growth areas are almost all in IT, electronics and communications (ITEC) and in biotechnology.

A further factor working against conversion from defense and aerospace to other mechanical engineering industries in the UK is that within Europe there is likely to be an abundance of excellent mechanical engineering expertise in Germany also looking for conversion opportunities. It may well be that declining areas of mechanical engineering will be seeking to covert into defense and aerospace rather than vice versa.

5. Conversion in the ITEC-Based Industries

The ITEC-based sectors present a very different picture for conversion. ITEC is continuing to grow rapidly and is expected to represent 10% of world GDP by 2005. The growth involves the convergence of several previously separated industries, including the convergence of defense and civil ITEC. Key themes are media technology, digital networking and mobility with an explosion in new information products and also the ubiquitous embedding of electronics in most manufactured goods. Much of the added value in future manufactured products will derive from the embedded electronics, often linking with information services. The commonality here between civil and defense is clear.

The Technology Foresight report [4] suggests that the ITEC sector will need to grow in the UK from its current level of around £43 billion (6.7% of GDP) to at least £78

billion in constant prices by 2005 (10% of projected UK GDP). This implies a compound growth of 6% per annum. But the growth could need to be much faster than this, perhaps as high as 15% per annum which would severely squeeze the available ITEC engineering workforce even though increased productivity could mean that the employment growth is only half the GDP growth.

ITEC is also becoming increasingly dominant in defense equipment. Therefore from a conversion perspective the likely scenario is that defense will converge with civil industry in ITEC, exploiting the discontinuous developments in civil ITEC technology and services. Defense manufacturers will need also to be mainstream civil ITEC companies and will need to be increasingly global, drawing on fast growing specialist companies worldwide. Defense and civil ITEC research will need to be joint or very closely coupled.

It is already the case that most of the ITEC companies in the UK are predominantly civil with less than 10% of their turnover derived from defense. Even GEC-Marconi, which remains primarily a defense company (70% defense, 30% civil), has shifted its turnover substantially towards civil products during the past 5 years. In 1990, half of GEC-Marconi's turnover came from UK defense, 30% from non-UK defense and 20% was civil. In the succeeding 5 years, GEC-Marconi's turnover for UK defense has halved, non-UK defense has increased by 50% and civil business has increased by 50%, with also an increase in the overall turnover compared with 1990.

GEC-Marconi provides a good example of the way dual civil-defense electronics products are evolving. The areas where GEC's civil business has grown in the past 5 years include:

- civil avionics (Boeing 777 flight control, in-flight systems, cordless cabin telephone systems, pilot landing radars);
- civil command and control systems for police and fire services;
- transport systems (automatic vehicle location, computer based traffic control, on-board route guidance, road pricing transponders);
- consumer products (video telephones, direct broadcast receivers, smart cards and embedded electronics).

Longer-standing areas of GEC-Marconi's civil business include communications equipment (radio and TV broadcast transmitters, tropospheric scatter, mobile radio networks), space systems (SATCOM, earth observation, ground environment, manpack terminals), civil night vision equipment, and commercial information systems. Emerging areas of civil business include car radars exploiting mm-wave technology, head-up displays, laser blind spot detection, sonar and radar reversing aids.

GEC is the largest ITEC defense supplier to MOD. Most of the other main ITEC suppliers to MOD, such as BT, ICL, Siemens, Racal, Northern Telecom, SEMA, Serco, IBM are predominantly civil companies

6. Defense Conversion and Europeanization

The restructuring of the UK defense and aerospace companies has been driven not only by the cuts in defense expenditure but also by the need to improve efficiency and productivity to be able to compete with the US defense industry. The industry also believes that this restructuring and any defense conversion strategy cannot be addressed just at a national level but has to be based on the development of a strong European industry and common European procurement led initially by the main collaborator countries France, Germany, Italy, UK and possibly Netherlands.

Though this pressure towards European restructuring and procurement is driven by the need to be able to compete against US industry, it is not anti-American and is not "Fortress-Europe" in its objectives - the UK is committed to continuing to purchase competitively from the US, and UK companies have very important commercial relationships with US industry and armed services. But the US industry is seen as becoming overwhelmingly powerful. The US industry has restructured vigorously and also has the benefits of the still massive US equipment procurement. DOD expenditure on R&D has been relatively protected from budget cuts whilst in contrast the UK defense R&D is being cut preferentially, creating the fear in UK companies that their technological base will wither away.

The view expressed by the UK defense companies through the Defense and Aerospace Foresight report [5] is that although European industry has begun to establish cross-border alliances, progress is too slow because there is insufficient progress at the level of governments. The Foresight report recommends therefore that:

> UK Government in consultation with Industry must accelerate where appropriate the establishment of common defense requirements and acquisition in Europe on bases which are efficient and which provide reciprocal market access.
>
> UK Government and Industry must work together at a strategic level to ensure that UK companies have equitable opportunities in new European collaborative programs, whilst at the same time recognizing that opportunities will continue to exist to collaborate and trade on a two-way basis with the United States.

This objective has also been emphasized in recent Ministerial statements. But European convergence is easier said than done, because there are great differences in procurement processes between the individual countries and also in their re-equipment needs and timescales.

7. Conversion- Differences in Business Culture

In the literature on defense conversion, it has long been argued that a crucial impediment to conversion is the differences between civil and military business practices. A host of

US studies in the 1980's and early 1990's argued that US defense companies were broadly incapable of acting like manufacturers of civil products, that they had little experience with commercial customers and that they were unsuited to the rigors of the competitive market [6]. It was postulated in the US that a "wall of isolation" reached down from the US defense prime contractors into the subcontractors creating an unbridgeable divide between commercial and military manufacturing. From this it was argued that the conversion of military production capabilities to civil or joint military-civil capabilities had little chance of success because the processes, timescales, cost constraints and indeed the cultures were too dissimilar. Further, it was argued that defense conversion would inevitably lead to the loss of any technical capabilities that were defense specific.

Such stark barriers in culture between defense and civil industry have not been the common experience in the UK. There are of course differences between very different sectors of the economy and also between companies involved in low volume high added value products and those in high volume manufacture, where every penny counts. But barriers are not conspicuous. Within aerospace there has always been a strong coupling between the defense and civil business. Defense funding for R&D has been important to the world class position of Rolls Royce in aeroengines and BAe's leading capability in wings derives from aerodynamics and materials capabilities from defense. Government research in aerospace has also been undertaken on a dual basis. In the 1960's the then Ministry of Aviation Supply covered both military and civil aircraft and components and since then part of the research at Farnborough has continued to be funded jointly by MOD and the Department of Trade and Industry (DTI). There has also been direct transfer of know-how and business practices for example between aircraft manufacture and car manufacture during the time whilst BAe owned Rover when Rover introduced the changes in its engineering and total quality practices that transformed its products in the early 1990's.

More recently, a rather different set of conclusions has emerged about the US industry from a study by Kelley and Watkins [6], conclusions that are more in line with these perceptions of UK industry. The Kelley and Watkins study was based on a survey from 973 randomly selected US production plants covering virtually all of the US capital goods manufacturing sector, both military and civil, and some consumer goods manufacturing. According to its authors, this was the first rigorous empirical study of a large range of defense and civil manufacturers carried out for 30 years. Its conclusions, in contrast to the earlier papers, were that the industry is not isolated and specialized as had been supposed, that the structural and behavioral barriers thought to divide fefense contracting and commercial manufacturing are actually quite rare, and that the fefense industrial base is substantially dual-use already, using the same facilities and workforce to meet the requirements of both commercial customers and military specifications. Half of all of the US plants surveyed had defense contracts in 1991, showing that the defense sector is quite pervasive, and 80% of these establishments integrated commercial and military production in the same facility, selling more than half their 1990 output to commercial customers.

Interestingly, the Kelley and Watkins study also found that the plants with defense contracts made more extensive use of advanced manufacturing technologies. This is attributed to the substantial DOD funding for advanced engineering and to better information sharing and supplier development activities by defense primes. The situation in the UK on advanced manufacturing is that MOD has had a policy of not funding manufacturing methods in industry, and probably it is for this reason that UK defense companies are generally trailing behind comparable civil manufacturing, particularly in the use of concurrent engineering. Industry through the Foresight report has drawn attention to this problem and recommended that much greater emphasis should be placed on design, lean manufacturing and concurrent engineering to provide dramatic reductions in time to market and cost. The industry sees this as important not only to reduce costs so that more can be invested in maintaining the research and technology edge, but also because companies expect competition in the future to come from civil companies based on superior civil practices. Civil companies are seen as being superior not only in development and production but also in providing support services throughout equipment life and worldwide to equipment users.

8. Conversion to Commercial Procurement Practices

The UK Industry believes that current defense practices increase the development cost of some military equipment very substantially. For example, in the Foresight report [5] RoLls Royce have estimated that the development cost of a military aeroengine could be cut by 60% through adopting an integrated approach to technology demonstrator projects which involves the joint development of product and process technologies and a shortening of the timescale from program launch to operational service to 5 years. The key to the savings is using concurrent engineering and demonstrators to reduce risk early and to avoid the development being drawn out with multiple changes in design and in requirement.

The industry has therefore been pressing MOD to alter its procurement practices moving away from the rigid arms length competitive policies towards valued-partne relationships, developing equipment concepts in partnership and giving greater freedom to use production facilities jointly for civil and military manufacture and greater opportunity for accelerated demonstration and development. Until recently, however, the MOD has been very wary of softening its arms length policy for fear of falling back into the "cosy" cost-plus procurement that characterized the 1970s and early 1980s and which is held responsible for many of the overspends during that period.

Recently several Ministerial statements have announced a shift in policy towards closer partnership with industry. This new policy accepts that MOD should have a concern for the health of the UK's defense industry and that whilst continuing to pursue a competitive policy, MOD will now take into account the implications of its procurement policy on the industrial base. The MOD's procurement executive is also applying business process re-engineering methods to its procurement processes.

Industry has also recommended in the Foresight report [5] that much greater emphasis must be placed on modelling, simulation and synthetic environments, and on the coupling of this into equipment design, concurrent engineering and life-cycle cost reduction. These techniques for product design apply also to the civil sector. UK academia is contributing through a new initiative - the Innovative Manufacturing Initiative (IMI) - which particularly addresses aerospace and business processes, and which involves industry closely.

9. Conversion of Defense Research

In thinking about defense conversion, attention has often focussed on the research base. There are several reasons for this. It is relatively easy to introduce schemes that link civil and military research more closely. Defense research has often benefitted the civil sector (spin-off) and there is a desire to increase this. Similarly, civil research and technology is increasingly exploited in defense equipment (spin-in) and is crucial in the ITEC area as already discussed. Also, government laboratories, such as the US national laboratories and the DOD laboratories, have been seen as national assets whose future as institutions of scientific excellence is a national imperative. An allied concern has been that serious proliferation risks and new threats could result from researchers and research knowledge falling into the wrong hands, particularly because of the massive cuts in research budgets for the military research institutions in the former Warsaw Pact countries. For all these reasons quite a lot of attention in some countries has been focussed on the question of how far the government laboratories can convert to undertake non-defense research, especially where these laboratories are geographically isolated.

The policy in the UK towards the government laboratories has been driven much more from wanting to minimize the role of the public sector and to introduce private sector practices into the public sector wherever possible. The introduction of commercial practices has been particularly evident in the defense research within government and has yielded major savings in costs. This conversion to commercial practices began in 1989 when the main UK government laboratories concerned with non-nuclear research were brought together as a single government agency, the defense Research Agency. The DRA became a trading fund in 1993 which means that rather than receiving block funding for its work it is now required to earn all its revenue through contracts from its customers, principally in MOD but also in UK and foreign industry and other government departments. Adopting commercial operation gave a handle on real costs and customer demands for the first time and revealed many unnecessary activities with the result that in the period since 1991, 20% has been saved from the costs without any loss of output to customers. Importantly the costs were reduced so that they were equivalent to or cheaper than those of industry, making it easier for the laboratories to take on work for civil customers.

This formula worked so well as a mechanism for saving cost that in 1995 most of the rest of the MOD's science and technology services, with the exception of nuclear

weapons, was transferred into an enlarged Agency, the Defense Evaluation and Research Agency, which encompasses the DRA, the Chemical and Biological Defense Establishment (CBDE), the Defense Testing and Evaluation Organization (DTEO) and the Centre for Defense Analysis (CDA).

The UK government's defense science and technical services have in this way gone through a major conversion in their culture and their business processes. This is admired in other NATO nations for its effectiveness in exposing and cutting costs and in focussing research on military objectives. But the international jury is still out on the question of whether this conversion model will also prove able to sustain the scientific quality in the long term or whether, as some suspect, the DERA is consuming its scientific and technical seedcorn. This is the same concern that dogs the UK defense industry - The anxiety that the UK is losing its technological competitiveness.

The question of how to maintain technological competitiveness was the issue that most concerned the Technology Foresight Defense and Aerospace panel. Its report [5] recommends that expenditure on R&D by Industry and Government needs to be increased and better use needs to be made of the largely untapped research in universities and research councils. The existing technology exploitation process, at least in defense and aerospace, is deemed not to work well between industry and the universities, even where industry funds the work in the universities directly.

The determination of the UK government to achieve better exploitation of university science, not just in defense but across all sectors, was a major motivation for the Foresight Initiative and is also demonstrated by the recent decision to move the responsibility for national science to the Department of Trade and Industry. This makes it unequivocal that national wealth is a key objective of university science. How well the universities will be able to adapt to this change is not certain, but there are examples of academic institutions strongly coupled to international industry and largely funded by industry which maintain a research program of academic excellence and long term value. The Media Laboratory at MIT is one impressive example and a model others might wish to copy.

To encourage further civil exploitation of defense research a joint civil-Defense working forum of government officials has been formed. Its role is to advise Ministers on ways of developing a more coordinated approach to the planning of civil and defense science, engineering and technology, informed by the priorities identified in the Technology Foresight program. This includes addressing opportunities and areas for collaboration involving industry to gain greater benefit from defense-related research, and also addressing how to improve collaboration mechanisms. Three important collaboration mechanisms already exist. One is the UK LINK scheme which encourages joint programs between universities, government and industry. A second is the Dual Use Technology Center scheme and the third is the Pathfinder scheme. These latter two schemes are described in Annex A and are discussed in the paper by Sir David Davies, MOD Chief Scientific Adviser.

10. Conclusion

Defense conversion in the UK has not been pursued as a distinct strategy but as part of the wider strategy for all parts of industry and commerce developed through the Technology Foresight program. The focus is on strengthening the technical competitiveness of the UK defense and aerospace industry, developing closer integration with civil technology and business processes and also greater integration within Europe. Technology Foresight is promoting stronger networking and intercompany information exchange within the defense and aerospace industry and between defense and civil sectors. It has forged new communities between parts of the economy that scarcely interacted previously.

The issues of defense conversion and dual-use have to be considered in the real competitive environment that companies face looking across the breadth of the industrial and commercial base and also considering how sectors are likely to grow or decline over the next 10 - 20 years. This is the approach which Technology Foresight provides. During the coming year, as the recommendations of the Foresight panels are implemented and as companies and laboratories explore the implications of the Foresight recommendations for them, we shall get a clearer understanding of how well this is all working as a strategy. Certainly within DERA and MOD the implications of the Technology Foresight reports are being vigorously addressed. Very many of the key technologies identified across all of the sectors are important for defense. demonstrating the opportunity there is for a stronger civil-Defense approach.

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ANNEX: DUAL-USE TECHNOLOGY CENTERS AND THE PATHFINDER SCHEME

A.1 Dual-Use Technology Centers

Dual-use Technology Centers are not one model but several variants. Even the word center does not imply that a DUTC is based on a single location.

The basic model which underlies all of the DUTCs is of a number of joint projects being undertaken within a common environment and able to share facilities, general knowhow, networking, vision of the future. The projects arise bottom up and each project has its own IPR arrangements, but broad information about the projects and generic skills are shared between projects. The "Center" provides common infrastructure. Investment in this infrastructure is determined by a management board comprised of the main partners and is based on commercial investment appraisal.

The DUTCs differ in their focus. One role for a DUTC may be to provide a widely accessible national facility needed both for Defense and civil purposes. Two examples are the Farnborough Supercomputing Center (section A.2) and the Haslar Marine Technology Center, which provides a national capability for hydrodynamic testing. A second role of a DUTC may be to promote a national program of collaborative projects. The Structural Materials Center (section A.3) and the embryonic robotics DUTC are two examples. Thirdly the DUTC may be based on national networking, sharing skills, developing common standards and creating a cluster of industrial capability. The Software Engineering DUTC (section A.4) is an example. Fourthly, a DUTC may comprise a portfolio of dual-use technology projects which are stand-alone and may be bilateral and quite close to market. The portfolio of Electronics Dual-Use Technology Projects is an example (section A.5).

A.2 National Facility- Example: The Farnborough Supercomputing Center

The Farnborough Supercomputing Center was launched in 1994 to fill a serious gap in UK national capability to do advanced supercomputing for applications that are commercially sensitive or Defense classified. The FSC is now the most powerful supercomputing facility in Europe and makes available to companies a capability that they could not possible afford otherwise and also a vital body of expertise in state of the art supercomputing. Civil applications of supercomputing include molecular and drug design, oil reservoir modelling, traffic flow modelling, civil aircraft design.

The centre consists of several linked supercomputers mostly belonging to DERA located in a BAe building at Farnborough and linked into the internal networks of the using organizations; it also comprises the professional staff belonging to or associated with the Center who provide the key body of expertise. The main work of the Center is

currently for Defense and the focus has been on setting up a good networked service for the main users - BAe, GEC, DERA, Cray Computers. In the future the FSC will provide services to civil and military users in continental Europe as well as in the UK.

The Center functions as a commercial operation which recovers its costs from its subscribing partners and other users. Profits accrue to the subscribing partners in proportion to their subscribing share (i.e. the proportion of the Center's core capacity which each partner has underwritten to pay for). The Center is managed by a steering group of all the major subscribing partners and is chaired currently by BAe.

A.3 National Program - Example: The Structural Materials Center

The SMC was the first DUTC and was established in April 1994. Whereas the FSC was created as a new venture by the subscribing partners, the SMC was created by bringing together the £40M DERA research programs on structural materials work from Sea, Land and Air programs including the extramural work carried out in industry and academia.

The main SMC site is Farnborough where a major new materials laboratory is being constructed as part of the redevelopment of DRA Farnborough. It is this laboratory which most of all will provide a national centre when it is opened in 1996 linked with other centres of excellence in academia, Birmingham.

The SMC currently operates as a DERA business sector with individual collaborative projects handled on a commercial basis. The current workforce is mainly DERA staff. It is envisaged that this will shift so that by 1998 around 30% of the staff in the new laboratory at Farnborough will be from industry and academia.

A.4 National Networking- Example: The Software Engineering Center

The Software Engineering Center was set up in 1994 through the relevant trade associations. Its purpose is to improve the UK's capability in software engineering for military and civil purposes through software development projects undertaken by multicompany teams. The Center has been set up based around the software developments required for MOD defense research but will tackle a wider range of projects in due course.

Its dual use benefit is that it is exploiting the substantial and sustained defense demand for software generation as a basis for improving and sharing software engineering skills across the industry: MOD gets the software products and the industry gets the improved skills and standardization. The assumption, derived from the cluster model of national competitive advantage, is that the UK needs to develop a stronger cluster of excellent software engineering companies who compete but also work together for mutual advantage and world influence.

A.5 Closer to Market: Dual-Use Technology Projects

Certain military technologies, such as uncooled thermal imageries, are expected to become major consumer technologies in the next 10 years. Once civil development takes off, it can provide the components needed for Defense much more cheaply. Therefore, in these dual-use technologies, DERA insists that the company or companies it works with are committed to make the investment necessary to be world leading civil suppliers. These projects involve joint investment and agreements about return on IPR. They are commercial joint ventures which offer a satisfactory return to DERA and MOD; they are not a soft transfer of IPR.

A.6 Pathfinder Scheme

The Pathfinder scheme was launched by DRA in November 1992. It helps industry benefit from the MOD's £500M program of research through DERA. An annual Pathfinder conference and handbook give industry an up-to-date coverage of the MOD's priorities for research and the opportunities for companies to participate. Through Pathfinder, companies can propose projects that meet MOD's needs and at the same time provide results that companies can exploit in their own products. There is usually a significant industry contribution to the funding of each project reflecting its commercial benefit to the company.

Participation in Pathfinder is open to any company undertaking research in the UK, are submitted and it is expected that around 25% of these are funded. An average project is at a level of £200,000 with MOD funding 70% and industry 30% There is no fixed limit to the level of Pathfinder funding: projects find their way into the program in competition with existing work. The competition is judged by MOD customers, with technical assessment provided by DERA.

The Pathfinder brochure is classified and outlines the entire MOD applied research requirements, highlighting areas where good proposals from industry are particularly welcome. This brochure has proved to be a very valuable annual document which is used by MOD as well as industry and gives the best overview of the program. The Pathfinder Conference, which provides a briefing for senior managers from industry, is held annually in November and is followed by workshops where middle managers can discuss opportunities in detail with DERA staff.

To minimize the effort involved in submitting proposals companies are encouraged to submit an outline proposal, which if it looks likely to be supported by MOD is subsequently developed into a full proposal. Pathfinder also has a fast-track process which allows projects of exceptional merit to be funded within 6-9 months of the outline proposal being submitted. Most projects, however, take 15 months from outline to funding. This is because they compete for entry into the MOD program as part of the normal MOD annual budget setting process.

In the next round Pathfinder will be expanded to include projects where academia is involved alongside industry. It is expected that Pathfinder will support projects where there is an academic component subcontracted by industry and also projects undertaken primarily within academia provided that the exploitability of the research by industry is clear. Thus Academic Pathfinder will have a balanced emphasis on science driven projects and applications pull from industry and DERA. Some of the projects will be undertaken within DUTCs.

DERA plans to provide a service for academia via Internet. This will be an unclassified subset Of the brochure excluding sensitive topics and focussing on underpinning technology. This will be provided as a service with password access. DERA is already providing such services to businesses via Internet and the password access gives reasonable protection against unauthorized access. DERA will also act as a marriage broker providing information on opportunities in projects proposed by industry by removing classified and commercially sensitive details.

CONVERSION EXPERIENCES AND POLICIES IN ITALY

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1. Introduction

In Italy, as in most industrial countries, the post-Cold War decline in military procurement has led to an increasing interest in the conversion of military industrial assets towards civilian activities, as a measure to reduce job losses and avoid major dislocations. However, no consistent policy has emerged in order to define a national strategy for promoting conversion activities.

At the firm level, the main Italian arms producers have considered expanding their ability to produce and to sell civilian goods as a key point in their strategies. In this perspective, a number of feasibility studies and market analyses have been carried out, but no consistent industrial strategy of conversion/diversification has been defined.

In this paper, the evolution and the current situation of Italian military industry will be described. Then, some conversion experiences, developed in the Italian military industry, and some conversion measures, implemented both by the government and the Parliament, will be discussed. Finally, future prospects for a military industrial policy, including conversion, will be examined.

2. Arms Production in Italy

2.1 FROM THE POST-WAR CONVERSION TO THE RESTRUCTURING IN THE 90's

The development of military industry in Italy in the post-war period has often been described as a succession of distinct stages. Battistelli [1] considered two main phases of development of this industry: the stage of **dependence** from abroad - mainly the US (1949-1968) - and the stage of **complementarity** in the 70s and the 80s.

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After the end of the war, the emphasis was on rebuilding the industrial facilities destroyed during the war and to convert the factories formerly devoted to military production [2,3]. During that period, for instance, Agusta and Piaggio produced motorcycles, Macchi produced motorbikes and trucks, Borletti sewing machines, and even OTO Melara produced farm tractors, trolleys, and textile machines.

State-owned industry played a central role in this process of conversion. In 1943, the State controlled 1,800 factories with 1.2 million employees and about 70% of all military productions. Nevertheless, the Italian governments failed in defining a comprehensive conversion plan and chose to manage the transition to a post-war economy using extensively the welfare system. The main public holding, Iri, agreed with the government to stop workers' layoffs and to maintain the existing level of salaries during a long period of transition.

Industrial conversion activities were carried out by individual firms, both private or State-owned. But the lack of coordination led to frequent overlappings in the civilian fields which are closer to military mechanical productions: engines, tractors, or railway carriages. Several problems also emerged on how to use the workforce with specific military skills, or the lack of efficiency of military firms when acting in commercial markets.

In the early 50s, when Europe entered the Cold War, the Italian governments, encouraged by NATO Allies, began a slow process of re-conversion towards military production. During the first period of reconstruction of military capabilities, some light aircraft, mainly trainers, were designed and produced, while Fiat and Macchi assembled the Vampire fighter aircraft, under British licence, for the newly established Italian Air Force. A major effort in sustaining the Italian post-war military build-up was made by the US funding of the production in Italy of US-designed equipment and weapons.

After 1956, the Italian military industry began to systematically acquire production licences from abroad, mainly from the US, and to develop domestic military equipment. In this period - described as of *limited dependence* - military hardware produced in Italy included F-86 and F-104 fighter aircraft, the AB-47 helicopter, the M-60 battle tank, and, among the Italian-designed systems, the Fiat G-91 light fighter and the Macchi MB-326 trainer aircraft. A group of main producers emerged in military industry. The State-owned holding Iri maintained a prominent role, but several private firms were acquiring a significant technological capability including Fiat (motor vehicles and aircraft), Agusta, Piaggio, and Macchi.

Since 1968, the Italian military industry has tried to shift from a large dependence on US military technology to an increasing collaboration, or complementarity [1], at the European level. The most important effort for coordinating military needs and industrial strategies at the international level in Europe was the agreement between Italy, Germany, and the UK for designing and producing the Tornado fighter-bomber (1968). During the 70's the involvement of the State in the military production significantly increased. Iri took over the main Italian shipyards and, when Fiat abandoned its aerospace activities, Iri took over the largest aircraft producer in Italy, Aeritalia. Also, in the electronic sector, Iri owned the main military companies; Selenia and Elsag. In the mid- 70's, a new

player emerged in the Italian military industry. Efim, another State holding, acquired OTO Melara, the leading Italian producer of tanks and guns, and Agusta, the only Italian helicopter manufacturer. In the next decade, three firms actually dominated the military industry in Italy: Iri (aircraft, ships, electronics), Efim (tanks and helicopters) and the private group Fiat (motor vehicles, aircraft engines). Other privately owned military firms included Italian and foreign firms mainly producing electronics (Contraves, Marconi Italiana, Litton, Elettronica, etc.) and aircraft equipment (Macchi, Piaggio, Microtecnica, etc.).

The strengthening of the Italian military industry, which became well known in 1986 when SIPRI [4] ranked Italy as the sixth largest arms exporter in the world, has been largely based on ten years of steady increase in military procurement spending. As pointed out by 1990 research funded by the Italian Ministry of Defense [5], a period of significant government support to arms production followed the "concentration" of military industry within the State holdings, which took place in the 60s. In the mid 70s, four laws passed the Parliament providing extensive financial support to the procurement programs defined by the Italian Armed forces. Then, a ten-year period of rising military (and procurement) spending began, with a consequent growth of the Italian military industry which employed in the arms production, in the mid 80s, up to 90,000 workers [6].

Since the mid 80's, the marked decrease of Italian arms exports has made the military industry increasingly dependent on the Ministry of Defesce purchasing. The largest prime contractors, mainly State-owned firms, were, to some extent, "protected" by the Ministry of Defense from international competition. The most relevant consequences of this were:

(a) an increasing concentration at the main contractors level;

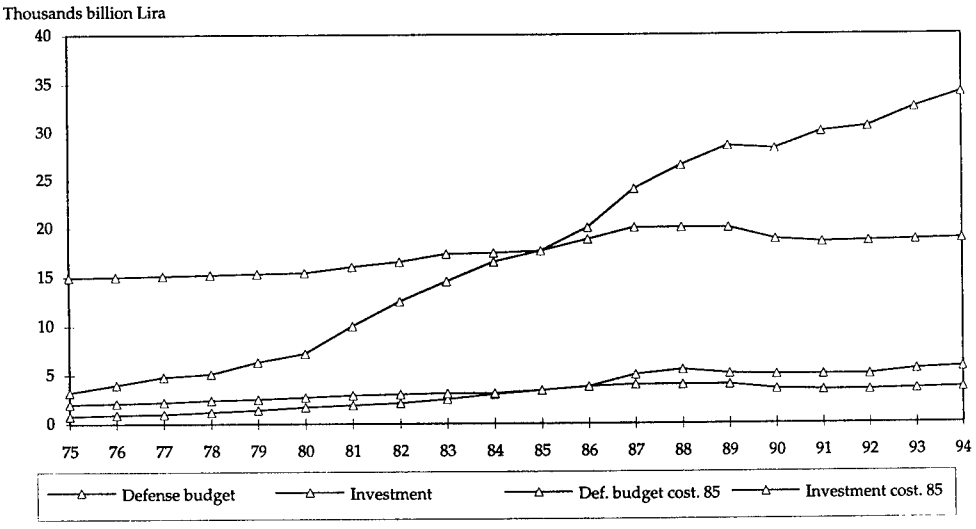


Figure 1. Italian Defense Budget and Military Investments, 1975-1994

(b) an increasing role of the State in controlling military-industrial activities;
(c) the creation of some *national champions*, even if without the *critical mass* needed to be competitive in the international markets;
(d) a fragmented production of components in hundreds of small and medium-sized firms [7].

2.2 THE RESTRUCTURING OF THE ITALIAN MILITARY INDUSTRY

Since 1989 the procurement budget of the Italian Ministry of Defense has been shrinking. According to the Ministry of Defense, the 1995 arms procurement budget is only a half of the 1988 budget in real terms [8]. The Ministry is currently asking for the same level of investment as in 1988 (at least at current prices) in order to modernize existing equipment and to avoid a further reduction in the size of the defense industry.

In the last years, the Italian military industry suffered unprecedented reductions in orders and, consequently, in turnover and workforce. According to unofficial estimates, the total military workforce in the Italian military industry may be currently estimated at about 27,000 employees[1]. In some sectors, aerospace, for instance, the existing production capacity is reaching what some industrialists consider a "minimum level" for producing and innovating in a high-tech context [9].

This process of downsizing has had relevant consequences not only in terms of restructuring at the industry level but also at the firm level. Even if lagging behind other European military industries, a process of concentration has advanced in Italy as well, in parallel with the growing dependence of the military industry on the Ministry of Defense procurement policy. The leading player in this process has been a sub-holding of Iri: Finmeccanica.

For a comparison over time see Table 1.

TABLE 1. Italian Military Industry: employment in military production, 1979-1993

YEAR	FIRMS CONSIDERED	NO. OF EMPLOYEES
1979*	≈300 military firms	≈ 65,000
1985**	≈100 military firms	≈ 90,000(1)
1990***	≈ 50 military firms	≈ 54,000
1993****	≈ 26 military firms	≈ 30,000(2)

[1] Sources: (*) Battisteli [1], p.184; (**) Archivio Diasrmo [6], p. 57; (***) Pianta and Perani [10], p.214; (****) Data Bank of the Coordination Nationale Degli Observation Sull'industria Military.
NOTES:
1. It may be overestimated because the calculations were based on the military percentage of total value added.
2. Estimate.

2.2.1 *The "Large" Finmeccanica*

Within Iri, Finmeccanica was reshaped, in the late 80's, in order to concentrate a wide range of State-owned high-tech industrial activities concerning aerospace, military electronics, industrial automation, power generation, and railway equipment. Such a process took place during a period of severe crisis of the military industry all over the world. Thus, the original project needed to be largely revised over time. In 1989, Iri concentrated in Finmeccanica its manufacturing activities in the electronic sector, that is, the Selenia-Elsag group. After this acquisition, Finmeccanica looked for other military electronic firms in order to strengthen its military activities. In 1990, the difficulties of the Ferranti-ISC group made it possible for Finmeccanica to take over the Italian firms controlled by Ferranti. The result of this agreement was the establishment of an integrated group which brought together different high-tech activities both in the civilian and military sectors. The next move of Finmeccanica was to merge its divisions dealing with aerospace (Aeritalia) and military electronics (Selenia). In 1990, a new firm designed to be the *national champion* within international cooperation agreements in the military field was created: Alenia.

In 1992, Finmeccanica moved towards a more integrated structure, merging Alenia and two other subsidiaries, Ansaldo (transportation and power generation) and Elsag (automation), into a holding company. The result was actually a "large" Finmeccanica. But in the same year the second State-owned manufacturing holding, Efim, was liquidated because of mismanagement and huge debt, and government requested by Finmeccanica to take over the military firms of Efim.

2.2.2 *The Collapse of Efim and the Restructuring of Finmeccanica*

Current estimates of the total debt of the Efim group are hovering about 10 billion US$. The experience of Efim has been a major failure both in economic and industrial terms. Without considering the negative economic results of most Efim firms, their experience in designing and producing high-tech systems and components has been wasted by the lack of managerial capacities both in terms of organizational structure and approach to the market, and by the dominance of government political parties in industrial and managerial decisions[2].

Thus, Finmeccanica has to deal in the future with several complex issues. First, controlling about two-thirds of the Italian military industry, Finmeccanica has a near monopoly in military production and is going to define the guidelines along which this industry must develop. It is significant that Finmeccanica has currently the chairmanship both of the Association of Italian Aerospace Firms (AIA), and of the Italian Group of High-Tech Defense Firms (RITAD).

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[2] A description of the relations linking the political parties and the Italian society during the so-called "First Republic" is offered by Guzzini [11].

Second, Finmeccanica needs to conclude its process of restructuring in order to be able to face, in the coming years, a growing international aerospace market with a streamlined structure. A more integrated and cost-effective structure is also a needed requirement to define international collaborations which will be essential for playing a role in future high-tech markets.

Third, Finmeccanica has to define the future of its industrial activities which do not appear competitive in the defense market. Several aircraft factories of Alenia, as well as some former Efim firms, have no clear future. Considering different options, they might be sold, closed, or heavily restructured. Obviously, Finmeccanica is currently mainly committed to reducing costs. But, in some cases, a strong opposition, both from trade unions and the government, has significantly slowed its restructuring program.

In short, Finmeccanica has chosen to become larger while maintaining its military productions. But, it is not clear up to now if this industrial strategy of Finmeccanica will make it able to compete, in terms of size and efficiency, with the largest European military or "dual" industrial groups.

2.2.3 *Prospects for the Italian Military Industry*

Currently, Finmeccanica is reaching the first results of its effort of reorganization. These first achievements will also influence the future structure of some military sectors in Italy. The main fields of military activity of Finmeccanica include aircraft, telecommunications, missiles, electronics, avionics, and armor/artillery. The latter is clearly not consistent with the structure of a firm producing mainly aircraft and electronics, and it has been suggested that the OTO Melara-Breda group - which is the main Italian producer of tanks, armored vehicles, and field and naval guns - might be sold in the future to a foreign industrial group, if the Italian government will allow it.

A new Finmeccanica "aircraft division" will probably merge the fixed-wing aircraft production of Alenia and the helicopter production of Agusta; also aero-engines production will also be included in this division. Missiles will be jointly produced in the former Alenia and OTO Melara factories, but Finmeccanica is strongly interested in developing international alliances in this field or in merging its activities with those of other European companies. As for avionics, Finmeccanica has a good technological record, ranging from airborne radars to electronic warfare equipment and night vision systems. Thus, the "avionics division" of Finmeccanica may become a key area for qualifying the more traditional airframe production from the technological point of view.

In the two remaining sectors, telecommunications and electronics, a new emphasis on joint ventures and collaboration is already evident. The communications division of Finmeccanica merged last year with Marconi, the Italian branch of the British GEC group, and naval electronics productions were merged with activities of the Fiat group in the same sector.

Summarizing, Finmeccanica is carrying out a wide reorganization of its activities based on:

(a) a growing emphasis on collaboration, both at the national and international level;
(b) a significant reduction of the workforce, in particular in the military sector;
(c) the definition of a company structure more market-oriented and potentially "dual";
(d) a continued reliance on the government, its main stock-holder, which has supported the Finmeccanica activities by procurement and industrial policies, but has also imposed on Finmeccanica the task of recovering the formerly bankrupt Efim firms.

A reduction of the role of private firms, like Fiat, in defining the strategies of the military industry has been a further consequence of this evolution. Fiat, which is the second largest producer of military equipment in Italy, has recently refocused the activities of its military branch on a few "core businesses" such as motor vehicles, turbine engines, and ammunitions. Other private groups or firms pursued a similar strategy of downsizing and refocusing among them the British Marconi, the Swiss Contraves, Litton Italia (controlled by the US Litton Industries group), and Microtecnica (controlled by the US United Technologies group).

A common feature of the different strategies of restructuring in the Italian military industry is actually to reduce the workforce and a firm's size while maintaining military productions as a "core business". Considering that the major industrial groups involved in military productions have also large commercial divisions, they *diversify* rather than *convert*. But diversification activities have been commonly carried out separately from civilian R&D and production activities within the same company; the result has been a higher degree of *segregation* of military research and production. This has been harmful for the Italian arms industry, which largely relies on technologies imported from abroad or developed on the civilian side of the Italian innovation system.

3. Conversion Experiences

3.1 FIRMS' STRATEGIES

As mentioned above, the main Italian arms producers have attempted to strengthen their ability to produce and market civilian goods. In this perspective, many feasibility studies and market analyses were carried out, even though no consistent strategy of conversion has emerged. The emphasis was actually on "diversification" as an instrument aimed at reducing dependence from military customers without modifying the military "orientation" of arm-producing firms [12].

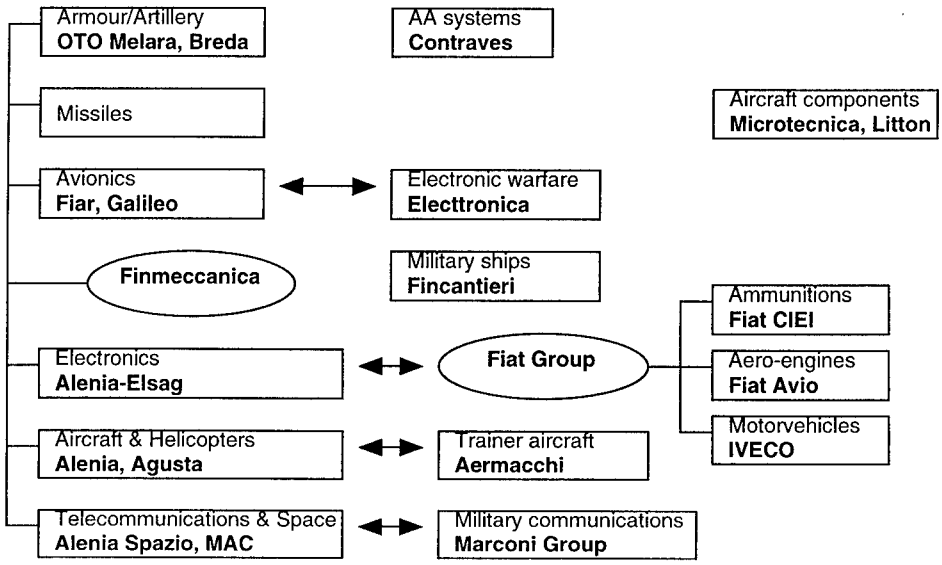


Figure 2. The structure of the Italian Military Industry, 1995

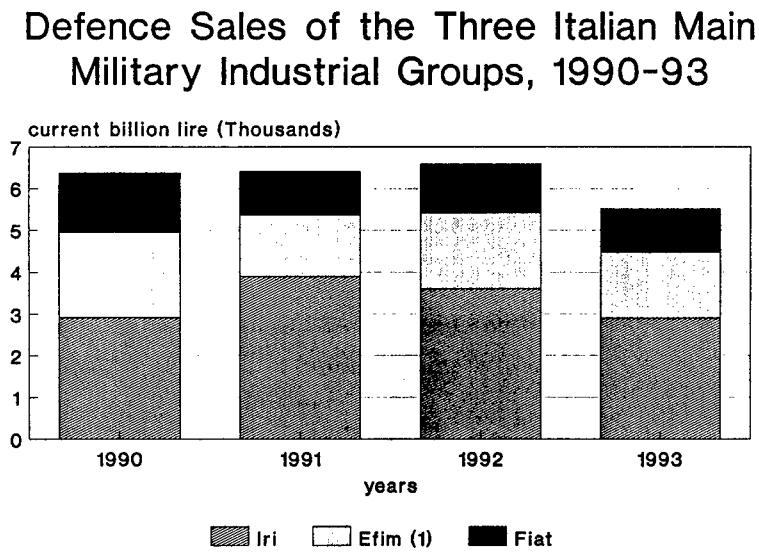


Figure 3. Defense Sales of the Three Italian Main Military Industrial Groups, 1990-93

In some cases, major arms producers decided to improve their offer of civilian products by creating civilian subsidiaries. However, most opted for keeping some civilian productions (frequently oriented to supply civilian systems to the Italian government) simply as secondary activities, investing mostly in strenghtening and qualifying their military productions.

An analysis carried out in 1992 by the regional government of Latium[3] on the reorganization plans of locally based military firms [13] pointed out three basic measures implemented by the major military producers:

(a) reduction of productive capacities and employment (up to 40% of 1990 levels);
(b) widening of the range of items to offer (considering military, civilian and dual-use products);
(c) reorganization of the firm structure.

More specifically, in order to produce more efficiently both military and civilian products, firms have focused on four points:

(a) strengthening of R&D and design capacities;
(b) strengthening (or creation) of marketing capacities;
(c) making the production process "leaner";
(d) flexibility in using the workforce, creating multi-faceted skills, simplifying hierarchical structure, widening the use of technological information, and introducing "just-in-time" or "total-quality" models.

An example can be offered by aerospace firms which have closer relations between their military and civilian productions. In these firms, diversification is easier than in other sectors. According to the study mentioned above, limits to a diversification strategy are basically due to a lack of demand in civilian markets and/or difficulty in facing highly competitive markets. For instance, Finmeccanica-Alenia is an international leader in producing civilian air traffic control radar systems for the commercial aerospace market. These are complex civilian systems which are by-products of military radar systems and their market has relevant technological entry barriers. But Finmeccanica would probably have no chance to enter in any other market of civilian electronic consumer goods.

A number of military aerospace firms are diversifing into "captive" civilian markets. For instance:

(a) Some Finmeccanica subsidiaries produce eolian generators, environmental control systems (such as forest fire early warning systems or air pollution control systems), radars for metereology, car traffic control systems, and naval traffic control systems.

[3]Several large plants producing military electronics are located in Latium, the region of Rome. The largest military firms with factories in Latium include: Alenia-Finmeccaqnica, Electronica, Elmer, Contraves, and Elicotteri Meridionali.

(b) Fiat Aviazione produces turbines for power generation as a spin-off of turbines for aeronautical or naval propulsion.
(c) Elettronica and SMA have developed electronic devices for medical use.
(d) BPD produces rockets with fire-extinguishing powder to be launched against forest-fires (a typical dual-use product) and rapidly inflatable automobile air bags.

None of these experiences can be defined as "conversion". These firms continue to produce military equipment and are not willing to shift their "core activity" to civilian productions.

In some cases successful civilian branches have been rapidly transformed into different companies with a specific task[4]. These newly established companies often prefer to hire workers from outside their parent company so that, such a diversification strategy can hardly be considered as a solution to employment reductions in military firms.

3.2 EXPERIENCES AT THE FIRM LEVEL

Some experiences of diversification of firms can show more clearly what has been in the last years the leading approach to conversion/diversification issues. Proposals and experiences carried out in three military-related Italian firms will be considered: Aermacchi, an aerospace company based in Lombardy; Galileo, an opto-electronic firm based in Florence [14]; and BPD, an ammunitions producer with a plant near Rome.

3.2.1 *Aermacchi* [15,16,17,18]

In 1988, during bargaining for a company agreement between the company managers and the trade unions, the question was raised whether Aermacchi, which was at that time more than 90% dependent on military sales, should define a diversification strategy. As a consequence of strong pressure from the trade unions and the workers, the final agreement stated that Aermacchi had to reduce its involvment in military production. Even more innovative was the role of the trade unions in verifying the progress made by the company on such an agreement.

As a consequence, Aermacchi defined a collaboration with the German aerospace firm Dornier to co-produce a civilian aircraft. In the following years the crisis in the military sector made it easier for Aermacchi to reduce the military share of its turnover, but it could not avoid a serious reduction in its workforce. In 1990 there were 2,706 employees at Aermacchi; this number dropped to 1,423 in 1994, with 300 more workers temporarily laid off.

Aermacchi has reafirmed its strategy of diversification and restructuring. In May of 1995, at least one-third of its production was in civilian aerospace.

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[4]For instance, we can quote: Samanta (ecolian power generators) from Alenia; Electrica Ingegneria Sistemi (civilian automation systems) and SEA (environment pollution monitoring) from Elettronica (electronic warfare Galileo Siscam (photogrammetry) and Galileo Vacuum Tec (vacuum technologies) from Officine Galileo (military opto-electronics); OTO Sistemi Civili (civilian control systems) from OTO Melara.

3.2.2 *Galileo* [19,20]

In Italy, the first experience of a company agreement mentioning conversion/diversification was signed in July 1988 between the military firm Galileo (of the Efim group) and the trade unions of Florence. Officine Galileo is a symbol of high-tech (and state-owned) industry in Florence. It became a case study in the mid 80s' when the Unione Scienziati per il Disarmo (Union of Scientists for Disarmament), a group of concerned Italian scientists, carried out a research project, in collaboration with the workers of Galileo, to propose possible peaceful applications of infrared technologies. Additionally, potential markets for infrared civilian products (environmental surveillance, remote sensing, etc.) were considered.

The regional government of Florence sustained this effort, funding the development and prototyping of an infrared camera to be used in surgery. A camera was built and experimented within a hospital in Florence.

However, the joint effort of workers, peace activists, and local authorities did not reach the objective of reducing military production at Galileo. Civilian products appeared too expensive and too complex for civilian use. The reduction in military budgets and the financial troubles of the Efim group caused additional problems to the firm and several dismissal occured. Currently, Galileo has been acquired by Finmeccanica and will become a specialized producer of military equipment.

3.2.3 *BPD* [13]

In 1991, when the European Commission launched the first phase of the Konver Program, several Italian firms proposed to their regional governments several diversification projects to be co-funded by the European Union. The BPD Difesa e Spazio, a Fiat subsidiary which produces ammunition, rockets and propellants for space engines, was developing a project for converting its plant at Colleferro, near Rome, which was jeopardized by the reduction in arms procurement spending. Basically, the project was aimed at using the experience of BPD workers in dealing with explosives for producing exploding caps for rapidly inflatable air-bags for cars.

This project could not be funded through the Konver Program due to the presence of the Fiat group as the main shareholder of BPD. The crisis at BPD also appeared to have serious consequences also for the small town of Colleferro, and the local authorities requested governmental support for the diversification of BPD. It was only possible to fund some training activities for BPD workers. However, Fiat decided to go ahead with the project and a joint venture was established between BPD and two major US major producers of air-bags (Allied Signal and Atlantic Research). The prospects appear positive and BPD might become a leading European producer of air-bags. BPD will probably supply its air-bags not only to the Fiat plants but also other car producers.

3.2.4 *The Results of Conversion Experiences in Italy*

The experiences discussed above show that a firm or plant implements a conversion strategy, at the firm or plant level, must consider several external factors to be successful.

Three elements appear to be significant in order to evaluate whether a conversion/diversification experience may succeed:

(a) the degree of involvement of the management,
(b) the support by the public authorities and, most important,
(c) the novelty of the designed products and their potential market.

When management carries out a strategy of diversification while remaining convinced the company must primarily maintain its military business, the diversification experience will probably be unsuccessful. On the other hand, groups of workers or trade unions have sometimes attempted to develop new business based only on the technical competence of workers and technicians. These attempts have also been rarely successful.

During a process of restructuring, a firm is modifying its structure and some assets (in terms of knowledge, working force, or fixed capital) will probably be lost. Public support may avoid such a waste of competencies accumulated over years. It may also be noted that some capabilities in the military industry have a strategic value, and it may be of national interest to prevent their dispersion.

A key question related to a conversion/diversification process is: Will the new civilian product(s) be bought by someone? Many conversion experiences failed in defining real business plans, and addressed unlikely potential markets. It is worth remembering that military firms often have a strong technological base but a lack of commercial experience. The experience of Galileo, which is able to produce advanced devices for surgery assistance but at a very high cost, shows that technical performance is not the most important feature for a commercial product.

Usually, there are two main alternatives for having some chance of success. On the one hand, a military company producing a new civilian product can cooperate with a civilian company already doing business in the same market, and use its commercial structure for promoting the new product. On the other hand, it may be possible to identify potential customers during the design phase. The customer may be a public body interested in sustaining that industrial activity (in this case only a "technical" conversion will be accomplished), or a company proposing itself as the main - or the only - customer. The latter is the case of BPD which proved to be successful in producing air-bags for cars by having the car-maker Fiat as its main shareholder and main customer.

4. Conversion Policies

Following Willett [21], a taxonomy of different approaches to conversion can be considered, including:

(a) a macro-economic approach;
(b) a company-based approach;
(c) a plant-based approach;

(d) a local community approach; and
(e) a comprehensive political approach.

Until now we have considered company or plant-based conversion experiences. In the following paragraphs, we will discuss national and regional/local policies.

4.1 THE ITALIAN LEGISLATION ON CONVERSION

Recent Italian experiences in national conversion policies are discussed in this section, defining the players involved and some policy options.

During the last 20 years, the Ministry of Defense in its official statements has repeatedly asked for a "defense industrial policy" [22], claiming a greater role in controlling the industrial activities of military concern. But traditionally, instead of coordinating different ministries and public agencies, the MoD has almost exclusively used the procurement budget as a tool for orienting and sustaining arms production.

As shown previous, procurement spending directly influenced the size of the military industry both during periods of rising domestic military spending (1970-1989), and in the last years of military budget reductions. From 1985 to 1989, the growth in domestic procurement compensated for almost completely the fall of arms exports.

After 1989, the decrease in domestic and international demand for Italian military products emphasized the need for a reduction in existing production capacities and the need for a conversion policy.

Such a need first became a matter of concern in the Parliament. Since 1987, at least thirteen bills have been presented to introduce policy instruments such as a conversion fund, a monitoring unit on arms production activities, or a financial support to regional conversion activities. Nevertheless, a comprehensive law has not yet been approved.

However, some legislation of recent years, designed with more general purposes, has also provided a partial support for conversion/diversifcation activities. For instance, Law 46/1982 has supported since 1982 technological innovation and applied research the Italian industry,funding several industrial projects, sometimes aimed at producing civilian items using military technologies. Similarly, Law 808/1986 is funding civilian activities in the aerospace sector.

In 1993 a Law (237/1993) was approved establishing the first Italian conversion fund[5]. This conversion fund offered to the government two main paths for promoting "rationalization, restructuring, and conversion of the war industry".

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[5]This fund was 500 billion lire, to be spent over 5 years. The fund is currently only partially active, but the initial appropriation has bee repeatedly reduced.

First, the Ministry of Industry can provide grants or loans to military firms willing to expand their range of civilian products - and also to strenghten their military competencies. Second, the government can support regional conversion policies in collaboration with local or regional governments, firms, and other public or private bodies. These policies can be aimed at recovering areas with declining military industrial activity and reduced employment.

Regulations for implementing such a conversion fund have been designed to keep procedures to support military production separate from procedures to fund conversion activities. These conversion activities will be mainly regional conversion activities. The combined pressure of the European Union (EU) regulations and the recent evolution in the concept of conversion has led to stressing less the need of converting large military industrial factories, and more possibility of creating several small and medium businesses to absorb those workers (but also machines and know-how) laid off because of the crisis of the military sector.

We argue that this policy guideline may be particularly successful in the Italian industrial context, including high-tech sectors, where a very important role is played by small firms.

An analysis of the Italian innovation system [23] pointed out not only the high growth rate of Italian R&D during the 80's, but also the presence of a dualism in technology innovation activities between small firms' networks (mainly within the so-called "industrial districts") and large firms. Smaller Italian firms appear to be more dynamic and export-oriented than larger firms (this observation has been largely confirmed by the recent export records of many small Italian firms). Nevertheless, despite their weakness, the larger industrial firms remain the core of the Italian R&D system and of the military industry as well.

Recently, the Italian government stated that because of the budget constraints only limited resources will be available for the goals defined by Law 237/1993. Additionally, the Ministry of Industry is devoting all currently available funds to support the restructuring activities of large military firms. As to conversion activities, the EU Konver Program will need to replace in the next years, according to the Italian government, the national support provided for by Law 237.

4.2 THE INSTITUTIONAL FRAMEWORK OF CONVERSION POLICIES

The institutional framework in which policies influencing the military industry are currently carried out in Italy is summarized in Fig.4. On the left, the main public policies which are able to influence the military sector are listed, ranging from the Foreign and Security Policy to the Regional Development Policy. Above, the main players in this field are considered.

Firstly, it is evident that the military procurement policy may be largely considered as a result of other public policies: the security and the Defense policies influencing the demand side, and the national industrial policy shaping the supply side. In this context, the Defense industrial policy, and a more specific conversion policy, is strongly related to

a wider industrial policy. The industrial policy is obviously linked also to developments in science and technology, to the evolution of employment trends and to specific measures of regional development policy. The European Konver Program, and other measures aimed to sustain the economic activity in those regions suffering from reductions in military spending, are not considered here as part of the conversion policy, but are included in a more general and composite "conversion strategy".

Secondly, a lot of interests, pursued by different players, have to be considered as positive or negative determinants of a conversion policy. The players considered include some concerned Ministries, international organizations, and social and political organizations.

In Figure 4, the roles of different players in defining (or influencing) different policies are showed. It can be pointed out that only two players have a direct role in defining conversion measures: the Ministry of Industry and the European Commission. The Ministry of Industry is increasingly carrying out a pivotal role in coordinating both the industrial policy and the conversion policy. From a different point of view, the Ministry of Defense is linking the defense and security needs, through the procurement policy, to the more specific defense industrial policy. But a crucial role is played by the

ACTORS / POLICIES	Cabinet-Min. of Foreign Affairs	NATO-WEU-WEAC	Ministry of Defense	Ministry of Industry	Ministry of Research	European Commission	Industry - Industrial Association	Trade Unions	Local Authorities
Security Policy	■		■						
Defense Policy			■						
Military Procurement Policy		○	■				○		
Industrial Policy				■		■	○		
Defense Industrial Policy			■	■					
Conversion Policy				■		■	○		
Science & Technology Policy		○			■	■			
Employment Policy						■	○	○	
Regional Development Policy						■			■

Legend:

■ = the actor has a direct role defining public policy

○ = the actor may be able to influence policies

Figure 4. The Institutional Framework of Military Industrial Policies in Italy

European Commission which, mainly through ad-hoc programs, is actually shaping a comprehensive policy in this field bringing together the support to regional development policies, the definition of labor policies, the promotion of European research, and the regulation of industrial competition.

It seems that a new institutional framework is currently under definition in which the role of the Ministry of Defense will be reduced to the protection of those production capacities which will be "strategic" for the armed forces, leaving to the Ministry of Industry and European Commission a wider control on "dual-use" activities both in research and industrial production.

4.2.1 *Instruments for Military Industrial and Conversion Policies in Italy*

The relations described above emerge also from the description in Figure 5 of measures currently available for sustaining or converting the military production.

Apart from the procurement policy, the Ministry of Defense has neither the instruments nor financial resources to orient the arms production and related activities. It is worth noting that the procurement budget is shrinking, and until a New Defense Model and some extra-budget procurement laws passed by the Parliament, the Ministry of Defense will play only a limited role in defining the military industrial policy.

MILITARY INDUSTRIAL POLICY	CONVERSION POLICY
MoD procurement MoD budget (investments) ↓ defense industry **Law no.237/1993** **Ministry of Industry** ↓ *funding of restructuring activities* ↓ defense firms, mainly large and specialized **Law no.644/1994** **Ministry of Treasury and** **Ministry of Industry** ↓ *funding of restructuring activities* ↓ defense firms, mainly them involved in international collaborations New Defense Model ? Speciali procurement Laws ? ↓ defense industry	**Law no.237/1993** **Ministry of Industry** ↓ *fund for conversion* ↓ Regions and SMEs **Law no.808/1985** **Ministry of Industry** ↓ *development of civilian aircraft* ↓ civilian aerospace industry **European Union** **KONVER Program** ↓ *activities of regional policy for ustaining areas effected by reduction in military spending* ↓ regional government, local authorities, other public bodies (consortia, etc.), SMEs

Figure 5. Instruments of Military Industrial Policy in Italy

On the other hand, the Ministry of Industry is currently managing the restructuring, as well as the partial conversion/diversification, of the Italian military industry. As Figure 5 shows, the Ministry of Industry is currently involved:

(a) funding restructuring activities of military firms, according to the provisions of the Law 237/93 and the Law 644/94,
(b) supporting conversion activities by Law 237/93,
(c) sustaining civilian aircraft production, and
(d) managing projects funded by the European Konver Program.

4.2.2. *Relations Between Civilian and Military R&D*

In the field of R&D, some ties between research activities carried out for military and commercial purposes can be detected. But, as shown in Figure 6, there are very few experiences related to spin-offs coming from military research activities separately from civilian activities. On the contrary, it is more likely to detect transfers of technologies and technical knowledge from commercial R&D activities to the military industry.

In Italy, military R&D is mainly performed within the military industry, under Ministry of Defense contracting, or in the framework of the multinational WEAG-EUCLID Program. Additionally, Law 770/1986 provides funds for development and prototyping of military equipment, but its implementation has been until now unsatisfactory. All of these activities are focused on specific military needs and leave little room for dual-use.

On the contrary, commercial R&D activities appear to have a wider range of applications, both in civilian and military fields. At least the two main sources of public funding for industrial R&D in Italy - the *Fund for Technological Innovation* and the *Fund for Applied Research* - have a significant dual-use potential. A less important "spin-off effect" may come from R&D activities funded by Law 808/1985 aimed at promoting innovation in the Italian aircraft industry, or from projects carried out by Italian "dual" firms within European R&D programs.

The distinctive features of the military-civilian relationship in the field of R&D in Italy can be summarized as follows:

(a) Almost all research activities are performed within the industrial firms; most of R&D activities are carried out within "dual" firms and are therefore potentially "dual".
(b) A comprehensive R&D policy is not satisfactorily defined in either the military or the civilian field; as a result, firms are focusing on short-term goals - mainly related to product development - leaving aside long-term projects.
(c) Innovations developed within the industry, also coming from government-funded civilian research projects, are frequently used to produce both civilian and military products; thus, the technological demand of the Italian Armed Forces may be able to influence the innovation process of the main contractors of the Ministry of Defense.

MILITARY R&D ACTIVITIES	DUAL-USE CAPACITIES	CIVILIAN R&D ACTIVITIES
MoD procurement MoD budget (research) ↓ *mainly development* ↓ defense industry	*potentially dual-use*	Law no.46/1982 ↓ *←fund for technological innovation* ↓ industry (mainly medium and large firms)
Law no.770/1986 ↓ *development & prototyping* ↓ research institutes defense industry	*potentially dual-use*	Law no.46/1982 Min. of Industry ↓ *←fund for applied research* ↓ industry (mainly medium and large firms)
WEAG - EUCLID ↓ *basic & applied research* ↓ defense industry	*a limited spin-on effect can be pointed out*	Law no.808/1985 Min. of Industry ↓ *←mainly development* ↓ civilian aerospace industry
		Law no.317/1991 Min. Of Industry ↓ *technological innovation* ↓ consortia between small and medium firms and research institutions
		Min. of University and Research ↓ *basic research* ↓ universities, research institutions
	a limited spin-on effect can be pointed out	European Union Programs (EUREKA, SPRINT, ESPIRIT, BRITE-EURAM, etc.) ↓ *←a wide range of activities from basic research to technology transfer* ↓ mainly small and medium firms but large firms and research institution are involved, as well

Figure 6. Relations between Military and Civilian R&D in Italy

According to this analysis, innovations come from the commercial side of industry, but the high-tech industry is still highly dependent on public, mainly military, procurement. As a result, the Italian military products, relying only on medium-level military technologies, appear to be often less advanced than those produced in other Western countries but, at the same time, very expensive due to the complex military production system and its short production runs.

4.3 THE EXPERIENCE OF THE KONVER PROGRAM IN ITALY

In the last paragraphs, we have argued that the role of the European Union has emerged as crucial for developments related to conversion/diversification activities in Italy.

When the EU Commission decided in 1991 to establish a European initiative to support national conversion activities, great expectations rose in Italy for this unexpected chance to delegate to the Commission the definition of a national conversion policy (and its financial burden, as well). Therefore, in the first phase of the Konver Program the Italian government asked the regional governments for some proposals of conversion initiatives to be collected by the Ministry of Industry.

The final result was a collection of industrial projects out of any coherent national or regional strategy[6]. This package was submitted for approval to the European Commission, but was highly criticized for being focused on an industrial policy perspective instead of a regional policy perspective. Actually, Konver is not an industrial recovery program, but is specifically oriented to support regional policies of conversion/diversification. As a consequence of those criticisms, the Ministry of Industry substantially modified its approach to the conversion policy, defining some guidelines in order to put into action the 1993 phase of Konver and to regulate the mainstream 1994-1999 Konver Program.

Currently, EU co-funded measures for supporting conversion activities in Italy include:

(a) assistance to newly established companies engaging workers dismissed by military firms;
(b) funding to military laboratories and research centers in order to shift their activities towards civilian fields; and
(c) financial support to diversification, and retraining activities for workers dismissed by military firms.

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[6]In July 1992, the Italian government approved a Conversion Program considering 15 industrial projects. Four projects were recommended to the European Union for being financially sustained. They included: an assistance center for executive aircraft to be based in Genua and employing personnel formerly producing parts of military aircraft; a plant for precision casting activities in L'Aquila (A bruzzi) using a plant formerly producing missile components; production and assembling of "air-bags" for the car industry in the ammunition production plant of BPD Difesa e Spazio based in Colleferro near Rome; and a center for design and prototyping of fuselages in advanced composite materials for an advanced amphibious aircraft, based in Naples.

4.3.1 *Regional Conversion Activities and the Konver Program*

Some Italian regions, especially those with a significant military production, have defined in the last years some instruments to face the crisis of the military firms located in their territories. In particular, the experience of Lombardy and Tuscany can be of general interest.

In Tuscany, the regional government's major concern is to avoid a possible dispersion of technological capabilities existing in the Tuscan military electronic firms. These capabilities are concentrated in two firms, Officine Galileo and SMA, based in Florence and formerly controlled by Efim. These firms have been largely reorganized in the last years and have dismissed hundreds of workers. Recently they have been acquired by Finmeccanica, but their future role within the Finmeccanica group is not clear yet. As a result, the regional established a technology transfer policy at the regional level, making small and medium firms in Tuscany able to rely on the technological competencies of Galileo and SMA. A regional network aimed at diffusing technologies has been established and some public and private actors are working together to intensify relations among military firms, Universities, and research centres in order to increase the commercial application of radar military technologies from SMA and opto-electronic technologies from Galileo. Currently, possible applications in meteorology, medical devices, transportation, and space are being considered.

In Lombardy, a regional law passed in 1994 established a Regional Agency for Promoting Conversion (Regional Law 170/94). This Agency will:

(a) fund studies on the possibilities of conversion in Lombardy,
(b) promote technology transfer,
(c) support some conversion projects at the regional level, and
(d) propose to the national government and Parliament more general measures for supporting conversion.

This law represents an original effort at defining a regional industrial policy aimed at conversion. The limitations of this effort arise from the narrow focus of the regional industrial policies in Italy which have to be coordinated with national and European initiatives. In any case, Lombardy will probably be able to implement the Konver Program, or similar national measures, more effectively than other regions because of a higher level of coordination among the regional government, the industrial associations, and the Ministry of Industry.

In other Italian regions the decline in military spending has also led, in some areas, to high rates of unemployment and economic crisis. In Table 2, the proposals of the Italian regions more affected by the crisis of the military sector within the 1994-1999 Konver Program are compared. As the table shows, each region is defining different goals, according to its own needs. In some regions unemployment is the main concern, while in other regions the promotion of economic development through business creation is considered a major task.

TABLE 2. EU Program Konver II - Italian Governmental Proposal
The Implementation at Regional Level

Region	Measures	Players
Piedmont	(a) re-employment of dismissed workers in the military industry (b) restructuring of former military buildings	Workers, Local communities, Universities
Lombardy	(a) restructuring and re-use of dismissed buildings (b) support to industrial conversion promoting technology transfer from the military sector to commercial SMEs (c) support to business creation	Local communities, SMEs
Liguria	(a) support to SMEs, particularly aimed to identify conversion strategies (b) recovery of former military areas	SMEs, public bodies
Tuscany	(a) support to SMEs for technological qualification (b) establishment of an advisory panel for regional Konver activities (c) support of business creation	SMEs
Latium	(a) restructuring of former military buildings (b) improvement of infrastructures, mainly roads, in industrial areas (c) support to business creation	Local communities, SMEs, public bodies
Nation-wide activities (Ministry of Industry)	(a) support to diversification of former military activities/business creation (b) studies for promoting and assessing technology transfer policies from the military sector	New industrial firms

4.3.2 *A More Comprehensive Role for the European Union*

It would be an error to consider the Konver Program the only way the EU can sustain conversion activities. If we consider small firms as major players in the process of technology (and industrial capacities) transfer from military to civilian industries, the European Union's structural funds can also offer, in selected European regions, financial support to such a process. The Italian Mezzogiorno as a whole is considered by the EU a low-developed region. Thus, the region of Campania, for instance, may promote industrial recovery activities with up to 100 per cent of financial support from the European Union. Other areas with significant military productions, such as Varese, Turin, or Rome, are considered by the EU to be areas with declining industrial activity, and they can apply to the EU for funding for up to 40 per cent of their investments in infrastructure, technology transfer activities, consulting services to small firms, or training activities.

Nonetheless, it is well known that only 30 per cent of funds made available by the European Commission for sustaining small and medium industrial firms based in Italy are actually used. Similarly, Italian local governments are experiencing several difficulties in approaching EU funding sources. This limited collaboration between Italian public or

private bodies and the EU is probably due mainly to the inefficient bureaucratic machine of the Italian State. As a consequence, the role played until now by the EU structural funds in promoting the technological development of smaller Italian firms and in assisting economic development of Italian regions has been very limited compared to its potential.

5. Conclusion

From the analysis of the current structure of the Italian military industry, as well as from a brief overview of the Italian innovation system and a description of the institutional framework in which defense industrial policies are defined, we can draw some conclusions from the Italian experience.

First of all, we have observed a lack of coordinationamong different policies influencing the military production, leaving room for an increasing role of the largest firms in defining their own strategies. During the last years, the concentration of the Italian military industry has led to the creation of a semi-monopoly, Finmeccanica, which will be able in the future to influence the needs of the Italian Defense and the policies of the Ministry of Industry. In such a perspective, the emphasis by Finmeccanica on "diversification" vs. "conversion" may lead to underestimating the need for promoting an increasing "integration" between military and commercial industries.

On the other hand, the growing role of the Ministry of Industry in controlling both the State financial support to military industrial restructuring and the implementation of European programs may create a favorable environment for relocating technological and industrial capabilities potentially made available by reductions in military programs.

Considering also the other players involved in the definition of the industrial policies in this field, some general suggestions can be made.

(a) A regional policy is clearly needed. Attempts to change the final output and, more relevant, the organizational structure in order to reduce costs of large military firms will probably find insurmountable obstacles in the rigidity of "military" production processes and in the technological weakness of the Italian military-related sectors. A more useful attitude may be to evaluate the potential of areas hit by industrial crisis and defining a recovery plan aimed at employing existing resources in the most productive ways. New activities, dealing with both industries and services, may develop while traditional (industrial and/or military) activities can be reduced: the focus here is on flexibility and on the best possible use of local resources.

(b) The role of small/medium firms has to be emphasized. It is increasingly relevant in areas affected by lagging economic development or the decline of traditional industries to promote the establishment of a large number of small companies acting in different sectors with the aim of diffusing an entrepreneural attitude and spreading technological know-how. A basic motivation for supporting such an

approach is avoiding the misuse of economic resources often implied in large restructuring initiatives, as would be the case of large public-funded dual-use programs implemented by military firms. On the contrary, it is important to sustain market-oriented activities with ad-hoc measures, i.e., providing industrial infrastructures, banking assistance, legal and tax consulting services, technical training, and marketing services. In some countries, local governments have created so-called "firm incubators", which are service centres able to support the creation of new companies. A network of these centers - BICs Business Innovation Centers - is currently sponsored by the EU.

Small and medium firms can succeed not only in providing services or handicraft. Evidence from Italy shows that small innovative firms can play a key role in diffusing science-based knowledge (including military technologies) carrying out industrial activity. A national policy of technology transfer can support this process creating joint activities among large high-tech public-owned firms, universities, research centers, and small innovative firms. Some Italian laws are currently funding such activities and local governments are fostering the creation of "Scientific and Technological Parks". These parks are funded by both the Italian government and the EU Commission and are aimed at developing science-based industrial productions.

(c) Different public policies must be coordinated. A recurring barrier to implementing economic development policies is the difficulty in matching a wide range of diversified objectives. The task of transfering workforce and technologies from large military firms to a number of local small firms should be evaluated, not only considering the technical and economic feasibility of such a move, but also general concerns regarding national policies in fields such as Defense, technology, national economy, industry, trade, labor, etc. For instance, an agreement aimed at diffusing a military technology from a military firm to the commercial sector could be jeopardized if the Ministry of Defense would consider that technology as strategic. Or, a national policy supporting some industries could disadvantage investors willing to exploit regional potentialities, in terms of resources or technologies. Thus, it is very important to consider the institutional framework within which an industrial recovery plan will be developed. As a first step, general regulations by the EU must consider the general framework within which national industrial policies have to be defined. It needs primarily to evaluate possible contrasts between EU legislation and the goals of the national policies, such as promoting the development of some regions, favoring some means of transport, protecting some industries, or strengthening the national presence in some scientific or technological areas. Later, locally suited strategies can be defined, aimed at activating different tools (at the EU, national and regional level) for providing support to conversion/ development activities.

CRISIS AND CONVERSION IN THE FRENCH ARMS INDUSTRY NATIONAL AND REGIONAL ASPECTS

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The current Defense activities crisis is probably less significant in France than in other countries - notably in post-Soviet Russia, united Germany, the US or the UK. Nevertheless, the combination of the economic crisis, the military material price drift and the new geopolitical world situation, have led to a slow but constant decline in French military activities.

Several indicators underline the extent of this decline.

According to DGA (Direction Générale pour l'Armement) estimates, direct employment[1] in Defense reached its peak of 310,000 employments in 1982, and since then has shed more than 25% of its manpower, and this mainly in reduction of export activities until 1990 at least (Table 1).

TABLE 1. Direct employment in the French Defense industrial base. Evolution 1983-1993 (estimated figures)

	1982	1993	1993/1982
Total employment	310,000	230,000	-26%
including: export employment	100,000	40,000	-60%

official source: DGA

This trend is confirmed by turnover evolution. Indeed, during the same period (1984-1992), the Defense industry turnover fell by 14.5% in inflation-adjusted Francs, mainly due to a fall in export sales (Table 2).

R.F. Dundervill, Jr. et al. (eds.), Defense Conversion Strategies, 431–448.
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TABLE 2. Turnover for the French Defense industrial base. Evolution 1984-1992 (in billions of francs 1992)

	1984	1992	1992/1984
Total turnover	132.3	113.1	-14.5%
including: export turnovr	56.4	29	-49%

official source: L'avenir des industries liées à la défense. Documentation Française 1993.

Although some sectors withstand this trend better than others, no sector is spared. The main operators in the different sectors (and most of those following them), show considerable redundancy figures for this period. (Table 3).

TABLE 3. Employment evolution among main operators in leading Defense sectors

	1982	1993	1993/1982
Aircraft industry Aérospatiale	36,450	25,637	-30%
Shipbuilding industry DCN	31,540	26,900	-14.5%
Land arms Giat/Giat-industrie	17,000	11,600	-32%
Defense electronics Thomson-CSF*	64,200	42,400	-34%
Nuclear products CEA**	10,000	9,200	- 8%
Gunpowder and explosives SNPE	6,840	4,090	-40%

official sources: parent companies annual reports

* Thomson-CSF, 1984 and 1992 employment figures and 1992/1994 report. Thomson CGT report, March 1994.
** 1986 and 1992 employment figures and 1992/1986 report. DGA estimated figures.

Although the official political line, as expressed in the Livre Blanc sur la Défense 1994, advocates the maintenance of the Defense effort until the end of the century[2], the erosion of Defense budgets over the last five years (4 to 8% in inflation-adjusted Francs depending on calculations used), and the evolution of the political and economic world context seem to indicate that contraction will continue in the years to come.

According to the November 1993 Commissariat au Plan (French Planning) report, the Defense industrial sector, in its widest sense -direct and indirect employment could lose up to 20 to 45% of its manpower over the next four years (Table 4).

TABLE 4. Scenarios for the evolution of activity in the Defense industrial sector (1993-1997)

Scenarios	hypotheses	impact on employment (direct and indirect)
A	* + 2% productivity gain p.a * + 1% procurements * + 5% exports p.a	- 60,000 employment (-20%)
B	* + 2% productivity gain p.a * - 5% procurements * - 10% exports p.a	- 132,000 employment (-45%)

official source: L'avenir des industries liées à la défense. Rapport du Commissariat au Plan. La Documentation Française 1993.

This downward trend is not limited to Defense industrial activities, but also affects actual military activities. Thus, as is stated in the introduction to the aforementioned Official Report, between 1983 and 1994, 105,000 people were made redundant from a workforce of 700,000.

This generalized fallback in France as in all other countries concerned, has involved an economic and social adaptation process. Among the principal countries to be affected by the crisis in Defense activities, France is undoubtedly the country where State control in Defense activities is strongest, and where regional identity, the will to live and work in a particular region is most clearly expressed. These French particularities bear on the process of adaptation to the crisis both at the national level in relations between the State and the Defense industrial basis, and at the local level, in the will to integrate industrial conversion within a more global approach to regional development. These are the two aspects of the crisis and the conversion of Defense activities to be addressed in this study.

1. A Less Invasive State Presence[3]

1.1 STATE CONTROL

The State, which has the monopoly of legitimate force, exercises close control over the national Defense base whose main aim is to provide it with the "mechanical" or material means to exercise that force.

The ascendancy of the State over the arms industry in France dates back a long time. It goes back to the mercantile period in the economic history of France, to the age of Colbert, the famous minister of Louis XIV. It was under his administration that the first land arsenals, great military shipyards (Brest, Toulon, and also Dunkerque and Rochefort), and arms manufactures (the famous Saint-Etienne arms factory) were created. Crown property, these industrial establishments along with the Services des Poudres - itself under State control since the XIVth century - were to form France's first Defense industrial base.

With the development of military techniques, this industrial base has since increased. The successive nationalization laws of 1936 (aeronautics[4]), 1945 (Renault and SNECMA[5]) and 1982 (Thomson group, AMD-BA[6], Matra) confirmed this dominant feature of State control.

Even though waves of nationalizations have often been followed by partial denationalization movements, and though a dynamic Defense industry private sector has continued to prosper outside these significant industrial policy manoeuvres, the fact remains that today the Defense industrial base is still marked by the predominance of the public sector (State establishments, nationalized firms). Whether it be Aérospatiale for helicopters and strategic aircraft, Dassault-Aviation[7] for combat aircraft, the SNPE for gunpowder and explosives, GIAT industries for armoured tracked vehicles, the DCN for warships, Thomson-CSF for large detection systems, SNECMA for aircraft engines, a State controlled establishment is always to be found at the head of the different Defense industrial sectors.

As can be seen in Table 5, in 1993, of the ten firms with the highest turnovers in the sector, seven were from the public or nationalized sector[8].

The ascendancy of the State over the arms system is further reinforced by the presence of a state controlled regulatory authority: la Délégation Générale pour l'Armement (DGA), the government agency for military R&D and production.

Created in 1961 as the DMA (Délégation Ministérielle pour l'Armement)[9], at a time when France decided to commit itself to an independent nuclear Defense policy, this new administrative structure soon became "architect of French Defense programmes"[10]. Directly attached to the Defense minister's cabinet, at the same level as the staffs of the different army corps, the DGA imposes itself as their obligatory intermediary, responsible for harmonizing their own requests for military materials and regulating their orders placed with manufacturers within the sector.

DGA intervention in the process of arms production and acquisition is threefold: it produces arms, but also purchases them from private companies on behalf of the ministry of Defense, and in this same capacity it is responsible for control of arms companies. The polyvalency of the relations between the DGA and industry significantly colors the arms industry in France as a whole, compared with production and acquisition conditions existing in other European countries, and the link between arms manufacturers and the State has found its specific expression within the central position of the DGA.

TABLE 5. "Arms" turnover 1993 of main French companies

Manufacturer	Turnover (in millions of 1993 francs)
DCN	20,063
THOMSON-CSF	16,800
AEROSPATIALE	9,177
DASSAULT AVIATION	9,052
matra défense/espace	7,500
EUROCOPTER	5,200
GIAT INDUSTRIES	5,111
SNECMA	3,798
dassault electronique	2,631
sagem	2,090

* in small letters : private firms
source: Hebert,J.P (1995a)

One of the specificities of the DGA is its concentration of a significant number of arms engineers. The existence of this body structures the DGA itself and increases its possibilities of intervention, control or influence over industrial manufacturers and over other agents within the system.

1.2 ADVANTAGES AND DISADVANTAGES OF ADMINISTERED REGULATION

According to J.P. Hébert, the strict control exercised by the State on the the Defense industrial base, notably the presence of an organ of coordination at the intersection of the military and industrial spheres has had one advantage at least: "that of having allowed the State to economise a considerable fraction of the transaction costs it would have faced if it had been forced to find the means of appraising and comparing proposals (for military materials) from a large number of manufacturers situated outside the public sphere" [4].

In the present context of crisis, where the price drift of military materials, shrinking markets, increased international competitiveness encourage at the same time the partial conversion of activities and the internal and international regrouping of industrial groups within the sector, the drawbacks linked with the inherent rigidity of the system of administered regulation stand out particularly.

It is the industrial establishments of the ministry of Defense, those in which the State itself carries out production activity, which suffer the greatest drawbacks. Lacking legal entity these establishments have no shared capital, thus they are unable to have recourse to credit facilities, or to intervene on financial markets, neither have they any autonomy in the use of export profits. Worse, they are unable to undertake the slightest regrouping or alliance operation (takeover, merger, joint ventures etc...)[11]. A 200-year-old law, the Allarde law, strictly limits their diversification capacity. This 1791 law which is still enforced, stipulates that the State may not exercise commercial activity in domains other than those attributed to it by the legislator, unless the civilian market is particularly lacking. This law was regularly invoked in the past by private manufacturers to oppose attempts made by State Defense industrial establishments to diversify to civilian ends. This was the case in particular during the 1950s when the Pont-de-Buis plant of the Service des Poudres et Explosifs, armed with its technological advance in the field of composite materials undertook the mass production of Bakelite telephone receivers. Under pressure from the plastics industry, the establishment soon had to grant this activity to a private manufacturer. The same problem arose at the end of the 1960s when the machine-tools employers confederation forced an end to the production of machine tools intended for civilian markets in the Tarbes arsenal. Relying on the same law, a similar opposition occurred some years later (1972) when Brest military dockyard undertook the construction of two car ferries for an English shipowner. Despite its technical and economic success, the operation was not repeated.

1.3 WAYS FOR THE STATE TO WITHDRAW

The process of liberating the sector vis à vis the State is expressed in various ways.

It is first expressed as the transformation of State industrial establishments into national companies. Applied in 1971 to the Service des Poudres et Explosifs which then became the SNPE (Société Nationale des Poudres et Explosifs), the procedure was to be taken up again twenty years later during the transformation of GIAT's land arsenals into a national firm. It became a fully fledged firm, benefiting from all the attributes of responsibility, GIAT, henceforth GIAT Industries, could undertake a vast policy of takeovers and mergers (Luchaire, Manurhin, SFM, SMS etc...) which would enable it to federate around itself the virtual totality of French land arms.

Finished in the land arms sector, this "de-arsenalization" process is today being applied in the naval sector. In 1991 it led to the creation within the DCN of a public capital private law company: DCN International. Like any firm, DCN International operates on export markets from prospecting to signing sales contracts. It also carries out joint venture and acquisition operations originally at the development of the programs conducted by the DCN in cooperation with foreign partners[12]. From 1992 it was followed by a reorganization of the DCN consisting in distinctly separating the State activities pole - proposals, definition, specification and development of programs in relation with the Naval departmental staff- from the industrial pole - product design and experiments, assembling and expertise in the fields of naval architecture, systems

integration and logistics [1]. It is probable, as was the case for the GIAT within the Direction des Armements Terrestres (DAT), that this separation will soon lead to the industrial pole of the DCN becoming a national company.

It also appears in the opening of nationalized companies to private ...or privatizable capital. This already occurred during the denationalization of Matra and the CGE which took place in the late 1980s, and will reoccur if the current privatization projects for Thomson, Aérospatiale and SNECMA go through. This can also be seen by the entrance of the Crédit Lyonnais (another privatizable company) into Aérospatiale's capital (20%).

A significant number of mergers and takeovers have in other respects contributed to giving existing groups greater room for manoeuvre. That was seen to be true in the land arms sector (regroupings around GIAT industries) among others. Apart from GIAT, industries one may mention among the most active groups during the last period are Thomson-CSF (TRT takeover) and Labinal (Turbomeca and Technofan).

More fundamentally, the national horizon is no longer the framework of essential industrial action for firms. Indeed several of the major operators in the Defense industry have undertaken the creation of large industrial alliances at the European level. As examples, we could name the joint ventures created by Aérospatiale with the German company DASA (Eurocopter), by Thomson-CSF with GEC-Marconi for airborn radars, with Ferranti for sonar systems and with DASA in the fields of land arms and propulsion of tactical missiles, also by Matra with GEC-Marconi (Matra Marconi Space, now European leader in its field since the takeover of British Aerospace space activities).

One cannot underestimate the importance of this movement towards Europeanization as far as the functioning of the French arms production system is concerned. It bears on the firm-State relationship: firms are no longer facing the single national representative and the State is no longer facing such dependent firms. From this point of view, Europeanization is overturning the deal, introducing, moreover, the birth of a new political authority at the level of the Community, even if the field of Defense currently occupies a place apart at the Community level.

Finally, irrespective of the significant maneuvres of a financial nature, the link between firms and their chief project manager has somewhat slackened; for those at least which, to palliate the decrease in military orders by the State, have adopted a diversification policy for customers (development of export markets), and (or) products. As can be seen in the following diagram, during the 1980-1993 period, the movement towards products diversification is particularly marked in the aeronautics sector. The refocussing on military activities by Thomson-CSF and the SAGEM, two main operators in the Defense electronics sector should be perceived as an exception.

Key to the diagram: the angles at the center are proportional to the weight of the firms relative to their turnovers. The arrows point from 1980 to 1993, an arrow pointing outside the circle indicates a reduction in the military share, pointing towards the center it indicates an increase. The tips of the arrows give the military share in the total turnover of the firm for the two years used as reference [5].

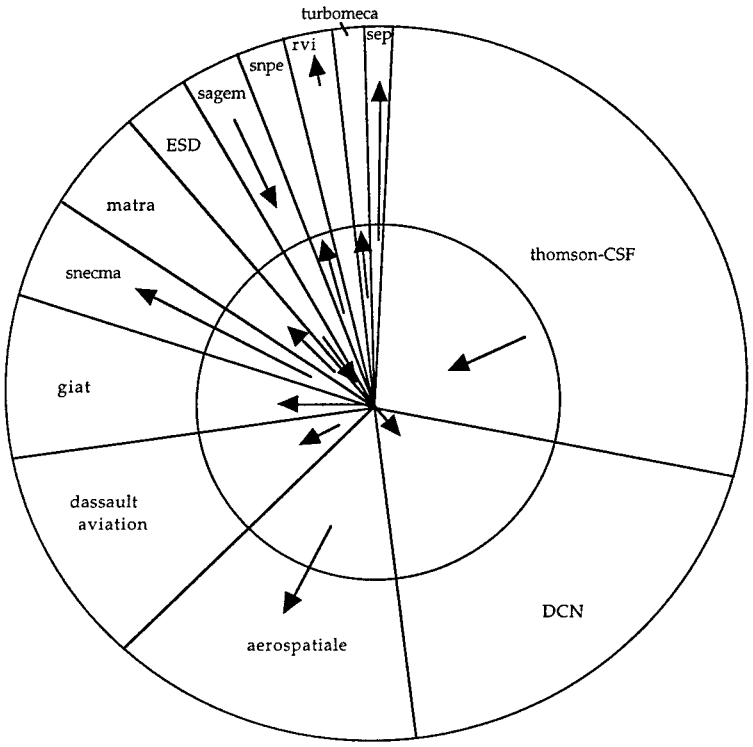


Figure 1. Evolution between 1980 and 1993 of the arms share in the turnover of the main Defense industries.

2. Conversion, a Regional Affair: The Case of Brest

If one discounts the Paris region - principal French concentration of Defense industrial employment- for reasons resulting from History and military strategy, the major part of Defense industrial activities are grouped in the western half of France, i.e also in the part which is less industrialized and further away from the main lines of European development.

Given this industrial deficit, Defense activities often play the role of lifesaver in the travel-to-work areas where they are situated. With the decline of these activities, today the very future of these travel-to-work areas is threatened. Henceforth, conversion takes on a new dimension. Originally an internal problem for the firm to adapt to a changing environment, conversion is becoming the affair of a whole region, a real question of planning, of regional development.

Examination of the case of Brest will illustrate this.

2.1 THE STATE OF DEFENSE ACTIVITIES IN THE REGION OF BREST[13]

Situated in the west of Brittany - the region most dependent on military activities in France[14] - the Brest employment zone alone concentrates, according to the 1990 census, from 40 to 45% of Breton Defense direct employments.

The considerable size of the Defense sector can be explained by the fact that Brest is both one of France's chief naval bases and also its main shipbuilding and repair yard - common practice in the naval domain.

First naval base on the English channel-Atlantic coast, Brest has been assigned the setting up and the protection of the Oceanic Strategic Force (FOST), the spearhead of the nuclear dissuasive force. Including FOST itself (five nuclear lance-engine submarines and their crews), accompanying nautical and aeronautical forces, land-based services and management and the naval colleges, this represented on March 1, 1992, 20,000 Defense employments, 90% of which being military[15].

Situated within the naval base itself, the naval military shipyard - the DCN-Brest, one of the DCN's decentralised establishments[16]- counted on January 1, 1995, a statutary workforce of 5,900 and in 1993 carried out 4 billion Francs in production value [1]. In terms of manpower today, it is the first DCN establishment, and by far the first industrial establishment in Brest, and second in Brittany after the Citröen factories in Rennes. Most of its activity is divided between the construction of large surface craft (aircraft carriers, LPDs and cruisers, representing 25 to 30% of its work program), surface craft maintenance and repair (20%) and FOST maintenance (40%).

Near these naval components of Brest's military complex, 50 kilometers away at the far end of the bay there is a gunpowder plant which also dates back to the days of Colbert. At that time, it was used as gunpowder supplier for the naval base in Brest. Its link with Defense activities is now much reduced. The military activity of the plant (military gunpowder and pyrotechnics, products for the maintenance of law and order) barely represents more than 20% of its turnover (140 million francs in 1993). The production of warfare explosives has been overtaken by the production of gunpowder for hunting. On January 1, 1995, the plant employed 252 people.

More recent arrivals (1962), Thomson-CSF and Defense electronics, are represented by two plants. The first, specialized in the construction of radars and other air navigation systems comes under the direct control of the group's parent company. Attached to its Radar and Counter Measures (RCM) division, it employs 1,080 people. The second, specialized in the manufacture of sonars for warships, is a 100% subsidiary of the Thomson-Sintra ASM group. It employs 309 people (January 1995) and in 1994 had a turnover in the order of 300 million Francs.

This complex of military activities plays an essential role in the economic life of the region. If one adds to the direct jobs in the complex the local indirect employment and services employments engendered by the households of people working in the complex as well as people working for its local suppliers, this adds up to more than 30% of total employment in the zone. Finally, local military activities provide a living for about one family in three in the region of Brest[17].

As can be seen in Tables 6 and 7, the decline in Defense activities which have already been mentioned at the level of Defense industrial groups has repercussions on their local establishments. In Brest the problem is accentuated because, at the same time, the naval base which had developed on a regular basis until the early 1980s, at the end of that period suffered a significant decrease in activities (10% job cuts between 1988 and 1992).

TABLE 6. Arms industry plants in Brest

	D.C.N	S.N.P.E	THOMSON CSF/RCM	THOMSON SINTRA
ACTIVITY	NAVAL CONSTRUCTION AND REPAIRS	GUNPOWDER EXPLOSIVES	RADAR	SUBMARINE ACOUSTICS
DATE LOCAL IMPLANTATION	1631	1688	1963	1969**
WORKFORCE*	5,900	252	1,080	309
% ENGINEERS	6%	<8%	25%	40%
MILITARY SHARE OF TURNOVER	100%	20%	75%	95%
% OF CAPITAL HELD BY PARENT COMPANY	100%	100%	100%	100%
DIVERSIFICATION OPERATIONS EXAMPLES	CLIENT DIVERSIFICA-TION	AIRBAG PYROTECHNICSYSTEMS CAR SAFETY DEVICES	ANTI COLLISION SYSTEM	INTELLIGENT FISHING CONTAINER LOCATION

* 1995, 1st January
** submarine action division of Thomson-CSF/RCM until 1985.

TABLE 7. Evolution over ten years of the number of employees in the industrial groups in the arms sector and their plants in Brest.

Groups and their plants in Brest	Number of employees 1st January 1982	1983	1995	Evolution 95/83(82)
Direction des Constructions Navales	31,251		24,500	-21.8%
D.C.N-Brest	6,884		5,900	-14.2%
Société Nationale des Poudres et Explosifs		6,843	4,961***	-27.5%
S.N.P.E Pont-de-Buis		516	252	-51.2%
Thomson-CSF		6,4200**	42,400***	-34%
Brest plants*		2,096	1,389	-33.7%

* one plant in 1983: Centre Electronique Brestois (CEB).
two plants in 1995: the submarine action division of the CEB became in 1985 an industrial establishment of a new affiliated company of the Thomson-Sintra group.
in 1984 * in 1993
official sources: D.C.N - Boucheron report 1985 and "Le Flot" n°142.
S.N.P.E - annual reports
Thomson-CSF - annual reports, C.E.B statement of accounts, local press.

2.2 DIVERSIFICATION INITIATIVES LED BY LOCAL DEFENSE INDUSTRIAL ESTABLISHMENTS

Although the decline in Defense activities led the large local establishments in the sector to react, the time taken and the types of action taken were different.

The first to react to the drop in its military markets, probably also because the declining trend in its traditional activities was already well underway - was the gunpowder plant at Pont-de-Buis. Basing itself on its competence in military pytotechnics, the local SNPE establishment in 1984 began the manufacture of safety devices for automobile safety belts for the Mercedes auto manufacturer. Convinced after this first experience that in order to establish itself on a long-term basis on the auto equipment market, it had to find a partner with solid experience of the market and with a large sales network, the plant in 1992 formed a partnership with Autolivclipan -a subsidiary of Electrolux and manufacturer of safety belts. Together they created a subsidiary at Pont-de-Buis, Livbag, with each of the two associates holding half of the capital. At the beginning of 1995, this new firm employed 120 staff for a turnover (1994) of 470 million Francs[18], more than double that of the gunpowder plant.

Concerning diversification towards civilian activities, without contest the establishments of the Thomson group offer the greatest possibilities. Electronics, the technology at the base of all their activities, is the exact type of generic technology, i.e., "a set of fundamental radically new skills for which (technology) there exists the greatest

potential for diffusion" [15]. And so, whether it be in the domain of submarine acoustics, magnetism or the analysis of air signals, several projects of technological application in the civilian field were designed in establishments in Brest. The major projects included: the container location beacon at sea, the intelligent fishing system (trawl positioning system), the multibeam echosonarsouder for marine cartography, the automobile anti-collision radar, and the electronic chronotachygraph.

Few of these projects have been carried out today. Indeed, diversification towards civilian production is contrary to the current strategy of the Thomson group. This strategy consists of focussing Thomson-CSF on the military and thus to take advantage of the crisis in the sector to become a restructuring pole for the European, and if possible the world arms industry. Consequently, it is generally under pressure from local protest movements demanding job security that diversification operations are set up. They are only tolerated to the extent that they do not interfere with the main lines of the group (military) and do not "mortgage" its financial profitability in the short term.

If one discounts the construction in the 1950s of the liner Antilles and of the two car ferries twenty years later, the military shipyard in Brest has only ever worked for the Navy[19] and does not intend today to depart from this tradition. On this point, there appears to be total convergence of opinion between the establishment's management and the workers who see in it the best guarantee of retaining their status[20].

Consequently, despite the setting up in 1991 of a cell to that effect, diversification experiences remained until very recently anecdotal, without any real economic impact. The bogey regularly conjured up was that conversion would mean that the DCN would end up making saucepans, an image which put an end to any talk of diversification of DCN activites in Brest!

In spite of this, under the pressure of current events, the idea of diversification of activities, of the need also to set up new relations with local private subcontractors, promoted by central management is beginning to have an effect.

Diversification is not limited merely to the manufacture of saucepans. Real diversification opportunities exist. The DCN does have at its disposal a huge industrial tool, in many cases the largest in Europe. On this basis, the DCN considers that the whole field of civilian activities leading to the construction of mega-structures and (or) requiring the use of mega-machines is open to it. This was the direction recently taken by the DCN Brest which, last year, was subcontracted the manufacture of oil platform sponsoons by a local private naval repair yard. Such operations are profitable on two counts at least. On the one hand they preserve an order book which was ailing due to the drop in military orders. On the other hand, by standing aside for a private project manager the DCN allows the company to situate itself on a market where, until then, it did not have the means to intervene; this may be considered as contributing towards the economic support of a travel-to-work area affected by a reduction in military activities.

The setting up of global subcontracting contracts for the fitting of an island on the nuclear aircraft carrier Charles De Gaulle and for the ventilation work on the SIROCCO LPD upon which work has just started, will also contribute to this aforementioned movement.

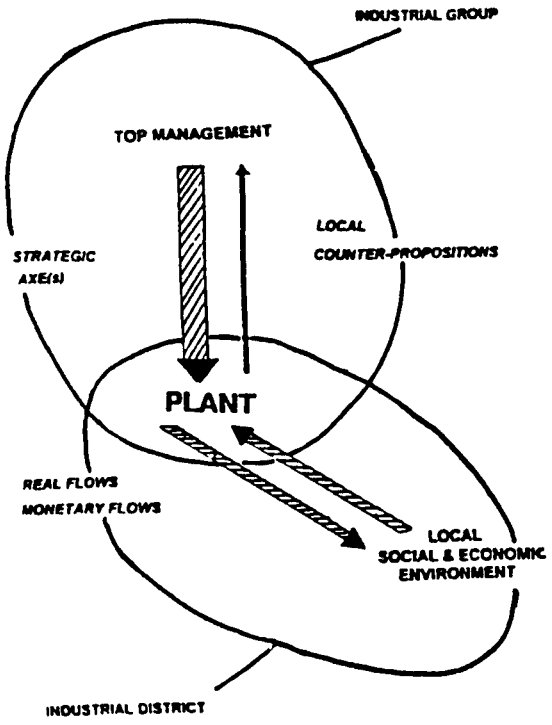
The urgent need to cut costs is today leading the DCN to give up its summary temporary manpower hiring contracts (contracts known as internal subcontracting) in favor of global subcontracts. Within the framework of a fixed price contract, the subcontractor in this type of contract becomes responsible for the design and the complete manufacture of whole parts of a ship, and organizes himself to meet deadlines and cost constraints. Apart from the cost-saving expected, this new type of subcontracting should allow subcontractors to move from a system of assistantship to one of responsibility. The time has gone when local SME played the role of temporary employment agencies, hiring out their manpower to meet very clearly defined demand. To get these new contracts they will have to set up research departments, fill out their supervisory structures, and very probably group together; these are measures which should reinforce local industry and, in time, permit it to become less dependent on its principal contractor for military shipbuilding and repairs[21].

2.3 TOWARDS THE CONSTITUTION OF AN INDUSTRIAL DISTRICT

A certain number of conclusions can be drawn from the examination of these few diversification experiences.

a. Firms with long practice in Defense public protected markets are not necessarily those which are best armed to penetrate private markets in the competitive sector.
b. Firms do not all enjoy the same technical opportunities for diversification. That depends on the more or less diffusive power of the technology(ies) they are based on. In this respect, irrespective of all political or corporate considerations, it may be illusory to think that the DCN should be able to become very involved in diversification moves.
c. The technical opportunity to diversify counts for nothing, unless it is accompanied by the political will to diversify. In this respect, the local industrial establishment (Fig. 2) may become the point of confrontation between two logics, the industrial logic coming from the management of the group to which it belongs -profit logic- and the territorial logic of maintaining the establishment workforce where it is. Finally, everything will often depend on which of these two logics will win in terms of the interactive play of influence in which they are both taking part.
d. Within local Defense establishments there exists real potential for diversification. The local will to transform this potential into a real process of industrial conversion in the region of Brest demands to assert itself that the skills and know-how currently employed in Defense industrial activities should find their true place.

These skills and know-how make up the base of industrial culture in Brest. This industrial culture, now three centuries old is both military and naval. Originally concentrated within the military port, it has since been greatly extended without: in the docks first at the turn of the century with the creation of a civilian ship repair yard[22], then to the west of the agglomeration where a Defense electronics pole was more recently installed.



source: R.de Penanros, T.Sauvin and M.N.Le Nouail,1995b

Figure 2. The Local Industrial Establishment

Around these three poles of activity and their main contractors - the DCN for the military naval construction and repairs, SOBRENA for civilian naval repairs, Thomson-CSF and Thomson-Sintra for Defense electronics- gravitate over fifty local SME with neighboring or complementary skills in metallurgy, mechanics, on-board electricity and naval electronics.

Brest has at its disposal the constitutive elements of an industrial district, or more exactly of a local productive system (LPS)[23], i.e., a configuration of firms grouped

within a close area around one or several skills belonging to the same branch of activity. The geographical, professional and cultural proximities of the agents within such a system make it a production site for positive externalities (economies of size, transaction costs, reduced uncertainty), a powerful source of innovation and efficiency [14]. "This source is, in fact, a place within which it is possible to establish a systemic coherence making it possible both to attract financial, investment and technoloy flows and thus to engender lasting regional development" [14].

For it to be a true source of innovation and efficiency, it is necessary for the firms which form it to maintain close quality relations with each other and with their socio-cultural environment of insertion. This condition essential to the reality of the LPS is sadly lacking today in Brest where the local arms contractors -the DCN in particular- have reproduced the hierarchical, compartmentalized model of organization which everywhere in France characterizes the relations between principal arms contractors and their suppliers and subcontractors[24]. Without doubt, the new relations which the DCN seems to wish to develop in the local industrial fabric (global subcontracting contracts, technical back-up for industrial projects led by civilian operators) run along the lines of greater horizontal cooperation. Without the prospect of renewal of this type of subcontracting markets beyond the current operations concerning the fittings for the Charle-De-Gaulle nuclear aircraft carrier and the TDC Siroco, these two contracts of current global subcontracting alone will probably not be enough to convince subcontractors to form partnerships and to develop their administrative and commercial study structures which would allow them to master control of industrial projects and thus free them from the supervision of the military establishment.

The attraction of the area in which an endogenous dynamic for development could be founded lies in its capacity to become a territorialised system of innovation. This means that the formal and informal relations which form the basis of the creation and diffusion of innovation have to multiply between firms and also with the other sectors of the LPS (State departments, local government, university and other public and private research organisms, chamber of commerce and industry, trade unions etc...). The setting up of a true LPS capable of maintaining an endogenous dynamic for development which, while relying on the skills and know-how currently underway in Defense industrial activities, would gradually reduce the importance of the latter, cannot be brought about by uncoordinated initiatives. The conversion of Brest's industrial site involves the concerted intervention of all the local agents, it is truly the affair of the whole region.

3. Conclusion

Confronted with a lasting crisis, the French arms productive sector is today undergoing a period of change. This can be seen at the national level by a relative withdrawal of the State from this sector of activity. This withdrawal is relative since it is far from being a renouncement by the State of its control of this highly strategic sector. Let us take as an example, the fact that sixteen Defense industry engineers were made available to regional

Prefects to carry out the delicate assignment of "assuring the durability of the Defense industry facing a difficult economic climate"[25] and the setting up in 1993 of a Defense industry structuring apparatus (ASTRID); added to this comes the extension at the beginning of the year of the 700 -million Franc aid-program to valorize SME technological potential which is expected to contribute to the creation of 10,000 new jobs in the Defense industry within two years[26].

Reducing the purchase prices of its arms systems in order to adapt them to its new budgetary constraints and maintaining the independence of its Defense system seem to be the present objectives aimed at by the State in Defense industry policy and strategy.

The first objective is met by State withdrawal, by a return to competitiveness and to market laws which are expected to lead to increased cost-effective production. The second objective is met by greater concern for "second level" firms which are "the source of indispensible innovations for Defense" and which, if threatened, "would represent a threat to our Defense industry as a whole and, in the long term, to our independence" (Livre Blanc sur la Défense 1994, p.200).

Although a conversion process has been started both among Defense industrial groups and on sites and in regions heavily dependent on military activities, it is more a de facto contraction of military activities resulting from an adaptation to new global circumstances than a positive, deliberate political will to reduce the volume of the military effort. In other words, to use the terms of J.P. Hébert, it is more the case of contained or creeping conversion than a deliberate conversion (J.P. Hébert and R. de Penanros, 1995).

However, real potential for conversion exists in those regions confronted with the decline in military activities -the case of Brest is certainly not an isolated one. But for this potential to be realized, it is necessary that the local agents have the will to work together to define and carry through a global and coherent development project for their region to break away steadily from military constraints. At the local level, the creation of a conversion agency responsible for leading a vast network of local socio-economic agents concerned by the problem, and responsible also for carrying out studies, collating experience and promoting substitution activities for military activities would without doubt be the best way to raise collective consciousnes.

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Notes

1. Employment in R+D, manufacture and operational maintenance of arms within the defense industry. To these direct employments are often added indirect employment which these activities generate among suppliers to defense manufacturers. The relation between these employments in France is currently estimated to be 1 to 2.5.
2. cf chapter 8 of the Livre Blanc sur la Défense 1994
3. This part is largely inspired by a paper presented by J.P. Hébert at the Prométhée conference in Moscow 24-26 April 1995 and partly taken up in the article "The role of the State in French defense industry conversion" which we wrote together for the review Peace and Defense Economics (cf references).
4. After an action led by Pierre Cot, Minister for Aviation, main aviation manufacturers were grouped together in six nationalized companies.
5. 1945 was also the year of the creation of the CEA (Commissariat à l'Energie Atomique)
6. Avions Marcel Dassault-Bréguet Aviation now known as Dassault Aviation.
7. Dassault-Aviation is classified inside the public sector: although the major part of its capital is private, the majority of votes put it in the public sector, given the number of double voting shares.
8. In 1993 the CEA, not in the table, received a "Defense" subsidy (to a certain extent a sort of defense turnover) amounting to 8,473 million Francs.
9. It was given its present name DGA in 1977.
10. As it names itself in the different brochures it publishes.
11. See parliamentary reports on these drawbacks (Boucheron, 1985 and Bonnet, 1995).
12. DCN International is, with GEC-Marconi naval systems for Great Britain and Orizzonte for Italy, one of the parties involved in the international consortium IJVC (International Joint Venture Company), the industrial project manager of the triparti program for the manufacture of Horizon frigates (Bonnet, 1995, pp86 and ss).
13. For a deeper analysis of defense activities and their weight in the local economy, refer to the article "Etat des activités militaires dans la région brestoise et expériences de diversification" (R. de Penanros, T. Sauvin and M.N. Le Nouail; 1995a).
14. Counting arms industries and defense services together, direct employment in the sector represents 6% of the total regional economy against 2.41% on average in the regions of the European Union (cf "The economic and social impact of reductions in defense spending and military forces on the regions of the European Community" Brussels, 1992).
15. Compared to its closest neighbors, Lorient and Plymouth, in terms of manpower at least, the Brest base is today three times greater than Lorient and, if only the armed forces are taken into account, it overtakes Plymouth by 40%.

16. Apart from central services, DCN International and the research departments and trial centers grouped in the Paris region, the DCN has seven establishments in metropolitan France (Cherbourg, Brest, Lorient, Toulon, Ruelle, Indret, Saint-Tropez) and one in the Pacific (Papeete). This represented a total statutary workforce of 24,500 on 1-1-1995 (Le Flot n°142).
17. cf "Les activités militaires" (R.de Penanros, 1994).
18. Information received from company managers.
19. The DCN-Brest never intervenes as project manager in export markets, at the very most it intervenes when necessary as subcontractor for Lorient or Cherbourg, project managers for this sort of operation.
20. Status of State worker, similar to that of civil servant
21. On the different subcontracting practices of the DCN see (J.P. Hébert and R. de Penanros, 1995).
22. The local naval repairs unit and its subcontractors, today representing a workforce of about 400.
23. Less restrictive than the concept of industrial district that Alfred Marshall, its creator (Marshall, Trade and Industry, 1919), defined as a localized system of SME, the concept of LPS (local productive system) which does not retain the latter characteristic is without doubt better adapted to the case of Brest, as the the DCN in particular could hardly be classified as a SME.
24. On this point the study carried out by L. Messissi and C. Serfati "L'innovation militaire et l'industrie des biens d'équipement en France: quelques hypothèses de travail" which deals more particularly with the case of Bourges. In Brest, this compartmentalization is present in the fact that the DCN's subcontracting firms do not work for the civilian naval repair unit.
25. cf "Les envoyés spéciaux de la DGA" in Info DGA n°72 March 1995
26. cf Air et Cosmos n° 1511, 24 mars 1995

WESTINGHOUSE DEFENSE CONVERSION PROJECTS

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Abstract. *On March l, Northrop Grumman announced the completion of its acquisition of Westinghouse Electric Corporation's defense and electronics systems business.*

Now called the Electronic Sensors and Systems Division (ESSD), this newest member of the Northrop Grumman team is a world leader in the development and production of sophisticated electronics systems for the nation' s defense, civil aviation, and other international and domestic applications.

With this acquisition, Northrop Grumman's leadership in design, systems integration and manufacturing now encompasses military surveillance and combat aircraft, defense electronics and systems, aerospace management and information systems, marine propulsion, precision weapons, and commercial and military aerostructures.

1. Introduction

It is part of the Westinghouse business practice that managers at every level of operations must continually try to improve in three (3) areas of their job:

- the efficiency of resource utilization, which in Westinghouse business terminology it is called measure of return on capital investment and personnel utilization.
- process improvement, which refers to the improvement of existing practices in design, manufacturing, and service procedures,
- customer contents, which refers to market shares and new & more profitable markets for Westinghouse.

The goals of such practices are to increase return for shareholders and to fend off predatory competitors. It is an on-going activity in Westinghouse, in the defense business sector or the non-defense business. Sometimes it is called innovation initiative; other times quality improvement; the latest nomenclature is Re-engineering. But none of those activities reach the elevation called Conversion in Westinghouse.

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Conversion means creating a new business with largely existing capital resources, i.e; factories, engineering and manufacturing forces, marketing and sales channels, but with very infusion of capital and management resources.

Conversion is usually induced or compelled by quantum change in economics, political, and social necessity, not preplanned. The conversion of vacuum tube manufacturing factories being made useless by the fabrication facility of solid-state transistors is a classic example. The massive cuts of government spending and closing of military bases in the United States are examples of the unexpected compelling forces at work. Naturally, defense conversion is not the only approach to addressing the difficulties generated by a defense budget down-turn.

- General Dynamics chose to sell its Fort Worth Division, the home of F-16 aircraft.
- Lockheed and Martin Marietta chose to merge and then downsize the new Lockheed-Martin Corporation .

I shall only talk about Westinghouse defense conversion efforts for the remainder of my presentation.

2. Definition

When changes in the global political conditions result in deep and sustained cuts of the defense budget in the NATO community, several Westinghouse product managers, who have had responsibility for the use of large portions of Westinghouse resources, must transfer some of their equipments and personnel to new product teams for design and manufacture of new products for new paying customers. This is conversion at Westinghouse.

Defense conversion means making use of present manufacturing facilities and equipment, workers and managers, for the creation and manufacturing of products for a new market that is not associated with the adjective "defense".

3. Process and Criteria

The conversion at Westinghouse is a simple two-step process. It is developed to address two questions:

- What has become surplus or redundant?
- For which product line(s) can the identified defense surplus capacity be profitably used?

An answer to the first question depends on the planning horizon Westinghouse managers elect to apply. It is influenced by the short-term and medium-range outlook of values associated with facilities and people skills deemed redundant. Decisions on this question is generally made by the top management.

Many criteria have been used as a possible measure of merit for a Conversion project. The following are the familiar few:

- to maintain full employment of original personnel
- to maintain full employment of facilities
- to maintain profit or growth potential
- to preserve market value of the business
- some combination of the above

Westinghouse's criteria is simply, to maintain profit and growth potential. An answer to the second question must come from multiple considerations:

Cultural differences between defense and non-defense markets regarding performance, availability or time to market (schedule), and cost of a new product.

In the Defense market, the highest premium is mostly put on performance, where alternatives to the best performing defense equipment does not always exist.

In the non-defense market, performance and schedule can be flexible if the price is right. Thus, cost and the time-to-market of a new product become critical.

With the above observation in sight, Westinghouse has decided on three principles or necessary conditions for initiation of a new product as part of the conversion effort.

First, in any conversion project, it should use Westinghouse core technology as an ingredient. Westinghouse has been a technology- or knowledge-based business enterprise for more than 100 years. This condition gives Westinghouse very good control of cost, performance, and schedule of new products being developed.

Second, the market for the new product should be a sufficiently large one that permits new entry. This conservative approach is expected to enhance the probability of success for any conversion project.

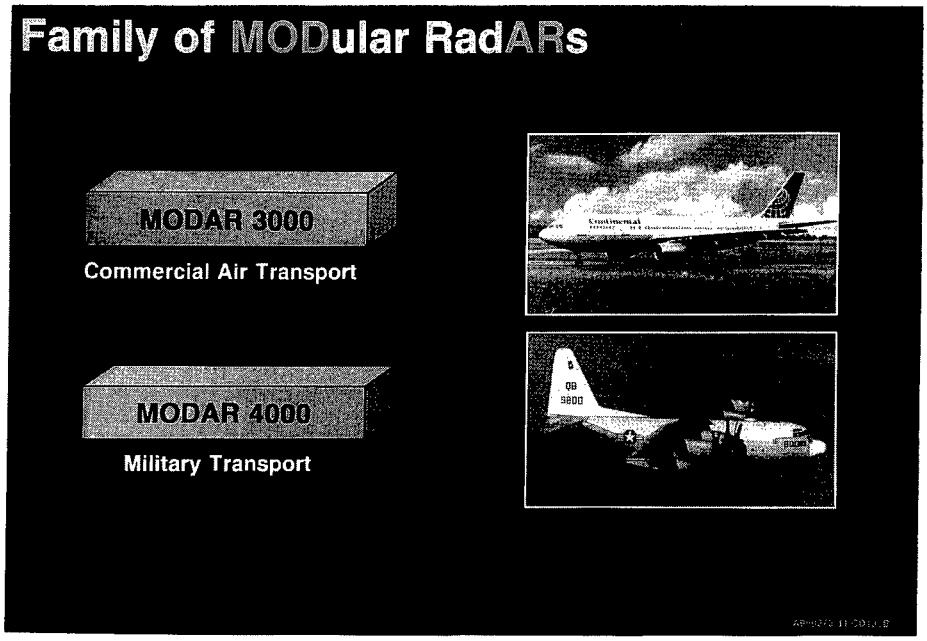
Third, Westinghouse should have a market insider as a strategic partner in the conversion project. This condition is largely derived from its own experience of doing business around the globe.

These three criteria are subject to change in the future.

4. Defense Conversion Projects

The following are two successful examples of conversion projects at Westinghouse:

1. All Weather Radar for Commercial Aircraft (MR3000 or APN-241 Windshear detection radar)



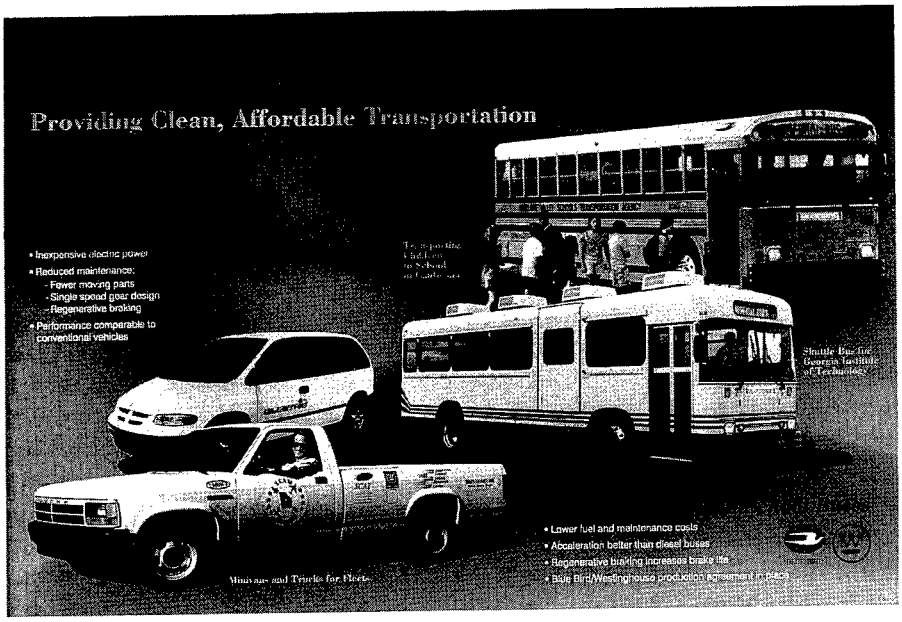
The MR3000 is designed for commercial aviation to detect dangerous windshear events and provide air crews up to 90 seconds of warning prior to encountering the hazard. The system was installed on a Continental Airlines A300, logging over 2,000 flight hours in demonstrating the feasibility of using a forward looking airborne radar to detect windshear. In 1992, Westinghouse adapted MR3000 to produce a navigation/weather radar for C-130 airlift aircraft. Certification of the algorithm for windshear detection is underway and is expected this year. The three necessary elements for the initiation of this project were met.

Westinghouse core technologies were: Pulse Doppler radar expertise, airborne high-speed processor manufacturing capability, strong weather processing, and display experience for military aircraft operational applications.

Market need for airborne radars capable of detecting windshear presence sufficiently early for commercial pilots to execute evasive maneuvers was determined.

A strategic partner, Honeywell, one of the incumbent suppliers of the commercial weather detection radar equipment, was available and chosen for the MODAR (modular radar) development effort. A total integrated product development team approach was used for this project. In addition, an integrated product development team was collected for this effort.

2. Electric Power Train for the Electric Vehicles



The three necessary conditions for initiation were checked.

Westinghouse core technologies used were high power control electronics, electric motor design experience, and patents in variable speed constant frequency generator technology.

The California (plus 5 other U.S. States) Air Quality Board stipulates a requirement for automobiles to have zero sulfuric particulate and carbon dioxide emission beginning in 1998. An electric power train of various power ratings becomes a possible choice for zero-emission automobiles.

Chrysler Automobile Corporation and Blue Bird Bus Co. are the insiders of the automobile industry to the Westinghouse conversion effort.

A brief Chronology of Westinghouse Electric Power Train Development:

1-6-91	Initiation of power train development with Chrysler
3-1-92	System bench test
3-2-92	First vehicle test (mini-van)
25-8-92	Awarded DOT grant for EV commercialization

15-12-93	Blue Bird Bus conversion from IC to electric
12-2-94	Tokyo R&D Inc. for city utility vehicles
14-6-95	Electric power trains for 2 demo buses in China
1966	One prototype for Dihatsu van in Japan

Competition: Siemens, Hughes, AC Delco, Allison, G.E.

Other Projects Attempted with Mixed Degrees of Success:

MSSA
Police C&C vehicle

5. Challenges and Lessons Learned

(a) The new product line needs to have a ready market.
(b) Identifying a seasoned management team that is skilled in innovative use of facilities and technical people on hand.
(c) Attracting (selling to) in-house or bank investors to fund the start-up activity.
(d) A conversion project is almost equivalent to creating a new profitable business in a relatively short period of time, with donated resources and assets (vis-à-vis planned and designed). Do not assign the task to those who have never had experience in starting a new business or never succeeded in any business.
(e) The result of a conversion, or the new product derived from the conversion effort, must be directed toward serving the need or requirement of a global market (vis-à-vis a local or regional convenience).
(f) Similar to managing a new global business, a certain amount of patience, hard-work and scavenging must be part of the management mentality in order to succeed. Defense conversion is not a hunting ground for the "get-rich-quick" artists.

U.S. DOD TECHNOLOGY TRANSFER POLICY AND MECHANISMS

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The Cold War has ended and the U.S. Department of Defense (DoD) has responded with massive reductions in manpower and expenditures for procurement. These reductions not withstanding, however, the world remains a highly uncertain place, with potential threats to U.S. interests from regional or ethnic conflicts, proliferation of weapons of mass destruction and possible failure of political reform in newly democratic states. DoD strategy is evolving to counter these threats and one element of that strategy is an $8B Science and Technology (S&T) program aimed at ensuring technological superiority for future warfighting needs. In light of reduced procurement budgets, it is clear that the DoD can no longer afford to maintain a separate defense industrial base and, hence, a major thrust of the DoD S&T program is to develop dual-use technology and promote DoD/industrial interactions for technology transfer.

In its earliest manifestation, DoD technology transfer was viewed as unlocking the huge investment in Defense technology for the advancement of U.S. global competitiveness. It is apparent now, however, that DoD must pursue dual-use technology development/tech transfer in its own self interest, in order to gain access to commercial technology to assure the future affordability of DoD systems. The DoD needs to promote the development of defense and commercial technology along parallel paths, so that technology upgrades driven by dynamic commercial markets will be compatible with defense systems. This paper will discuss the policy issues and mechanisms which presently drive this vision of DoD technology transfer and dual-use technology development. It will do so in the context of the overall S&T investment of the DoD.

1. Introduction

The adversary of the Western world for half a century is in disarray. At least at this instant in time, the threat of global confrontation has disappeared. It's time to declare victory in the Cold War and move on to other things ... or so it would seem. The world, indeed, has changed and the Department of Defense (DoD) has responded to those changes

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in a thoughtful, measured way. Force structure is down; equipment and bases are being retired; and procurement of new platforms has been stretched into the future. In 1996, the defense budget will be down by about $142B (in '96 dollars) from its peak in 1985. (Figure 1) [1]. And yet, the world is still a very uncertain place. Potential threats to U.S. national interests, from the spread of weapons of mass destruction, dangerous regional or ethnic conflicts or failure of newly democratic states, still remain.

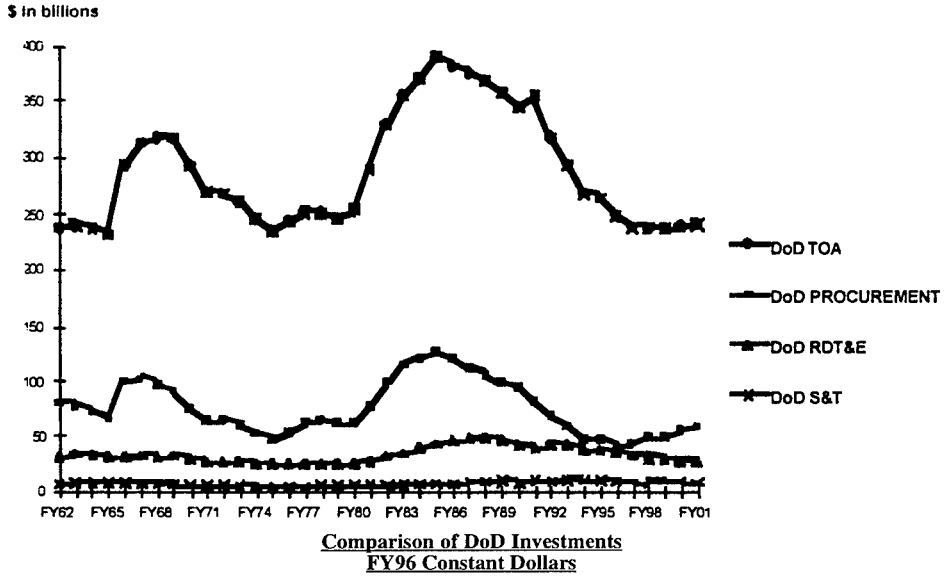


Figure 1. DoD investments the curves from the top of the chart, are for Total Obligation Authority (TOA total funds DoD can spend): Procurement (portion of TOA spent to purchase equipment); Research, Development, Test and Evaluation (portion of TOA typically referred to as the DoD Research and Development investment); and, Science and Technology (the "real" DoD R&D. as R&D would he defined by other Federal Agencies and industry).

In this milieu, fierce competition reigns for expenditure of every DoD dollar. Requirements to maintain readiness, to invest in hardware, to pay for troop deployments to the World's troublespots and to invest to maintain the defense science and technology base all vie for scarce resources. For those in DoD charged with the health of the tech base these are very challenging times.

The foundation of U.S. national security policy has been technological superiority. The technology so vividly displayed in Desert Storm was developed as part of a sustained investment strategy. The U.S. was ready when a crisis arose and defeated an enemy with remarkably low losses to our own people. There were no technological surprises. The ability to anticipate such surprises and maintain technological superiority depends on constant vigilance and dogged determination to pursue new inventions in technology where they lead.

The world today is becoming one giant computer network capable of rapidly diffusing technology from anywhere on the globe to potential adversaries. Thus, the difficulty of maintaining technology lead time is increasing relentlessly. To respond to this challenge in the face of limited resources, it is clear that the DoD must leverage the vast research and development (R&D) resources of the U.S. industrial base (Figure 2) [2], especially the commercial industrial base, through dual-use technology development and technology transfer [3]. Past DoD investments in advanced technology sometimes had a profound impact on commercial markets and resulted in feedback of commercial products for defense applications, but the DoD involvement was largely passive. In the present environment, the DoD must be proactive.

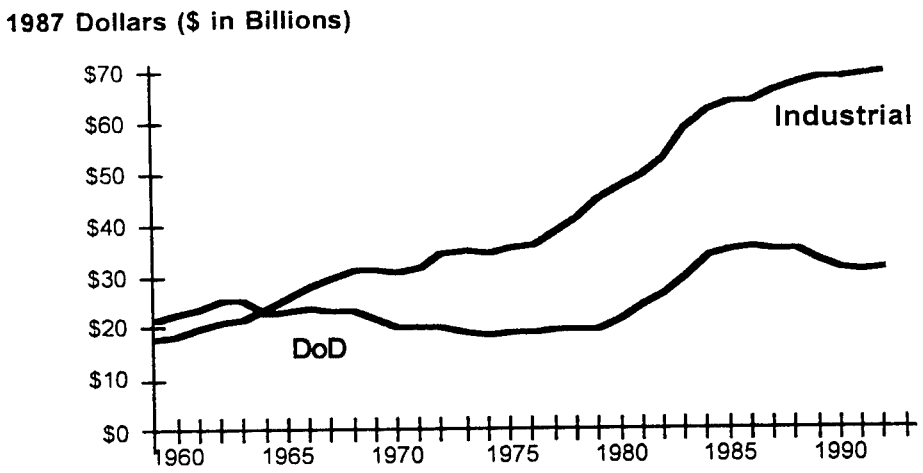


Figure 2. Trends in DoD and Industrial R&D Expenditures. Industrial R&D expenditures have exceeded those for DoD since 1966. Note that the DoD total includes funds for test and evaluation of hardware, which would not be classified as "R&D" by industry.

In some quarters, dual-use technology development and technology transfer have come to be synonymous with "defense conversion", as in "the creation of commercial products using dollars appropriated for defense needs". In this paper, to the contrary, we view dual-use technology development and technology transfer as "two-way" exchanges. The DoD needs access to commercial markets to be able to transfer in or "spin-on" commercial technologies for defense applications. Transfer out or "spin-off" can contribute to the national economy, but it can also lead to development of defense and commercial technology along parallel paths, so that technology advances driven by dynamic commercial markets can he fed back for defense applications; and products based on that technology will be available to the DoD at low cost from high volume commercial markets.

2. DOD Dual-Use Technology Strategy

The Department published its dual-use technology strategy in February 19954. The three "pillars" of the strategy are:

- Investment in Research and Development on dual-use technologies and encouragement of the adoption and improvement of these technologies by industry, so that defense ultimately has a richer base of technology on which to draw.
- Integration of military into commercial production to lower DoD costs by permitting the sharing of fixed infrastructure costs and by taking advantage of cost conscious, market driven commercial practices.
- Insertion of commercial materials, products, components, processes, practices and technologies into military systems wherever possible.

For the purposes of this paper, the focus will be on the first pillar, which is related most directly to Defense Science and Technology (S&T).

The DoD S&T investment in fiscal year 1995 (FY '95) will be ~$8.2B. This total comprises the so called 6.1, 6.2 and 6.3 budget activities, corresponding, respectively, to Basic Research, Exploratory Development and Advanced Development [5]. The breakout for these activities is: 6.1 - $1.2B,6.2 - $3.0B and 6.3 - $4.0B. The DoD dual-use technology strategy document indicates investment of $2.06B in dual-use 6.2 and 6.3 S&T projects in FY '95 (Table 1), mostly through the "core" projects of the Advanced Research Projects Agency (ARPA). These projects are those for which explicit attention is given to commercial as well as military application of the technology. The report (and Table 1) does not include about $500M of other 6.2/6.3 dual-use projects at the Services and other Defense Agencies, so the total dual-use S&T investment of the DoD is about $2.5B or about 30% of the total S&T investment. As indicated, the dual-use numbers do not include the $1.2B of basic research, which by its nature has generic dual-use potential, but does not target specific defense or commercial applications. As noted below, however, it should be recognized that the support of basic research plays an important role in technology transfer.

Dual-use development and technology transfer occur through a number of complimentary mechanisms, ranging from interactions with universities and industry through the core basic and applied research programs of the Services and Defense agencies, to the Technology Reinvestment Project (TRP), the Small Business Innovation Research Program, Cooperative Research and Development Agreements and the Federal Defense Laboratory Diversification Program. We will consider each of these activities briefly below.

TABLE 1. Dual-use S&T Investments (6.2, 6.3)
FY '95 & '96 ($M)*

	FY '95	FY '96 (Req.)
ARPA Core Projects	**$1384.8**	**$1288.4**
Information Technology	391.5	409.9
Materials Technology	295.2	214.4
Electronics Technology	563.4	535.4
Advanced Simulation and Modeling	82.7	79.0
Other ARPA	52.0	49.7
Other Legislated Initiatives		
Technology Reinvestment Project (TRP)	**443.2**	**500.0**
Small Business Innovative Research (SBIR)	**161.0**	**161.0◊**
Other RDT&E	**73.7**	**16.1**
TOTAL	**$2062.7**	**$1965.5**

*FY '95 Appropriation as of February 1995; FY '96 President's Budget Request.
◊ These funds are a subset of the total SBIR budget (see below). By about FY '98, this figure should equal the total SBIR budget.

3. Basic Research and Technology Transfer: The Role of Universities

Driven by the shock of Sputnik, the DoD moved aggressively to enlist the nation's universities to provide the research base for technologies of interest to U.S. national security. This was not always an easy sell. as many academics viewed defense money as somehow tainted and/or were reluctant to accept any direction which would "compromise" their pursuit of pure science. In time, accommodations were reached and, as we fast forward nearly 40 years, universities now execute about 60% of the DoD's $1.2B fundamental research investment.

Technologically dynamic areas are the domain of DoD funding. DoD provided 75% of all U.S. federally funded research in electrical engineering in FY '94 and 59% of federal funding for university electrical engineering research; the comparable numbers for metallurgy and materials are 62% and 62%; and for mechanical engineering,59% and 46%. The DoD provides 56% of federal computer science research funds and 52% of federal university research funds in math and computer sciences. Overall, DoD provided 42% of all federal engineering sciences university research funding in FY 4946. These funds are provided in the DoD's own self interest, as these are fields offering great opportunity for future military capability. This funding is critical to the technological infrastructure of the nation as well. It creates a pool of talented technologists suitable for the high paying jobs that are the backbone of a strong economy; in 1992. DoD funding supported about 9000 science and engineering graduate students [7]. These technologists feed into both the defense industry and commercial industry and, especially in the latter case, provide a highly effective means to transfer fundamental technology developed for its relevance to future defense applications to commercial uses, allowing the nation to maximize the return on its Federal R&D investment.

As in all relationships, real and imaginary, stresses wax and wane over time. Fundamentally, the DoD is the customer of university personnel conducting DoD funded work. There are some who believe that the universities need to be reminded that successful relationships are customer driven. Others appear to believe that many universities have never accommodated to the need to do defense relevant research on defense dollars. These views lead to recent suggestions that DoD sponsorship of university research should be scaled back. In fact, however, the DoD is well served by the nation's universities; the research which is supported is done so because of its relevance to defense needs and the real losers in curtailing DoD funding would be the DoD and the nation.

4. Core Exploratory/Advanced Development Programs

The number one priority of the DoD S&T investment strategy has been., is, and will be to provide U.S. armed forces with the best technology in the world. The success of this strategy depends on establishing relationships with industry of sufficient continuity that critical technologies can be nurtured to maturation. This approach has been remarkably effective in the past; defense R&D and early procurement of prototype hardware have stimulated some of the most significant technological innovations of the twentieth century, e.g., in the computer, semiconductor and aerospace industries. In the present environment, with declining procurement budgets, a shrinking defense industrial base and reduced Independent Research and Development (R&D) spending, DoD will be increasingly reliant on the use of commercial components and technologies, whose development will be stimulated, in many cases, by the 6.2 and 6.3 dual-use programs alluded to above.

There will, of course, be few, if any, platforms or systems developed which will find both military and commercial uses, but there are countless subsystems, components, discrete devices, etc., which can find application in both arenas. A few key dual-use initiatives presently being pursued in DoD, indicative of the opportunities and challenges of dual-use technology development, are highlighted below:

4.1 ELECTRONICS MANUFACTURING

Electronics now represent over 40 percent of the procurement costs of many defense systems. The current design of the F-16 includes 17,000 electronic components. Superior electronics, as determined by such measures as performance, weight, size, reliability, interoperability, maintainability and cost, are critical to the effectiveness of standardized military systems. In developing electronic components, DoD has benefitted and will continue to benefit, from leveraging the robust domestic commercial base for electronics components and systems. ARPA will invest over $500M in electronics technology in FY '95.

4.2 FLAT PANEL DISPLAYS

Flat panels are millimeters thick, very light, rugged and portable and represent the next generation of display technology, needed for the battlefield of the future. To ensure the realization of economies of scale, while remaining abreast of technological advances, the DoD has adopted a dual-use technology and acquisition strategy to allow it to work closely with leading edge companies that also compete in commercial markets. Defense demand will be only a minor factor in the flat panel market and technology will be driven by commercial demands. The department plans to spend a total of about $580 million on precompetitive development of technology over the next five years. with industry providing a like amount.

4.3 MICROELECTROMECHANICAL SYSTEMS (MEMS)

MEMS technology merges information processing and communication with sensing and actuation; it builds on the existing national capability in microelectronics design and production. Broad defense and commercial applications include, for example, on-chip inertial measurement devices; embedded MEMS condition-based maintenance sensors; fluid metering and regulation devices for analytical instruments, rockets, etc.; and precision subsystems for mass data storage and optomechanical systems, such as aligners, switches, scanners and displays. DoD investments of about $30M in FY 95 are aimed at realizing advanced MEMS devices and processes, developing and fielding MEMS systems and catalyzing a MEMS technology infrastructure.

4.4 INTEGRATED HIGH PERFORMANCE TURBINE ENGINE TECHNOLOGY (IHPTET)

The IHPTET program aims at doubling propulsion system capability for all DoD aircraft and cruise-missiles at the turn of the century. Achieving these goals would provide a 100% increase in range or a 50% increase in payload capability for a typical fighter with no increase in size or weight, or alternatively, would enable the same capability to be obtained with a 35% reduction in gross weight (and air vehicle cost). Qualitatively analogous tradeoffs would apply to commercial aircraft performance. DoD funding for IHPTET is approximately $135 million in 1995. Seven engine manufacturers are participating in IHPTET on a cost sharing basis.

4.5 ROTORCRAFT TECHNOLOGY

As military demand for rotorcraft declines, commercial sales become increasingly important for sustaining a robust and dynamic technology base. DoD will bolster the industrial base for rotorcraft by establishing the National Rotorcraft Technology Center, which will facilitate development and implementation of a dual-use technology plan to address both civil and military rotorcraft needs. Project costs of $10-12 million per year

will be matched by industry. This investment will leverage the approximately $100 million per year of ongoing Army, Navy, National Aeronautical and Space Administration and Federal Aviation Administration rotorcraft science and technology programs.

4.6 ADVANCED COMPOSITES FOR AIRCRAFT

Manufacturing technology leadership in the use of advanced materials/structures is vital to the U.S. military and commercial aircraft industries. Superior materials open up new engineering possibilities for the designer by offering the opportunity for more compact designs, greater weight efficiency, reduced operating cost and longer service life. In the case of composites, DoD will focus on development of design methodologies, affordable manufacturing processes and insertion programs to demonstrate improved performance and/or reduced cost of advanced composite structures. Funding for these efforts for FY 95-96 will be about $ 147M.

5. Technology Reinvestment Project (TRP)

TRP was authorized by the National Defense Authorization Act of FY '93, passed just prior to the Presidential election of November 1992'. In early 1993, the incoming Clinton administration adopted TRP as the flag ship dual-use, defense reinvestment program of the Department of Defense and the program enjoyed strong support in the 103rd Congress. About $812M was obligated against FY '93 and '94 solicitations for cost shared projects in technology development, technology deployment and manufacturing, education and training; the cost share offered was approximately $1B.

As is evident from comments in the Senate Committee on Appropriations Report'° for the FY '95 Department of Defense Appropriations Bill, there was some concern that TRP projects were not well focused on defense needs, a position with which the Office of the Secretary of Defense strongly disagrees. With the installation of the 104th Congress in January 1995, TRP came under increased scrutiny on the same grounds, as part of the consideration of supplemental appropriations and recessions to the funding for DoD. The outcome of this exercise on April 10, 1995. was a sharply reduced appropriation of $220M for FY 95 vs. 5550M appropriated late in September 1994. TRP will go forward in FY 95 with just the technology development component. For FY 96, the President's Budget requests $5500 M for TRP. but it is unclear how this request will be received by Congress.

6. Small Business Innovation Research (SBIR)

In passing the Small Business Innovation Development Act of 1982 [11]. Congress found that while small business is the principal source of significant innovations in the

Nation, the vast majority of federally funded research and development is conducted by large businesses, universities and Government laboratories; and small businesses are among the most cost-effective performers of research and development and are particularly capable of developing research and development results into new products. Thus, the SBIR program was initiated in FY 83 to stimulate technological innovation, to use small business to meet Federal research and development needs, to foster and encourage participation by minority and disadvantaged persons in technological innovation and to increase private sector commercialization innovations derived from Federal research and development. On October 28, 1992, the SBIR program was reauthorized and expanded by Public Law 102-56, in part to emphasize the program's goal of increasing private sector commercialization of technology developed through Federal research and development.

To qualify as a small business for the SBIR program, a firm must have 500 or less employees. As is evident from Figure 3 [12], however, about 65% of firms which make proposals for SBIR awards have 20 or less employees. Thus, the program clearly encourages the development of new technology-based enterprises.

SBIR is funded through an assessment against all DoD extramural Research, Development, Test and Evaluation funds (RDT&E funds expended outside the DoD) [5,13]. Hence, SBIR funds are not separately appropriated and the program is shielded to some degree from the vicissitudes of Congressional support. In 1992, the assessment was 1.25%; with the reauthorization of SBIR in 1992, the assessment was doubled over a phase-in period of five years. In FY 94 the assessment was 1.5% and the SBIR funds amounted to $330M [14]; in FY 95 the assessment is 2.0% and the SBIR budget is $445M; in FY 97 the assessment will be 2.5% and the program will exceed $500M.

Execution of the SBIR program occurs in three phases. Phase I is an exploratory phase and allows funding of up to $100K over 6 months. Successful phase I projects move to phase II, which allows $750K funding over 2 years [15]. Phase III is the commercialization phase, which can employ private funds or Federal funds, but not SBIR funds. From the inception of the program in FY '83, through FY '94, the DoD received 91,193 Phase I proposals and made 11,707 awards. Of these awards, 3,836 received Phase II awards.

To support the program, and particularly the commercialization goal, the DoD and the National Science Foundation jointly sponsor regional and national SBIR meetings, to introduce potential new participants to the program, and "Phase II" meetings, to provide a forum for Phase II winners to display their technologies and meet with potential commercialization partners/investors. Dual-use technology development and commercialization were explicitly linked together beginning with the FY '94 DoD SBIR program; all topics proposed by the Services and Defense agencies are now required to explicitly discuss "dual-use commercialization potential". Those which fail to do so are excluded from the solicitation.

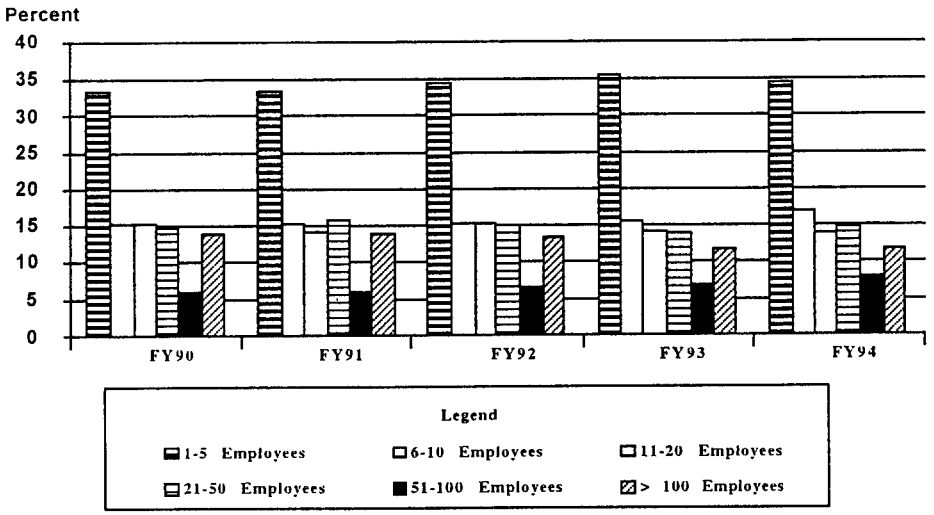


Figure 3. Proposing firm size for the DoD SBIR Program for fiscal years 1990 to 1994. Each FY set of bars from left to right is for larger firm size. i.e.. left bar: 1-5 employees: right bar > 100 employees.

In an attempt to track the program's goals of fostering commercialization, the U.S. General Accounting Office examined phase III activity through July 1991, for projects which won phase II awards from aU participating Federal agencies from 1984 to 1987." Of 2090 projects queried,1457 responded, reporting sales of $471M and additional developmental funding of $646M. On a per project basis, these amount to $323K and $443K, respectively, vs. an initial SBIR investment of about $550K. It will be instructive to revisit these projects at some later date, when they could reasonably be considered to have reached commercial maturity, to determine, in so far as possible, the return on the SBIR investment.

The authorization to carry out the SBIR program will terminate on October 1, 2000. Not withstanding the findings of Congress that small businesses play an important role in innovation and commercialization in the U.S., there are no apparent a-priori bases for establishing the optimum set aside for SBIR from Federal agency budgets. An interesting and important reauthorization issue will be whether SBIR is presently at its optimum size.

7. Cooperative Research and Development Agreements (CRADAs)

The Stevenson-Wydler Technology Innovation Act of 1980 (P.L.96-480) [17] established the transfer of Federal technology as a national priority. Congress found that; "No comprehensive national policy exists to enhance technological innovation for commercial

and public purposes. There is a need for such a policy, including a strong national policy supporting domestic technology transfer and utilization of the science and technology resources of the Federal Government" Stevenson-Wydler required that each Federal laboratory with more than 200 scientists and engineers have an Office of Research and Technology Applications to act as an interface with State and local governments and the private sector for technology transfer, however, it provided no effective mechanism to achieve technology transfer. The Federal Technology Transfer Act of 1986 (P.L.99-502) amended Stevenson-Wydler to correct this deficiency, by authorizing government operated laboratories to enter into CRADAs with non-Federal parties.

A CRADA is defined as any agreement between one or more Federal laboratories and one or more non-Federal parties under which the government, through its laboratories, provides personnel, services, facilities, equipment intellectual property or other resources with or without reimbursement (but not funds to non-Federal parties), and non-Federal parties provide the same, toward the conduct of specified research and development efforts which are consistent with the missions of the laboratory. A CRADA is not a procurement contract and, thus, the Federal Acquisition Regulations (FARs), supplements to the FARs and the Competition in Contracting Act (P.L.98-368) do not apply. Hence, a non-Federal party interested in initiating a CRADA with a government laboratory is not subject to competition requirements.

Under Stevenson-Wydler (as amended) each Federal agency may permit the directors of its laboratories to enter into CRADAs and negotiate licensing agreements for inventions or other intellectual property owned by the Government. With respect to inventions made under a CRADA, the government may grant to a collaborating party patent licenses or assignments to inventions made in whole or part by a government employee and may waive rights to inventions made by an employee of the collaborating party, both subject to retention by the Government of a non exclusive license to practice the invention or have the invention practiced on its behalf. Labs may also permit employees or former employees of the lab to participate in efforts to commercialize inventions they made while in the service of the United States. With respect to lab royalty income, the lab inventor receives at least 15%, up to a maximum of $100,000 per person per year.

Early attempts to enter into CRADAs were treated with caution by the DoD and other Federal agencies because they represented a radically different nonprocurement instrument for cooperative government - private sector interaction. Agreements were subject to careful headquarters review. The delegation of authority permitted by Stevenson-Wydler is now largely in place and CRADAs are frequently approved at the laboratory Director level. This has contributed to a rapid increase in the number of active agreements; as of April 1995, the DoD has about 835 active CRADAs, as compared to about 240 in October 1992 and only a few prior to 1990. For FY '94, it is estimated by the Army, Navy and Air Force that their laboratories contributed ~ $124M towards R&D work: conducted under CRADAs. The GAO has also conducted a limited review of CRADAs and concluded that they are an effective mechanism for technology transfer [20].

CRADAs offer the best mechanism for researcher to researcher interactions between Federal laboratories and nonFederal parties. While the focus of the law is to transfer Federal technology, it is clear that such interactions expose Federal scientists and engineers to leading edge technology in the private sector, allowing for the "spin-on" of information to the government as well as "spin-off" to the private sector.

8. Federal Defense Laboratory Diversification Program (FDLDP)

The National Defense Authorization Act of FY 1993 required the Secretary of Defense to establish a Federal Defense Laboratory Diversification Program to encourage greater cooperation in research and production activities carried out by defense laboratories and industry [21]. The defense laboratories, in coordination with the Office of Technology Transition (OTT), were directed to carry out cooperative activities with industry to promote transfer of defense or dual-use technologies from defense laboratories to industry. The OTT was created by the same Act [22] and is charged to monitor R&D activities of the Department of Defense, identify R&D activities that result in technological advances that have potential for non-defense commercial applications, serve as a clearinghouse for and coordinate and actively facilitate the transfer of such technological advances to the private sector.

The President's FY '95 Budget Request included $61.6M to initiate the FDLDP. These funds were intended to provide for an enhanced and more flexible response of the defense laboratories to tech transfer opportunities. For the defense labs, FDLDP provides an alterative to TRP. The criteria for TRP stipulate at least 50% cost sharing for participants in a project and disallow the use of other federal funds for the cost share; hence, defense labs can not use their own funds to cost share for TRP funds and are, effectively unable to participate as developers of technology in TRP projects. (The labs do frequently act as contract managers for TRP projects). Thus, the labs eagerly anticipated initiation of the FDLDP. However, the final FY '95 appropriation for FDLDP was only $7.5M. This will permit the program to start, but will allow relatively few of the defense labs to participate [24].

The labs compete for funding from FDLDP at two levels. They brought forward their best technology transfer opportunities as potential topics for a Broad Agency Announcement (BAA). Due to the limited funds, only 19 were selected. A BAA containing these topics was issued on April 12,1995, with proposals due 45 days from that date. Lab-industry partnerships will prepare one proposal for each of the 19 topics and about 10 of these will be funded at up to $1M each. In order to foster an integrated development team environment, 80% of the award will go to the contractor team (and requires 50% cost sharing) and 20% will go to the laboratory scientists/engineers activity engaged in technical aspects of the project. A successful output of an FDLDP project will be a brass board/prototype which will bring a technology to the threshold of commercialization (spin-off) or system integration (spin-on). In the continuum between research, development and engineering, FDLDP projects are intended to involve more

mature technologies toward the engineering end of the spectrum, as opposed to CRADAs, which typically emphasize early stage research.

9. Conclusion

DoD dual-use technology development and technology transfer have historically occurred in an inefficient, ad hoc way as part of the development and procurement of military hardware. Explicit efforts to enhance these processes are largely a product of the 1980's and 90's and it's clear that the R&D activities noted above, related to electronics, materials, jet engines, and rotocraft, and others such as communications and computer based learning, offer excellent opportunities for the DoD to develop and transfer dual-use technology to and from the private sector in a proactive way.

The passage of the Stevenson-Wydler Act of 1980 and the SBIR legislation of 1982 were both indicative of a desire to provide private sector access to the huge investment made by the nation in technology development, in the interest of increasing global competitiveness of U.S. industry. An element of this thinking was also present in the creation of the Technology Reinvestment Project in 1992/93. Enhancing international competitiveness is clearly a worthwhile goal, but the present fiscal environment dictates that the DoD must look to its own needs first and consider technology transfer as a two-way process, allowing access to commercial technology as well as spinoff of defense technology. Moreover, cooperative development of dual-use technology must be considered a critical element in the goal of DoD to achieve affordability of future weapons systems. The authorities and programs which have evolved to offer a variety of mechanisms for dual-use technology development/technology transfer all contribute to the overall DoD goal of fostering the creation of an integrated defense and commercial industrial base, better able to respond to DoD needs at lower cost.

Dual-use technology development,. at least in so far as the Technology Reinvestment Project is concerned, has become a politically sensitive issue. This seems somewhat ironic, given that TRP projects require 50% (or more) cost share. This would appear to ensure that, at worst, the DoD pays only for the defense related aspects of a project; and, at best, defense technology would be developed at a 50% discount. The TRP may also be held hostage to the notion that the government should not "pick winners and losers" as a surrogate for the commercial marketplace, although this would appear to be a non issue when the ultimate purpose of the project is to satisfy a defense need. It will be interesting to see how TRP and other dual-use/tech transfer activities fare in Congressional FY '96 budget deliberations.

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Research, Development, Test and Evaluation from Office of the Comptroller, National Defense Budget Estimates for FY '95, March 1994, pgs 83-85.

3. For the purposes of this paper, we sometimes use dual-use technology development and technology transfer interchangeably; they are closely related, though not quite synonymous. Technology transfer usually refer to the exchange of information, e g, from government to industry, after the technology has been developed in a government lab. Dual-use technology development refers to the simultaneous development of aspects of a technology which can be used for defense and commercial applications. If this development is done jointly by a government-industry team, technology transfer can occur contemporaneously.
4. "Dual-use Technology: A Defense Strategy for Affordable, Leading Edge Technology," Office of the Under Secretary of Defense for Acquisition and Technology, Department of Defense, Washington. DC. February ,1995.
5. Budget activities 6 1 to 6 3 re a subset of the total Research, Development, Test and Evaluation (RDT&E) account; this account also includes 6.4 - Demonstration and Validation, 6.5 - Engineering and Manufacturing Development, 6.6 - Management Support and 6.7 - Operational Systems Development RDT&E will be -S34.6B in FY '95. The fiscal year extends from October 1 to September 30.
6. National Science Foundation, Federal Funds for Research and Development:Fiscal Years 1992, 1993 and 1994, v42, NSF 94-328, (Arlington, VA, 1993)
7. National Science Foundation. Selected Data on Graduate Students and Postdoctorates in Science and Engineering Fall 1992, NSF 94-301, Pg. 18. (Arlington, VA 1994)
8. IR&D refers to contractor cost for bases research, applied research development, and systems and other concept formulation studies, which may be included in General and Administrative expenses allocated against government contracts. Federal Acquisition Regulation 31.205-18.
9. Public Law 102-484, October 23. 1992; Title 10. United States Code. Section 2491 et. Seq.
10. Report 103-321, July 29, 1994, p 233, U.S. Senate Committee on Appropriation.
11. Public Law 97-219, July 22, 1982; Title 15, United States Code, Sections 631 and 638.
12. Department of Defense data.
13. Any Federal Agancy which has an extramural research or research and development budget in excess of $100M must participate in SBIR. For the DoD, this include the Army, Navy, Air Force, ARPA, Ballistic Missile Defense Organization, Defense Nuclear Agency and Special Operations Command.
14. The SBIR base" was expanded in FY 93 to also include the previously excluded 6.7 RDT&E activity; total 6.7 funding will be - $10B in FY '95.
15. Prior to reauthorization in 1992. phase I allowed $5OK and phase II allowed $500K.
16. GAO/RCED-92-37, U.S. Gener l Accounting Office, P O Box 6015, Gaithersburg, MD 20884-6015
17. Title 15, United Statcs Code, Section 3701 et seq.
18. Title 15, United States Code, Section 3710a.
19. Title 15, United States Code, Section 3710c.
20. GAO/RCED-95-52, U S GAO, P O Box 6015, Gaithersburg, MD 20884-6015
21. Public Law 102-484, October 23, 19.°2; Title 10, United States Code. Section 2514
22. ibid; Title 10, United States Code, Section 2515.
23. This proved particularly contentious, since Service K&D budgets were under continual pressure to transfer funds to increase the funding for TRP. For example they were tasked to transfer $140M in FY '94, although the transfer did not actually occur.
24. If one counts multiple sites, e.g., the Air Force Armstrong Lab has four sites, there are 81 defense laboratory and warfare center sites which are classified as "laboratories".

APPENDIX A: POSTER PAPERS

THE PROSPECTS FOR THE INTERNATIONAL COOPERATION IN CONVERSION

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A group of CIS participants of the NATO ASI on Defense Conversion Strategies would like to suggest the following proposals, based on the reports presented during the ASI, as well as on informal discussions with participants.

1. The subject of the current NATO ASI is very important. Now that there is already an experience, both positive and negative, in conversion, reviewing this experience is timely.

2. The approaches to the conversion process have already been formulated in some countries (the United States, Germany, France, and the United Kingdom). There is an understanding that the conversion is an inherent part of the scientific and industrial policy, and that the conversion problems are closely connected with the problems of national security, social problems, and development of dual-use technologies. Some of the countries have already developed or suggested practical mechanisms of conversion.

It's important that the results of this NATO ASI are promptly summarized as policy recommendations and made available to the all interested government bodies of the NATO, Eastern European, and former Soviet Union countries.

3. The conversion process in Russia and other former Soviet Union republics in practice led to a very difficult situation in military industrial complexes of those countries. One of the main reasons for that was the background against which the conversion has been taking place: large-scale changes in these countries, including democratic reform, transition to a market-oriented economy; significant decreases in real incomes of the population; and political instability. Under this circumstances the government, itself unstable, has been unable to come up with a consistent conversion program. Without support from the government, the conversion process proceeds in a somewhat disorganized manner.

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Since the people who work in the military industry account for about 40% of the CIS population, solution to the most acute problems of the military industry could make a significant contribution toward political and economic stability in the countries of the former Soviet Union.

Given all that, we would suggest the NATO leadership and the Western governments consider the situation in the Russian military-industrial complex and take some measures, which in our view will help to diminish political uncertainty in the former Soviet Union. Such measures may include:

a. Development of joint programs of conversion. This work must be done in cooperation with the Russian government (including the Ministry of Defense).
b. More active involvement of various institutions, such as the EBRD, OECD, Eximbank, and others, in the conversion process as major sources of investments.

4. To support these initiatives, we would suggest establishing a special international committee, similar to AGARD, that would deal with the problems of conversion. Such a committee will include representatives of the NATO countries, as well as those of Eastern Europe and the former Soviet Union. Responsibilities of such a committee would include:

a. Analysis of the situation with conversion in various countries, including development of models of the conversion process.
b. Technical support of conversion programs at national and regional levels.
c. Technical assistance to enterprises and companies involved in the conversion process.
d. Analysis of legal barriers that prevent international cooperation in the conversion area.
e. Development of recommendations aimed at improving the legal environment for the conversion process.
f. Providing support to educational programs in management in Russian universities and supervision of student exchange programs.

The major objective of these steps would be to focus the relationships among our countries to a new level, and help in solving many of Russia's social and economic problems.

CRISIS IN THE RUSSIAN MISSILE AND SPACE SECTOR

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As of the beginning of 1995 the Russian missile and space sector (MSS), which has traditionally held the key positions in the Country's geopolitics, was on the brink of deep crisis.

The modern situation in the Russian missile and space industry, the reasons for its crisis, and the quest for the possibilities of regulation of the crisis are discussed in the paper. But first, some details of MSS conversion history are addressed.

1. Introduction

As is well-known, in 1988 the missile and space industry was affected by conversion as much as any other defense industries in Russia. Three main periods of conversion are visible.

1988-1991. The industry's conversion proceeded under centralized state control. Annual military output was not cut dramatically. The need to increase the share of civilian output, retain highly skilled personnel, and improve the quality of production were declared. The corresponding budget financing was foreseen.

Mid-1991-1994. Following the disintegration of the USSR, accompanied by the drastic changes in industry financing, conversion assumed an uncontrollable character. However, some conversion programs were developed. Work was being carried out in the following fields: Conversion to transport and communication (about 19 enterprises participating); Conversion to agriculture and the consumer sector (52 enterprises); Conversion to medicine (28 enterprises); and Conversion to the fuel and energy sector and for energy conservation (12 enterprises). In 1992, nearly 72 enterprises in the industry took part in the conversion programs and produced in total more than 377 new, mainly technologically advanced, items. Moreover, as part of the missile and space industry conversion, a series of programs were being drawn up for using the strategic arms systems which were due for reduction, together with the scientific-technological work that had been done in anticipation and the missile and space sector's advanced technology, on a commercial basis, in the interests of the civilian space industry.

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But the steadly decrease in industry financing, associated with the situation when conversion and originated commercial activities did not stimulate the influx of private investments, led industry to a crisis (the main characteristics of which will be discussed below).

The end of 1994-1995. The intensive quest of the possibilities to overcome a crisis situation. And it can be argued that from this period conversion was mainly transforming to the systemic implementation of reconstructing measures.

2. Examples

A few examples will illustrate the extraordinary situation in the Russian MSS as of the beginning of 1995.

Financing. In 1994 the level of financing for space programs (in constant prices) had been reduced to 20% as compared to 1989; military-space programs were down to 10% of 1989 levels.

Production. The volume of production of missile and space techniques had been decreased by more than 70% in 1993 as compared to 1989 (Figure 1). In 1994 the situation was aggravated. The index of production in 1994 was 71% (95% in 1993).

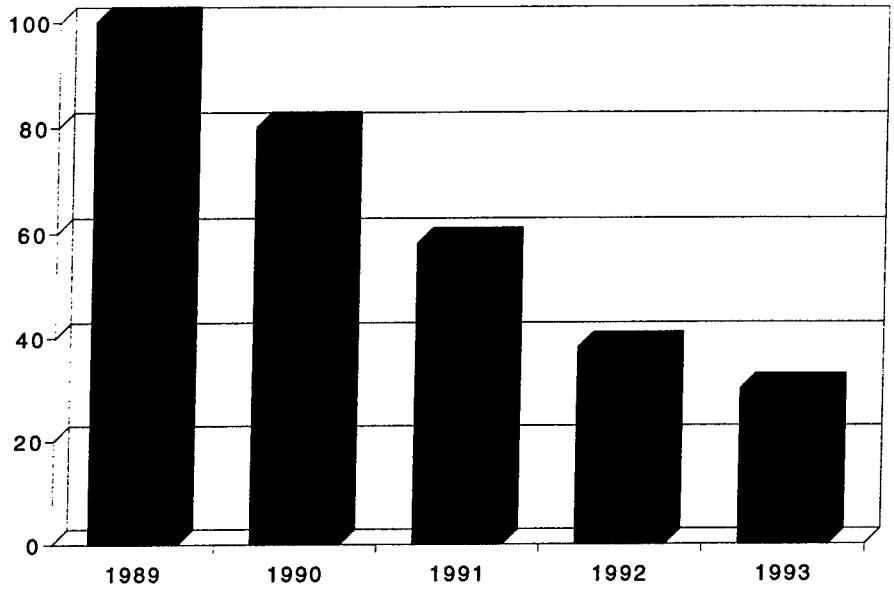


Figure 1. Volume of production, %

Employees. Significant cutbacks in production, inadequate financing in the industry, low wages (approximately 1,3 times lower than in the national economy as a whole) caused a loss of nearly 50% of its highly skilled employees (Figure 2).

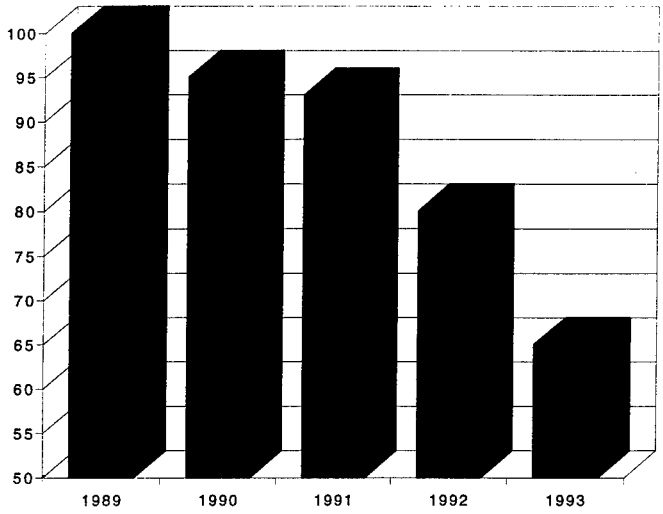


Figure 2. Number of employees, %

Infrastructure. Nearly 70% of space vehicles which are in orbits have exceeded the guarantee (Figure 3). Consequently, the restoration of orbital complexes is an urgent need. The deterioration of the state of launcher installations is also foreseen. To 1996, without extra expenditures, the possibility of Russia using heavy launches could dropped to zero (Figure 4). The re-equipment of missile and space production capabilities has practically stopped. Since 1989, the machine park of the industry has not been renewed. Nearly 40% of equipments were put into operation 20 years ago (Figure 5).

According to expert estimates, without urgent measures for overcoming the crisis situation in industry, Russian space activities could stop in 2-3 years.

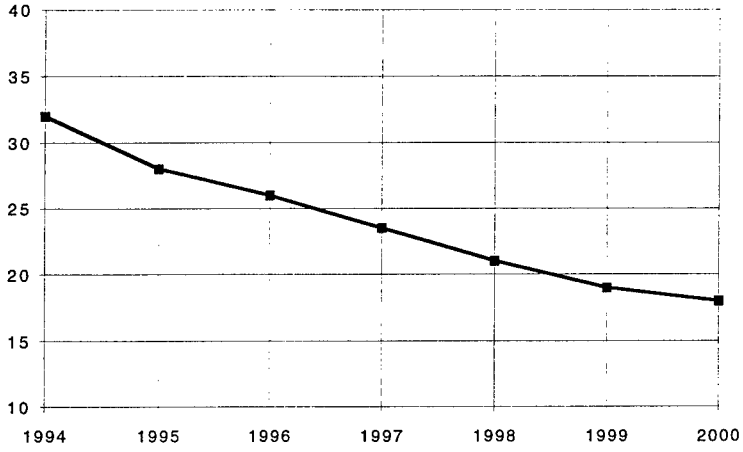


Figure 3. Share of orbital vehicles with guarantee, %

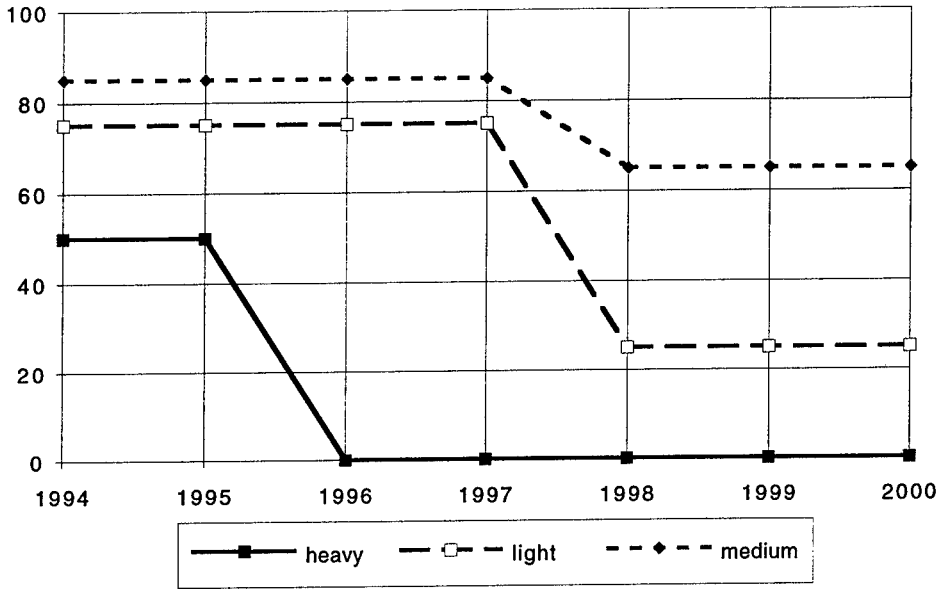


Figure 4. Share of functioned launcher installations, %

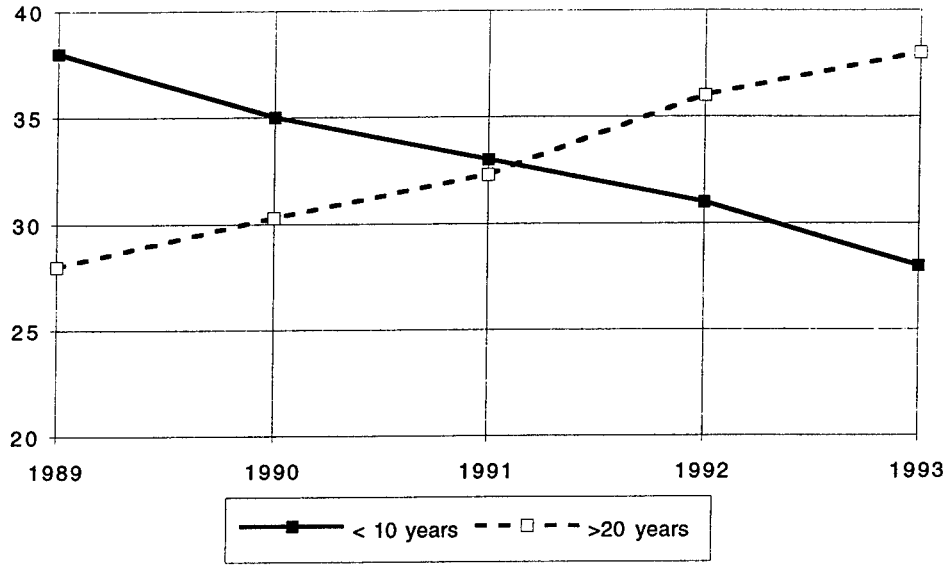


Figure 5. Share of machine tools, which are inoperation, %

3. Reasons for the Crisis and Possibilities of Overcoming

Reasons. First of all, the crisis is due to the lack of a strategy for conversion and serious study of financial, economical, organizational, and technical problems related to the reorientation of the missile and space industry potential towards fulfillment of civilian needs. To a certain degree this was due to the delayed implementation of military reforms and the delayed drawing up of a national plan for Russian defense. Second, it is due to the disintegration of economic links over the territory of the former USSR - something to which the missile and space industry, with its extensive intra and inter-branch cooperation-operation, is extremely sensitive. Third, this is due to the extremely inefficient state policy with regards to the missile and space sector as a whole and to its enterprises in particular. Further, there is the lack of clear industry priorities. Moreover, measures for structural reconstruction of the missile and space industry were not adopted in a timely manner.

Overcoming the crisis. The main directions to overcome the crisis may be defined as follows. First and foremost, ensure financing reflects selected priorities, and close cumbersome and, in most aspects, redundant productions. Of next importance should be the restoration and expansion of cooperative relations with the missile and space sectors of the CIS-member countries (and first of all with Ukraine; a Treaty is already prepared and awaits signing). Then, the development of export possibilities of MSS is of great importance. At present, some Russian experts consider export possibilities of MSS as one of its main economic potential. Finally, the formation of large and competitive companies on the basis of scientific-financial-industrial groups should be accelerated. Given the intensive quest of measures for state support of private investments on the basis of risk division, it may be expected the formation of the above-mentioned groups around a bank-investment company.

There is no doubt that great possibilities exist in the missile and space sector of Russia. Its high-technology enterprises have much to offer to Western countries. Russian missile and space technologies are in many cases the most advanced in the World, but very often at much lower cost. And it can be argued that the growth of the missile and space sector (which is considered a "locomotive" of industrial development) is independent of the type of industrial development of Russia.

At the end of the first quarter of 1995, the Leaders of the Russian MSS were able to convince the Russian government to increase the MSS budget for 1995. From the results of the first-half of 1995, the missile and space seem is one of the more growing industries. It may be considered as a first, but important, sign of the turning point of the negative tendency of the MSS development.

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FLUOROPLASTIC COATINGS OF COLD DRYING "TETRON"

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Abstract. *All flouroplastic coatings are highly resistant to the most aggressive media. But their main disadvantage is their low adsorption and adhesion abilities and the necessity of thermal treatment of polymers deposited on a material surface. The purpose of this work was to develop a "solution technology" for producing a fluoroplastic coating with high adhesion which would not require thermal treatment. We also developed a method of preliminary surface cleaning.*

1. Methods of Coating Characteristic Investigation

We investigated copolymers of vinylidene fluoride and tetrafluorethylene, chlorotrifluorethylene, hexafluoropropylene. Ethyl acetate, cyclohexanon, acetone, butylacetate and other organic solvents were used. Various compounds were used as modifiers. The diagram of the phase state was being investigated by isotherm titration. The viscosity of diluted and concentrated solutions was measured with the help of a viscosimeter. Internal stresses were determined by measuring the intensity of light passed through a glass substrate at a boundary with the coating. Adhesion strength was measured by a breaking-off method. Deformation/strength characteristics of the coating were determined at an insertion breaking-off machine.

2. Methods of Films and Coatings Production

Before applying the coating a metal surface was sandblasted. The films were manufactured of a copolymer (10%) - solvent compound by drying a solvent out at a temperature of about 20 C. While the coating was formed carbon steel plates were used as a substrate. Free films were formed on Teflon substrates.

3. Mechanical Characteristics of the Coating

The coating film is formed by evaporating a solvent which causes shrinkage and a sharp increase of viscosity. The film strength changes radically depending on the

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solvent/precipitator ratio, with the maximum strength corresponding to an optimal level of rheological parameters. Minimal inner stresses could be reached in the metastable region.

4. Investigation of Adhesion of a Tetron-Modifier-Metal System

As the inner stresses of the films decrease and their strength grows, strength and durability of a metal-polymer adhesive composition increase. Flyoropolymers have rather small adhesion on a metal substrate (about 40 kg/ cm^2). That is why we performed chemical modification of the coating.

The Auger-spectrum of the TETRON surface without modifier is given in Fig. 1a. Figure 1b shows the spectrum of the same coating but with a modifier. The Si2p and N1s points attest that the surface is enriched in chemically active groups. The changes of the adhesion of the coating with a modifier are shown on Fig. 2.

Breaking force for the modified surface was 200 kg/cm^2).

The relative film elongation reached 700%. And the film elasticity is so large that it does not disintegrate when the steel substrate breaks.

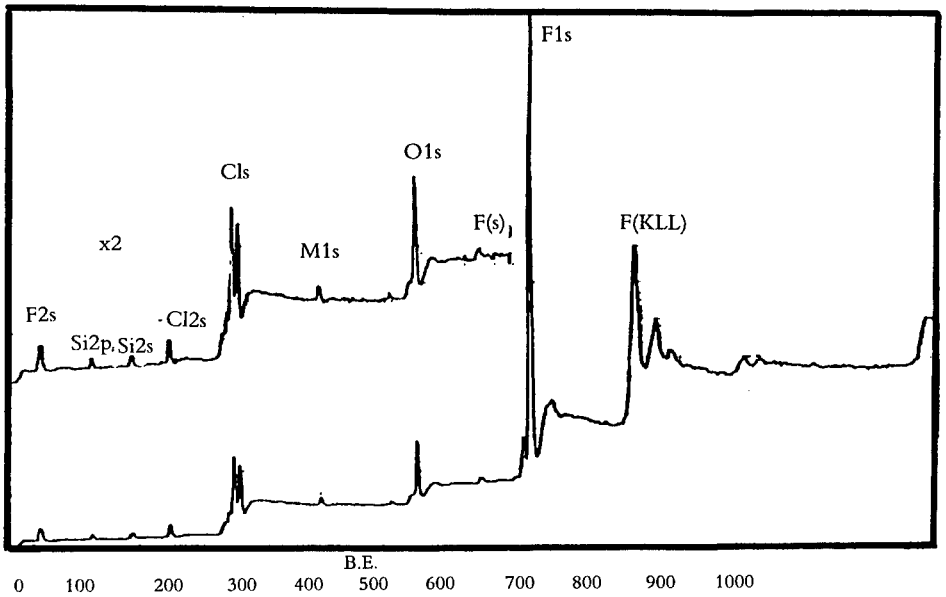


Figure 1a. Spectrum of a bottom side of a film removed from a substrate

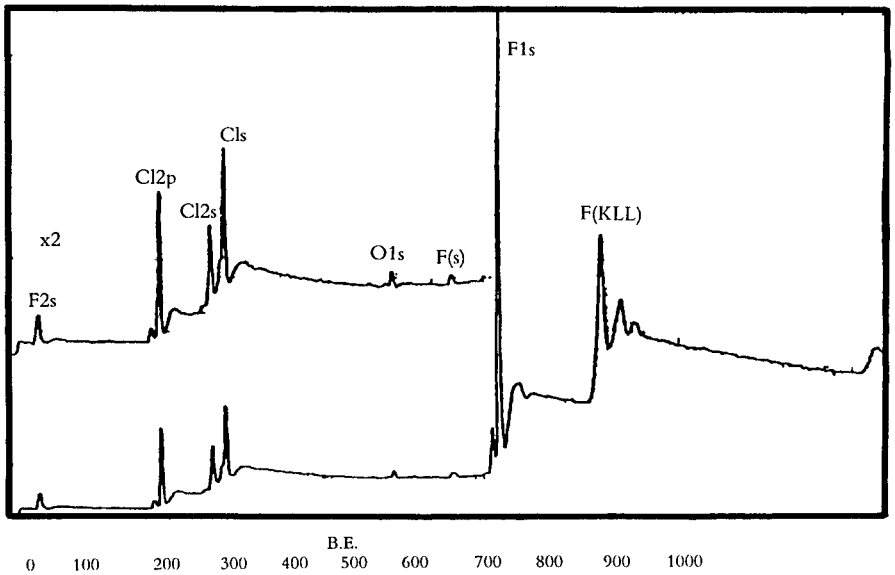


Figure 1b. Tectron without the modifier

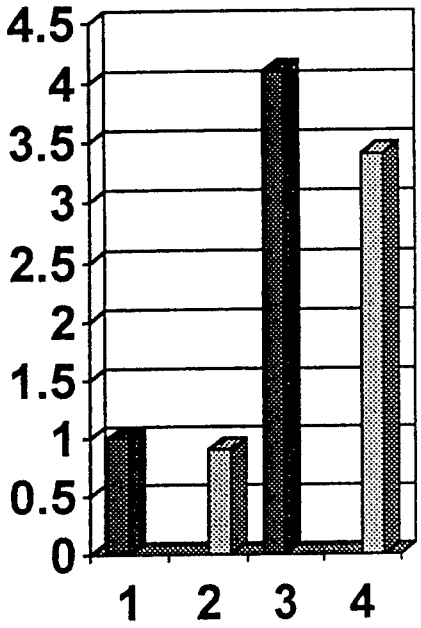


Figure 2. Adhesion strength of the Tetron coating on steel and Al. Non-modified surface: 1 - steel; 2 - Al; modified surface: 3 - steel; 4 - Al.

5. Investigation of the Coating in Aggressive Media

Anti-corrosion properties of the coatings are defined mainly by the stability of adhesion under aggressive media.

Chemical modification of the metallic surface radically increases the stability and even at high temperatures.

6. Electrical Characteristics

Insulation properties of the TETRON coating do not change after the coating has been kept in water for 24 hours.

Its resistance is 10^{14} - 10^{15} Ohm cm. Breakdown voltage 100-130 kV/mm.

TABLE I. Test Results

Oxide	Concentr	Test time, months, 20 C	Test time, months, 70 C	Test time, months 90 C
Hydrochloric acid	3% 25%	>41 >17	>41 >17	22 3
Hydrochloric acid	25%	>17	>17	>17
Nitrogen acid	17% 25%	>41 >17	>41 >17	25 10
Sulphur acid	25%	>17	>17	>17

7. Application

The man sphere of application for TETRON coatings is a long - term (10 years and longer) protection from corrosion of chemical reactors, pipe-lines, vessels, ventilation systems, parts of lock equipment at chemical, radio-chemical plants and in the oil production.

The coatings could also be used as decorative for those metallic parts which operate in sea water, fertilizer solutions and other aggressive media.

The coatings are easy to clean and do not emanate toxic substances.

The coatings wetability is very low which makes them attractive for anti-corrosion protection of planes and cooling parts of refrigerators.

Fluoroplastics are very inert and their absorption coefficient is very low. The TETRON coating could be used for inner surfaces of UHV systems.

8. Tornado

Tornado is a new technology in engineering industry used for the treatment of inner surface of pipes. The technology utilizes the energy of compressed air and the pneumovortex effect caused by air and air-abrasive flows within the pipe.

- TORNADO TECHNOLOGY

  - Fast and effectively dry-cleans inner surface of hollow parts from dirt and removes damaged layers (corrosion, oxide film, coatings, scale etc.);
  - Makes the surface ready for applying various coatings (paint, enamel, polymers, halvanic);
  - Creates a surface with given degree of roughness for applying coatings with small adhesion;
  - Abrasive-free cleaning from loose, viscose and other soiling and sediments (food processing equipment, luminofors in fluorescent lamps);
  - Provide very effective facing and strengthening treatment and ball polishing (for pipes with walls thickness as small as 0.2 mm); and
  - Produce mat light absorbing surface with given degree of roughness on various materials (metal, glass, polymers etc.).

- What is mostly important about TORNADO

  - It reduces labor consumption, ensures total mechanization, makes it possible to use only one operation instead of multi-stage techniques to prepare a surface for the application of a coating.

- The principle of operation

  - The TORNADO plant creates the pneumovortex effect within a hollow component. The air compressed at 0.6-1.0 mPa is swirled at about the sound speed with the help of the special device - pneumovertex head. An abrasive is then injected into the vortex flow. The flow carries the abrasive with it and the abrasive is pushed toward the inner surface due to the centrifugal force. Moving along a spiral the abrasive cleans the surface.

- What is the best about TORNADO

  - Ecologically safe
  - Free of wearing out
  - Complex form of the inner surface of a component or a hole (which is not a through one) is creates no obstacles for TORNADO
  - Easy to utilize

- TORNADO is protected by Russian patent #2005057, dated 18.05.95

- Spheres of application

  - pipe manufacturing industry
  - automobile industry
  - machines building

- TORNADO has been working successfully!

  - The TORNADO plants have been developed, assembled and put into operation in industry for cleaning and treatment of short pipe components.

- Technical Parameters of Pilot Plan TORNADO

- inner diameter of a component	20-60 mm (up to 120 possible)
- component length	120-150 mm (up to 2000 mm possible)
- air pressure	0.63 mPa (6.3 atm)
- supply voltage	220 V / 50 Hz
- power consumption	0.2 kW
- Dimensions	
» length	2000 mm
» width	500 mm
» high	1300 mm

9. TETRON Business Plans

- Set up a Russian company - Authors (60%) and an Investor (40% - individuals or any legal entity) to manufacture and utilize the Tetron coating in industry.
- Set up a Foreign company - Foreign Investor (40%), Authors - (36%), Russian Investor (legal entity or individuals - 24%) to manufacture and utilize the Tetron coating in industry. The company will have exclusive rights for Tetron coating for all the countries except CIS.
- Investments required:

- Production area rental fee - 150 sq.m. X $100 per year	$15000 per year
- Maintenance costs	$ 6000 per year
- Purchase of the equipment required to produce	
- 5 ton/month of Tetron (2.5-5.0 k sq.m.)	$70000
- Purchase of the materials required to produce	
- 60 ton of Tetron (the year program)	$100000
- Wages for 10 people	$50000 per year

- Patent protection (about 10 countries)	$12000
- R&D to investigate new areas of application	$25000 per year
- License	$100000
- Business trips (first year)	$15000
- Contract with commissioners (first year)	$20000
Total	**$423000**

Within two weeks after the decision has been reached to open either a Russian or a Foreign company it would be necessary to open a credit line and wire the sum of $225000 to the account of Russian company "Vacuum Marketing and Production" which would be used for the purposes as follows:

- rental fee	$ 10,000
- equipment rental fee & maintenance costs for 6 months	$ 10,500
- purchase of the equipment required to set up the Tetron production in industrial scale	$ 70,000
- purchase of the materials required to produce 60 tons of Tetron	$110,000
- contract with commissioners and wages for the first 3 months	$ 18,500
- business trip expenses	$ 6,000

Above all this it would be necessary to purchase a license for Tetron production and pay the authors $100,000 within the first month after the new company has been registered.

- Design output - 5 tons/month - In 6 months after the first investment.
- Pay off period - about one year starting the first day of Tetron manufacturing provided the price is $10/kg.
- The foreign investor to ensure marketing and orders abroad, the Russian partner - within the CIS.

10. TORNADO Business Plan

Stage I "Marketing of the TORNADO Technology in the Gas Industry. RFP for an experimental set-up. Beginning of the experimental set-up design".

- Stage duration
  - 1/2 quarter
- Stage cost
  - 9,000 $ USA

- Work to be done
  - Analyze technology problems in the gas industry to pipes inner surface cleaning and their anti-corrosion protection. Define the spheres of TORNADO technology applicability. Identify the priority spheres where TORNADO should be introduced. Chose initial data for RFP for the design and manufacturing of the experimental set up. Technical parameters of the installation (pipe diameter and length) to be determined by the customer or based on the researches carried out during the pre-development stage. Start designing the experimental set up.

- Stage result
  - Initial Data for the project

Stage II "Experimental Set-up Design (termination). Design drawings and documentation for the experimental set-up manufacturing"

- Stage durability
  - 1/2 quarter

- Stage cost
  - 20,000 $ USA

- Work to be done
  - Finish the development of the design of the experimental set-up. Make all the drawings and compile all the documentation for the experimental set-up manufacturing.

- Stage results
  - Complete design of the experimental set-up.

Stage III Reparation of Drawings and Documentation (termination). Set-up parts purchase.

- Stage duration
  - 1/2 quarter

- Stage cost
  - 25,000 $ USA

- Work to be done
  - Prepare all the drawings and compile all the documentation for the experimental set-up. Purchase parts of the experimental set-up.

- Stage result
  - Complete set of drawings and technical documentation

Stage IV Experimental Set-up Manufacturing

- Stage duration
  - 1 quarter
- Stage cost
  - 80,000$ USA
- Work to be done
  - Manufacture the experimental set-up under the authors control.

Stage V Experimental Set-up Manufacturing (termination). Set-up testing.

- Stage duration
  - 1 quarter
- Stage cost
  - 60,000$ USA
- Work to be done
  - Manufacture the experimental set-up. The authors to exercise permanent control over the manufacturing process. Test the experimental set-up.
- Stage results
  - Assemble and put the experimental set-up into operation.

Stage VI Comprehensive Tests of the Experimental Set-up (termination). Correction of the drawings and the cleaning technology to produce the first pilot plant.

- Stage duration
  - 1/2 quarter
- Stage cost
  - 9,500 $ USA

- Work to be done
  - Test the experimental set-up in order to determine its characteristics. Make corrections in the drawings and documentation as well as in the cleaning technology to start the work on the first pilot plant.

- Stage result
  - Report with test results and recommendations

Stage VII Pilot Plant Manufacturing

- Stage duration
  - 1 quarter

- Stage cost
  - 73,000 $ USA

- Work to be done
  - Manufacture the first pilot plant. Authors to control the plant manufacturing process.

PRACTICAL EXPERIENCE: INTERNATIONAL COLLABORATION IN MILITARY CONVERSION TECHNOLOGIES

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This report describes proposals of private Russian consulting company on how to apply high-technology conversion to the civil market in Russia. Being the co-authors of high tech projects and having six years of experience in business consulting, the authors created a wide data bank about Russian institutes and research groups among the former military industrial complex having proposals for business technology development. Now they are planning to create an advanced technology foundation to choose the appropriate technology projects for business development, carrying out marketing research, etc. The company which exists now provides legal consulting, and technical and business expertise of new technology projects even in existing unfavorable conditions of the recent economy.

1. Introduction

Since the Cold War finished a new term "conversion" is introduced into both political languag and economical life of the "New Aliases". Considering the national economy one can found many types of "conversion": resources, machines, equipment, materials, services, communication, specialists and technology - all could be converted from the military industrial complex for civil use. The last from the list - technology - could be of special interest for business because the market of technologies could not be saturated in principle. Speaking about technology conversion, a "conversion" of specialists and research teams developing the technologies should be also added. Unfortunately, considering today possible investments in former military technologies in Russia it should be taken into account that a lot of obstacles come from both the economy and political state making impossible long term investment policy.

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2. Situation and Obstacles For Investment Policy

The opportunities for a long-term collaboration between Western and Russian industry are limited. The industry in Russia is destroyed in a sufficient extent. The so-called "privatization" did not bring any change into the headquarters of the industrial enterprises. The same directors which previously fulfilled the customs of the ministries of the FSU (Former Soviet Union) now are making decisions should they wish. Jut in one subject the situation have been changed dramatically. If previously the Soviet state controlled the expenditures which had been offered for enterprises, then now there is no control at all. For directors it allows putting as much as possible into their own pockets - preferably using Western bank accounts. The plants and factories are considered as the loot which could be taken away from you any time and which should be used with a self-benefit as soon as possible. Going with these conditions nobody is interested in future investments; even expenditures on maintenance of hardware are senseless as tomorrow another person will steer.

One of the main reasons is also that the political system is still non-stable. Let us go beyond the question is it reasonable or not but now people are waiting changes in the political system together with a property relations. If so, not many of them are ready to long-term creative work. The other reason is senseless taxes which make a total tax on the net profit at least 92 percent and from the other hand it is not possible to determine the expenditures by a single way to deduct them when determining net profit. If a person could not obtain a favor of the financial inspectors by this or that way (with no comments!) then he should pay a salary from the profit after taxes have been taken.

You should not forget that in Russia there is no complete legal support. The law does not act according to the modern economic relations; laws are often contradicting and their applying excludes each other the same time and from time to time they are retroactive. But the main obstacle - an enormous growth of the bureaucracy. Everything is "determined", for everything you need a special permission and at least one certificate from each organization dealing with the subject which confirms the fact that no permission is required. An ancient Russian tradition says that department gives you a certificate only in the case when you offer it another one which explains why this certificate is necessary. Recently, it did not loose its actuality. After disintegration of the SU a number of Russian ministries has grown at high extent. For example, in Moscow the problems of foreign trade are resolved by a number of officials two times as high as that during the last years of the SU existence.

In practice many managing and control administrations exist at the same time doing the same work and dispute against each other every time when making a decision. You also should not forget that many administrations collaborate with crime structures (Russians use word "Mafia") and before making an economical decision ask their opinion. As a result, the capital investments in the Russian industry especially could not be recommended with some exclusions. This is illustrated by Western banks and Nikolay Shmelev saying that in 1993 the West had invested only 1 billion dollars into

the Russian economy compared to 5 billion into the Hungarian and 150 billion into the China P.R. economies.

3. Can We Do Anything?

On this dark layout there is nevertheless one branch which seems to be of some prospect when thinking about how to create a long-term relationship. We propose the work in the field of high technology. Of course, there are particular problems of high-tech development in Russia especially for former Soviet military enterprises looking common: lack of funding, total secrecy, difficulties with marketing research and advertising their production, and undevelopment of patent and copyright law in Russia making possible technology leakage into another country. A lot of former military enterprises could not support any additional expenses such as reconstruction and marketing research.

At the same time the creators of technology are interested to obtain financial investments directly from the investor excepting bureaucracy that allows to support work teams and transformation of the technology production for business.

In the FSU there were at least two branches of highest achievements: the defense industry and cosmonautics. These areas took a lot of funding from the SU budget, but nevertheless the results appeared to be much cheaper than Western analogs in comparable taxes due to low salaries and cheep resources. Recently, the advanced technologies for the first time have become available for the business use.

In seems to us that if any interest exists in principle we should expect an interest of the Western business to this area to invest money in high-tech and as we could see it in the years 1991 to the beginning of 1993 there was a wave of the certain interest that allowed us to establish contacts with Western companies, especially when we have carried out the First Consulting Workshop on International Collaboration in Military Conversion Technologies (June 15-22, 1993, St.Petersburg, Russia). The high-tech Russia is really possessing could be an important opportunity for our country to support measures improving economy and make partnership on the world market more reliable not only exporting oil, nickel, uranium and other resources and importing foodstuffs and nuclear wastes.

4. "Experiments"

So the further development of this idea was to create a private company which could provide business consulting services in the field of high technology, support high-tech research, and form the market even in unfavorable conditions as no consequential state strategy, no interest in high-tech support, and no investments in high-tech and military conversion science. The consulting services now are oriented toward both Russian and foreign investors and to consulting of foreign partners on how to make business in

Russia. The services include information, technical and legal consulting, clearance, technical expertise, etc.

5. Information Obtaining and Utilizing

The first problem we were faced before is a lack of information about the market. In 1989 we have started from information base creation and now we are possessing an information bank having 55,000 industrial enterprises of the FSU in different areas (from aviation and optics to microbiology, including traditional Russian exporters). The general information regarding the enterprises is as follows: Classification codes, Ministry, Branch, Name, Address, Phone, Fax,Telex, Director's Name, Exporting Production (if any). This information is related to years 1993-1995. The classification of business projects starts from the application forms and resume which describe the topic of the program, keywords, areas, copyright, owners of the inventions, patents, know-how (indicate if exist), trade-marks, total evaluation costs, terms of cover expenditures and other technical information. After receiving the resume the company estimates this information and makes marketing research (the contract between the technology owner and the company is signed), it also gives some general information to interested parties to advertises the projects (informing the owner of the project). After some resumes received they are ranged and for most interesting problems the company tries to find investments. It is possible to work from the other side when a customer/investor who seeks a certain technology/process/article, comes to the company which gives him information he needs and consults on how to proceed with this information. No research grants are offered for the working teams, just completed business applications of technology are considered.

6. Consulting

The consulting services offered are connected with registration of companies with all types of property rights and their legal support during the time of their existence. Another kind of consulting could be offered for the carrying out projects of the working teams (which have no or would not like to have its own company that is typical situation) within the frames of Intercontact with lesser bureaucracy and higher salaries connected with manufacturing and R&D but this time this work is canceled because of no interest to invest money in high-technology.

The next step is the creation of the foundation concerning advanced technology for groups from the former military industrial complex on a base of Intercontact Co. Ltd. which has a 5-year experience, close ties with the heads of research institutes and ministries, wide data bank, and in the creators of high-tech production. Intercontact since 1989 (created in 1989 under support of Academician E.P. Velikhov) has made more than 200 research and industrial projects with support of Kurchatov Institute, Lebedev

Physical Institute, Res. Ind. Association Energy, Res. Ind. Ass. Astrophysics, High-Temperature Institute, State Optic Society, Efremov Institute, etc. Main technology research projects were the litotrypter certified by the Health Ministry of the USSR and a national program created together with Kurchatov Institute on radiation technology.

The company also have been made has a wide experience in the international research collaboration and international education. Since 1989, four international conferences and youth schools on plasma physics and controlled fusion (PPCF) being performed including the participation of the headquarters of research programs from all over the world, being an opportunity for continuous education for young researchers in plasma physics.

7. Conclusion

Above we have briefly described some experience of the small Russian company which has been working since 1989 on high-technology market in Russia. This material could be considered as an opportunity to realize efforts of this company (not to ask for some money) to find possible Western companies/institutions which have long-term interest in Russian market with a prospect to invest money in high-technologies in Russia. The other idea to use this report at this NATO ASI to establish relations with Western organizations dealing with the conversion of former military technologies.

THE TECHNOLOGY DEPLOYMENT CENTER

Bridging the Technology Gap

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1. Background

In October of 1992, as part of the reconfiguration of the U.S.A. weapons complex, the U.S. Department of Energy (DOE) Pinellas Plant in Largo, Florida was identified as one of the DOE facilities from which production would be moved to consolidated locations. The DOE mission at the Plant was to end in 1998. In preparation for the anticipated economic impact of the closure, a Defense Conversion Task Force was established in the Tampa Bay (Largo) area under Part 3161 of the Defense Appropriations Act of 1992. The Task Force developed a reuse plan for the facility which included technical assistance from the University of South Florida (USF). Working together, the Task Force, DOE, Lockheed Martin Specialty Components (the Managing and Operating contractor for the Pinellas Plant), and USF developed a defense conversion plan for the Plant which included a Technology Deployment Center.

2. Mission

The Technology Deployment Center (TDC) is a joint program developed by the University of South Florida (USF) and Lockheed Martin Specialty Components (SC) at the Pinellas Plant in Largo, Florida. The TDC has been funded by the DOE and the U.S. Department of Defense (DOD). The primary mission of the TDC is to make the equipment and technical expertise at the Pinellas Plant available for new economic and business development. The TDC is synergistically merging the technical capabilities of SC, USF, and the private sector to develop prototypes of products for commercialization. Pinellas Plant technical production staff and USF research faculty work together to develop prototypes that can be manufactured at the Pinellas Plant or at other business locations. This program was designed to preserve the core technical production capabilities of the Pinellas Plant as the DOE mission ends and to convert the facility to private sector use.

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3. The Strategy

After a careful analysis of the technical strengths of USF and SC, the project team decided that the unique capability the Plant had to offer was its expertise in prototype design and manufacture. The team believed that the presence of a working prototype would greatly enhance the ability to transfer technology from universities and federal laboratories to the market place. The strategy which the TDC chose to implement was to identify companies which had a need for prototypes in commercial areas that were compatible with the expertise of the Plant and USF--thereby, creating a "market pull" for the technical specialization of the TDC.

4. The Program

As previously mentioned, an analysis of the technical capabilities of the Plant and USF was completed. Once core technologies were identified, a needs assessment was designed to identify companies in the Tampa Bay area which had similar commercial interests. The initial assessment data was drawn from USF's corporate contacts and from Cooperative Research and Development Agreements (CRADAs) the Plant had conducted as part of its DOE mission. (Currently, a more comprehensive Needs Assessment has been commissioned to identify a larger pool of potential private sector partners.)

The next step was to identify a technology pool of laboratory models which could be refined and rapidly developed into prototypes. This pool then was subjected to an initial screening. First, a good idea that required research was not eligible to be part of the pool. Only working "widgets" were considered. Second, the concept was subjected to a review of the literature and intellectual property rights, the technical potential for developing a prototype, and the business potential for maintaining and/or creating jobs at the Pinellas Plant or in the community.

When the program began, the first four projects--the Rapid Start Projects--were selected by the TDC Advisory Board based upon staff recommendations. By initiating the program with Rapid Start Projects, the TDC staff was able to evaluate the process and prepare for the first Request for Proposals (RFP) for the Standard Program. Also, from a political perspective, it gave the TDC a chance to demonstrate quick success (if the staff guessed right) to the business community and to the DOE/DOD; and, to positively affect SC employee morale.

The first RFP (RFP #1) signaled the beginning of the Standard Program. Through a series of technology briefings, the TDC staff attempted to eliminate inappropriate proposals and promote those "widgets" which best met the technical and business interests of the TDC. The staff also assisted the potential project managers in determining which Phase of the TDC best met the technical maturity of their project.

The TDC staff established a three-phased-program. Phase 1 projects are feasibility studies which take about three months to complete and cost about $50,000. During Phase 1, the conceptual design of the laboratory "widget" is refined and bench scale

studies conducted. These studies normally lead to some design modifications and to the assessment of the potential to develop a prototype. Simultaneously, a preliminary market analysis is conducted. At the end of Phase 1, the projects are reviewed for technical progress and commercial feasibility (which includes the identification of a private sector partner) before they are eligible for Phase 2 competition.

Phase 2 projects are prototype development projects which typically are about nine months in duration and cost ~ $500,000. During a Phase 2 project, the project staff, with TDC staff oversight, complete the preliminary engineering design, the materials selection and compatibility assessment, and the fabrication of the prototype. An experimental evaluation of the prototype leads to refinement of the prototype design and the creation of CAD-CAM configuration drawings for product design. This Phase also requires a formal business plan for licensing and commercialization. The private sector partner has to be a significant player in all aspects of the project. Some projects are started at Phase 2 because they have already advanced beyond Phase 1.

Phase 3 is the Deployment Phase. In this Phase, the private sector partner will contribute a minimum of 50% of the project costs and will negotiate a commercialization agreement (normally an exclusive royalty bearing license). The Deployment Phase consists of three segments--**production model, manufacturing program,** and **commercialization**. During the **production model**, the production design and assembly drawings are to be completed. The production model will be fabricated and tested. A configuration audit of the assembly may result in a refinement of the assembly drawings. The **manufacturing program** and **commercialization** are the primary responsibility of the private sector partner(s). During these aspects of the Deployment Phase, a materials inventory will be conducted and an assembly line design finalized. Concluding estimates will be made of the production rate, the capital equipment and investment required, labor costs, product liability, and the cost of maintenance. This data will contribute to the final business and market plan.

With these three phases as a program construct, all proposals are considered by a Review Panel composed of scientists, business persons and technologists. The Review Panel evaluates the proposals based upon their analysis of the technology and the proposed work plan, the demonstrated market pull of the project and the commercialization plan, and (where appropriate, e.g., Phase 2) the commitment of the private sector partner. Those proposals which meet the minimum score based on program criteria are passed on to the Advisory Committee which reviews the projects to see if the resources to complete the project are available at both the Plant and USF. The projects that survive this review are recommended to the Executive Committee which is composed of members of the Defense Conversion Task Force of Tampa Bay. The Executive Committee assesses the proposals on how well they fit the business and re-use plan for the Pinellas Plant. The last review is done by DOE and DOD, who are not only sponsors of the TDC, but are also partners in the cooperative funding agreement. Those projects selected for participation in the TDC (either Rapid Start or Standard Program) are initiated as either a Phase 1 or Phase 2 project.

5. Results to Date

As the TDC staff prepares to issue RFP #2 (June 22, 1995), we are very much aware of our brief history. It is quite clear that a number of factors (some anticipated and some not) have shaped the program. Perhaps the most pervasive is the synergistic relationship that has developed between SC and USF. While the institutions are markedly different in purpose and background, it is these very differences that have bonded them together. SC is a quality control and precision manufacturing facility which has made components for nuclear weapons. Less than 1% of their workforce have a Ph.D. Since the essence of the TDC program is to create economic development by preserving jobs and converting the Plant to civilian use, a basic question was, "Why partner with USF?

The answer was not readily obvious because the Plant was a classified facility; but, the sense of the matter was that USF had been a major player in the economic development of the Tampa Bay area and could probably bring something to the table--if nothing else, a sense of stability.

The project was first conceived in 1992 and funded in the Fall of 1994. This delay, although initially painful because it led to an ~50% downsizing of the workforce, was also constructive because it enabled the prospective partners to establish a working relationship prior to the start of the TDC program. Therefore, when the funding was awarded, the TDC was able to start immediately with Rapid Start programs which had been initially developed through CRADAs or through other DOE Defense Program Conversion funds. To thoroughly understand the TDC, it is necessary to look at some of the factors that brought the program to its present point.

5.1 PROGRAM FACTORS

The TDC was originally based on several assumptions: the technology pool would come mostly from USF; the private sector would not become a factor until Phase 2 projects were started; the number of "widget" technologies was limited; most of the funding needed to be spent at the Plant to preserve core jobs; and, companies would participate even though no direct funding went to them because prototypes were a valuable inducement.

The first assumption proved to be invalid. Of the fourteen projects that are in progress, four technologies have come from USF, four have come from other DOE facilities, and six have come from the private sector. The second assumption also proved to be in error. Of the fourteen projects, eight are Phase 1 and six of those already have private sector partners. (All of the Phase 2 projects have private sector partners.) As to the number of "widget" based technologies, thirty four were eligible proposals in response to RFP #1, as well as the initial four Rapid Start projects.

The last two assumptions proved to be more accurate. Over 70% of the funding for the first fourteen projects was allocated to the Plant and, as can be seen by the response,

the private sector was extremely interested in developing prototype technology, even though they received no program funding.

5.2 RELATED FACTORS

As might be expected, there were a number of related factors which influenced the course of the TDC program. Perhaps the most pervasive factor was culture shock. Survival is a strong motivator for change; and, change in business attitude was the key ingredient at the SC Pinellas Plant. During the first few days of 1994, before TDC funding, it became apparent that DOE was going to end their mission in October of that year; therefore, the management of SC had to completely change its attitude toward doing business. The contractor funding by DOE had to be replaced by revenue. This meant that a workforce which had existed on a guaranteed funding source had to become entrepreneurial almost overnight. Customers for services and new business alliances had to be found and cultivated. The cost of overhead (not a serious factor as a DOE facility) had to be drastically reduced and the facility had to be declassified to allow the outside business community to learn what the Plant had to offer. To their credit, the SC management made the transition, not without casualties, but successfully.

The TDC became a way of subsidizing manufacturing costs while SC reduced its overhead. The Pinellas Plant was sold to Pinellas County on March 1, 1995, and SC declassified and reduced its portion of the facility to about one-third of its original square footage. Once SC began to recruit customers and business partners, the mission of the TDC became much easier. Several specific factors then came into play.

As businesses began to seek out the expertise of the facility, it became apparent that there was a demand from small- and medium-sized businesses for both the precision manufacturing expertise of the Plant and its ability to design and produce prototypes. This demand was first experienced through the CRADA process and later enhanced through the TDC. Larger companies saw the Pinellas Plant as a potential secondary manufacturing site which could function as a supplier of specialty components and prevent the company from having to create its own production line.

In addition, SC and the TDC were selective in the types of small businesses that were encouraged to establish a partnership with the Plant. Instead of spending a lot of time nurturing start-up companies, the TDC made it a priority to deal with companies which had built a corporate infrastructure, but were in need of prototype and manufacturing support--a strategy to adopt a company, not to grow their own.

Another by-product of the relationship, which the TDC established between SC and USF, was the development of educational programs which combined the staff, equipment, and expertise of both organizations. (For example, a National Forensic Institute has been planned at the Pinellas Plant. This Institute will train professionals in forensic techniques, establish uniform forensic protocols, and conduct forensic research.)

All of these related factors have increased the interest and involvement of the private sector in the Pinellas Plant and in the TDC. Therefore, it is not surprising that the TDC experienced an important private sector participation earlier than expected. (Currently,

the TDC requires private sector partners to manufacture either components or the finished product at the Plant, or to negotiate a business alliance for manufacture outside the Plant.) The key to maintaining this interest is the continued reduction of the overhead rate and the cost of manufacturing at the Plant (a necessary evil for a nuclear weapons facility). Otherwise, when the TDC-subsidized rates expire, the private sector partners may have difficulty keeping their unit costs competitive. To date, several companies have decided not to participate in the TDC due to a concern over SC's ability to continue to lower overhead. However, this concern may be offset by the attractive lease rates Pinellas County now offers for vacant space in the Plant.

6. Conclusion

Although the primary problem the TDC was designed to help solve was the defense conversion of the Pinellas Plant to civilian use, the staff also had to deal with the more pervasive problem of bridging the technology gap--of successfully transferring technology to the commercial marketplace. The TDC staff used prototype development as the bridge.

Most technologies developed at universities or federal laboratories, other than incremental product improvements, are not ready for production and marketing without a major financial investment and risk. Many small- and medium-sized businesses have neither the expertise nor the facilities to develop production models without a similar financial risk. Larger corporations are often not willing to establish expensive prototype production lines for unproven technologies. By providing a technology which has already been developed through the prototype stage, the TDC has been able to cut the financial risk assumed by the private sector partner and to reduce the time necessary to bring a product to market.

The availability of a prototype production facility has enabled businesses to develop and test prototypes without establishing their own unique facility. Small- and medium-sized businesses have been able to develop their own internal expertise by participating with their SC and USF partners. Through the TDC, the Pinellas Plant has been able to establish a relationship with these companies which should lead to future business alliances.

The TDC has developed a model which can be used for the downsizing of other federal production facilities. On a broader scope, the TDC model of technology transfer through prototype development may serve as a bridge across the technology gap in the USA.

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NUMERICAL SIMULATION OF MICROWAVE GENERATION FROM VIRTUAL CATHODE DRIVEN BY HIGH REPETITION SHORT PULSE ELECTRON GUN

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A foil diode axial vircator is investigated by numerical simulations, using the code KARAT. A transverse electromagnetic (TEM) wave pulse with a trapezoidal shape is applied to the solid cathode of the device. The maximum diode voltage is 300 kV. The efficiency of microwave production is 1.35 percent at Δt = 3 ns duration of the pulse flat top. When Δt is less than 1 ns, the efficiency increases by a few tens percent.

The rapid development of high-power microwave sources during the 1980s was to a great extent due to the availability of a technology base that had been developed for other applications. Usually high-power microwaves are driven by pulsed electrical system referred as an electron gun. These machines were developed in 1960s to enable nuclear weapons effects simulation. Later controlled fusion, biology, medicine, chemical physic, communications etc. Became drivers for pulsed power technology.

In our article we report on numerical simulations of virtual cathode oscillator experiment. These simulations have been performed for the high-power electron gun

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designed and constructed in ENEA (Frascati) - Fig. 1. The machine is simply composed by a Pulseforming Network (PFN), charging a double, water filled Pulseforming Line (PFL). At the output of the PFL is mounted voltage multiplication system consisting of three 50 Ohms cables charged in parallel and discharged in series. The compactness required for the accelerator has brought the constructors to develop a machine operating at high repetition rate (1000 Hz), with very short pulse duration - 3 ns. The full configuration is able to generate a voltage pulse up to 1.8 MV In our simulation we use the reduced scheme without multiplication section. In these case the accelerator is able to supply lower voltage pulse (300 kV) with a clearly defined flat top and very high current - above 20 kA which is quite enough for vircator operation.

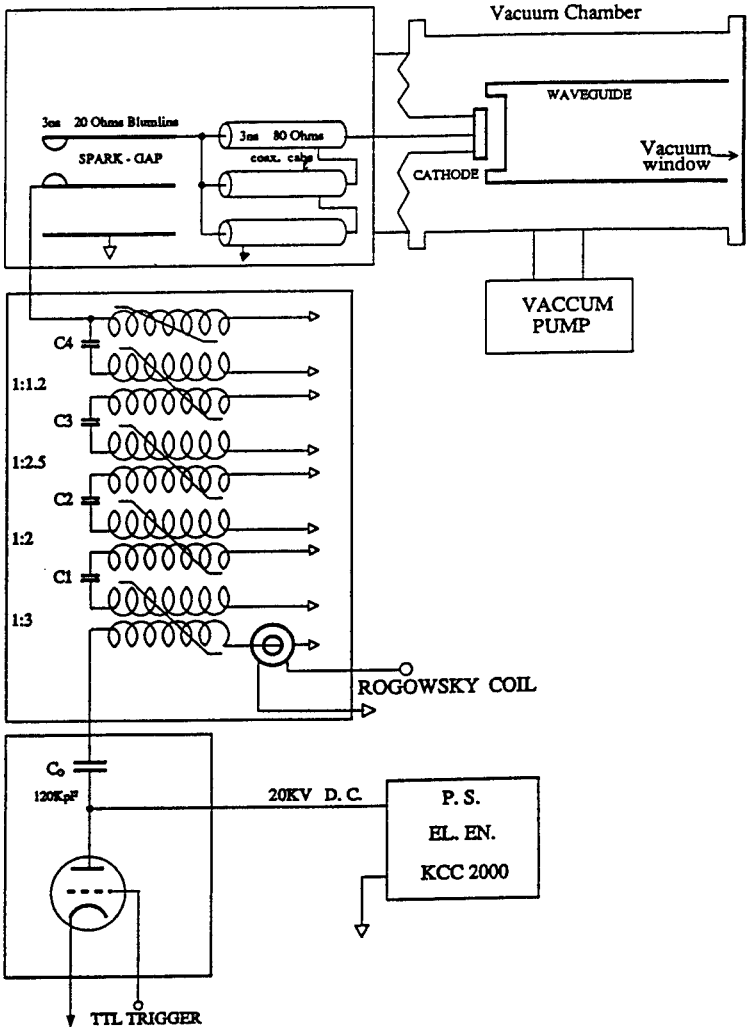


Figure 1.

An outline of the modelled axisymmetric system is shown in Fig. 2. The electron beam is formed in a foil diode with a 44-mm-radius anode tube. The electrons are generated by an explosive plasma emission from a 34-mm-radius solid cathode. A guiding magnetic field is absent. The distance between the cathode and the anode foil is 6 mm. The electron beam is injected into an output drift tube (output waveguide) with a radius $R_w = 40$ mm. The anode tube, the output waveguide and the foil are grounded.

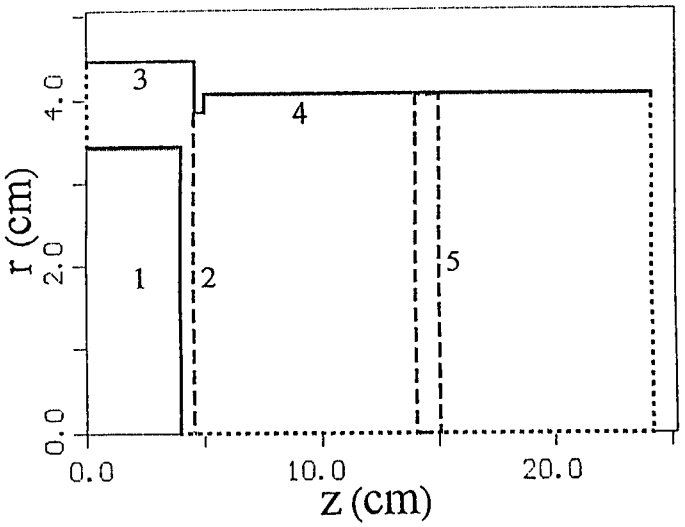


Figure 2. Outline of the modelled system: 1 cathode; 2 anode foil; 3 anode tube; 4 waveguide; 5 electron absorber.

The code KARAT [1] is used for numerical simulations of the described system. This code is fully relativistic, electromagnetic, 21/2 - dimensional (two spatial dependencies - r, z and three velocity components in an axisymmetric cylindrical coordinates), based on particle-in-cell method.

A 300 kV transverse electromagnetic (TEM) wave was launched at the left hand boundary into the coaxal transmission line. The rise, duration, and fall times of the atrapezoidal TEM pulse are 1 ns, 6 ns, and 1 ns, respectively. A relatively low field (the field emission threshold of 20 kV/cm) causes space-charge-limited emission from the front surface of the cold cathode toward the anode foil. The probability of electron absorbtion by the foil is accepted to be zero. An electron absorber (a dielecatric region with a dielectric constant $\varepsilon_r = 1$) is used in the simulations to stop all particles that would get the points of fields and power monitoring.

At time $t \approx 0.6$ ns a virtual cathode (VC) is formed inside the waveguide. The distance between the foil and the VC is approximately equal to the A-K gap (≈ 6 mm). After the VC formation a microwave emission starts. Its Poynting vector $\Pi = \mathbf{E} \times \mathbf{H}$ ($\mathbf{E}$ and $\mathbf{H}$ are the RF electric and magnetic fields, respectively) is monitored at a point near the right-hand boundary of the simulated region. In Fig. 3 a time history of Π at a point

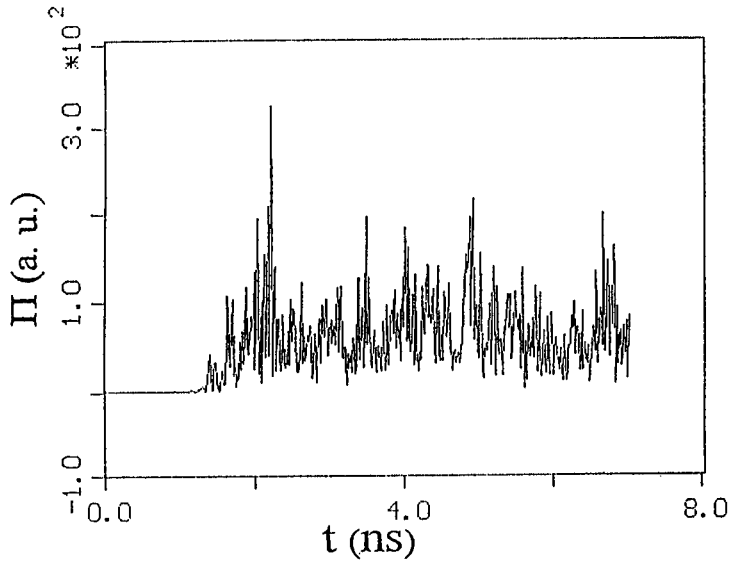


Figure 3. Time history of the Poynting vector at the point r=3.5, z=22cm.

with coordinates r = 3.5 cm, z = 22 cm, is shown. It is clearly seen that Π has a maximum in the beginning of the microwave pulse. This behavior of Π leads to the conclusion that if the TEM pulse is short (less than 1 ns in the flat top), the efficiency of microwave production would be larger.

For a 300 keV, 3.4-cm radius solid electron beam, propagating in a 4-cm radius waveguide, the space-charge-limiting current $I_{scl} \approx 2.8$ kA [2]. It is obtained in the simulation that the average current I, emitted by the cathode at the TEM pulse flat top is about 25 kA. Thus, the ratio $I/I_{scl} \approx 9$. At large values of I/I_{scl} , the predominant dource of microwave radiation are the bunched electrons, reflexed by the VC [3]. To get an additional confirmation of the microwave source, we follow the method, used in [4] where the azimuthal component of the RF magnetic field $H\phi$ is monitored at the right hand boundary (here in the point, mentioned above - r =3.5 cm, z = 22 cm). The axial current I_z is monitored at the anode foil. In Fig. 4 and Fig. 5, the Fourier transforms of $H\phi$ and I_z are shown, respectively. It is evident that $H\phi$ peaks at the same frequency as that of I_z ($\approx$ 9 GHz). From the coincidence of both frequencies it follows that the main source of microwave radiation are the electron bunches oscillating between the real and the virtual cathodes.

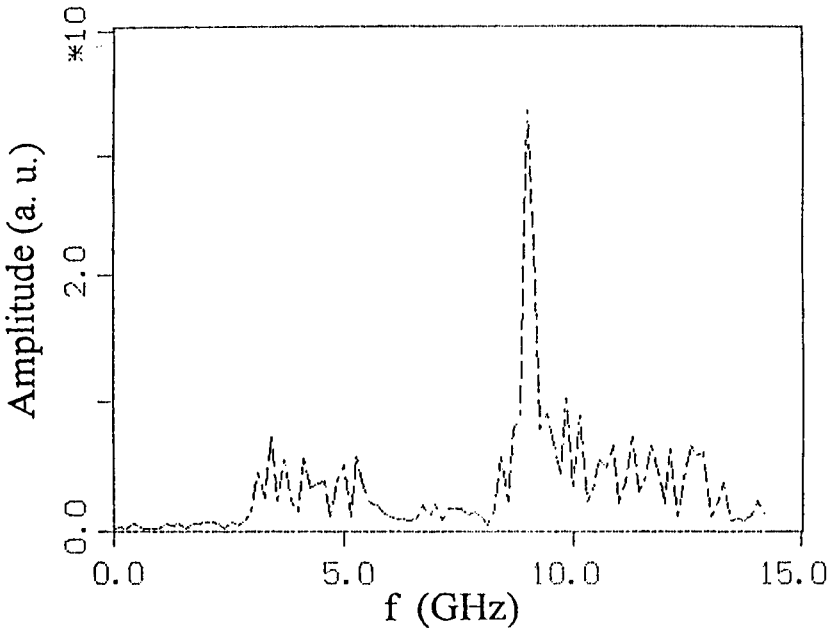


Figure 4. Fourier transform of the azimuthal RF magnetic field at the point r=3.5 cm; z=22cm.

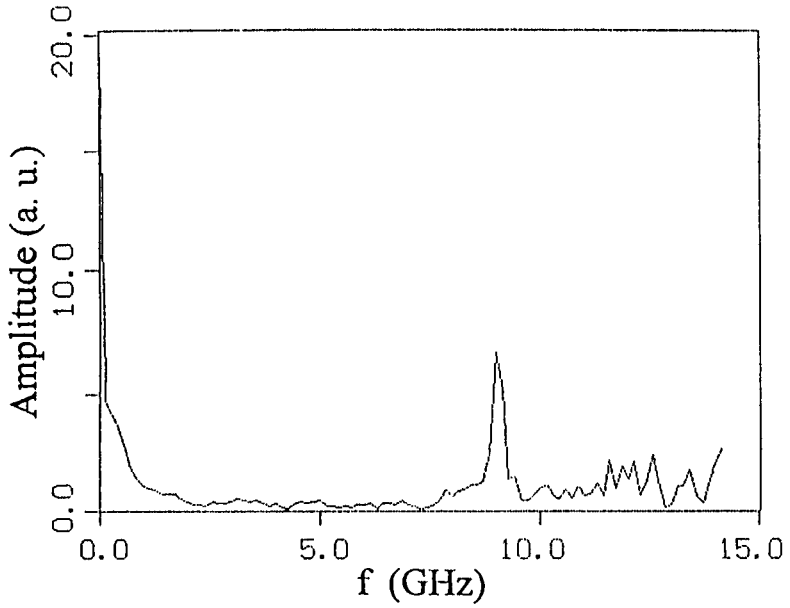


Figure 5. Fourier transform of the beam current through the anode foil.

The frequency f_μ, corresponding to the maximum amplitude in Hϕ Fourier transform

($\approx$ 9 GHz) is higher than the TM_{01} and TM_{02} cut-off frequencies for a 4 cm radius waveguide - 2.87 GHz and 6.59 GHz, respectively, but lower than the TM_{03} cut-off frequency - 10.34 GHz. Consequently, the dominant modes, excited in the waveguide are TM_{01} and TM_{02}. However, the average power separately in these modes has not been determined. Instead, the total output power of microwave radiation is calculated by integration of $\prod$ over the cross-section of the waveguide near the end of the simulated region. This is performed in a second simulation, where the rise, duration, and fall times of the TEM pulse are 0.8 ns, 3 ns, and 0.7 ns, respectively. The aim is to decrease the time of simulations. All conclusions drawn up to here for the longer pulse (7 ns) remain valid for the shorter pulse (3 ns). The average power P_{av} is closely at z = 22 cm in the time interval (1.5 - 2.2) ns - first interval, is 132 MW. In the time interval (2.2 - 2.9) ns - second interval, P_{av} is 82 MW. This behavior of P_{av} is closely connected with the processor electron bunching.

Let's determine approximately the time τ for propagating of the microwave pulse from the VC region (with a coordinate $z_1 \approx 5$ cm) to the cross-section of P_{av} monitoring ($z_2 = 22$ cm), using the relation [5]:

$$(k_z c)^2 = \omega^2_{\mu} - (\mathbf{k}_{On}\, c/R_w)^2 \qquad (1)$$

Here $\omega_{\mu} = 2\pi f_{\mu}$; k_z , c and $\mathbf{k}_{On}$ are the longitudinal wavenumber, the velocity of light, and the zeros associated with the Bessel function of zero order J_o. From (1), taking into account that $f_{\mu} \approx 9$ GHz and assuming the dominant mode, excited in the waveguide is TM_{02} ,the value of k_z can be determined: $k_z = 1.27$ cm^{-1} . Applying subsequently the formulae for the phase v_{ϕ} and the group v_g velocities ($v_{\phi} = \omega_{\mu} / \kappa_z$, $v_g = c^2/v_{\phi}$), it is obtained that $v_g \approx 2.10^{10}$ cm/s. Therefore, the time τ_1 for propagating of microwave pulse from z_1 to z_2 is ≈ 0.85 ns. Using the same procedure and assuming the dominant mode is TM_{01} , the value of τ is evaluated to $\tau_2 \approx 0.63$ ns. For τ, it is reasonable to use the average between τ_1 and τ_2 : $\tau \approx 0.75$ ns. Consequently, P_{av} in the first time first time interval results from the electron bunching process between approximately 0.7 ns and 1.4 ns. Similarly, P_{av} in the second interval results from the same process between 1.4 ns and 2.1 ns. In Fig. 6 and Fig. 7, the Fourier transforms of the current through the foil for intervals (0.7 - 1.4) ns and (1.4 - 2.1) ns are shown, respectively. Clearly defined peak at 9 GHz in Fig. 6 corresponds to a single bunch of electrons moving between the real and the virtual cathode. It is evident from Fig. 7 that the peak at 9 GHz decreases and a peak at $\approx$ 14 GHz, appears. The second peak is a result of formation of a new electron bunch with a greater transit frequency ω. The reason for the splitting of the reflexing electrons roughly into two bunches with different transit frequencies is a two-stream instability [3]. The streaming instability leads to an angular divergence increasing of a part of the electrons and therefore to an enhancement of their

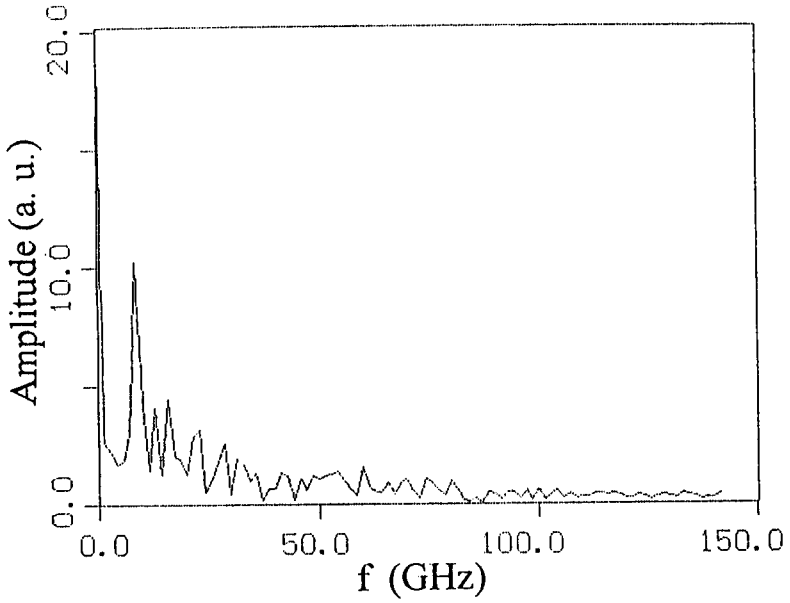


Figure 6. Fourier transform of the beam current through the anode foil for time range (0.7 - 1.4) ns.

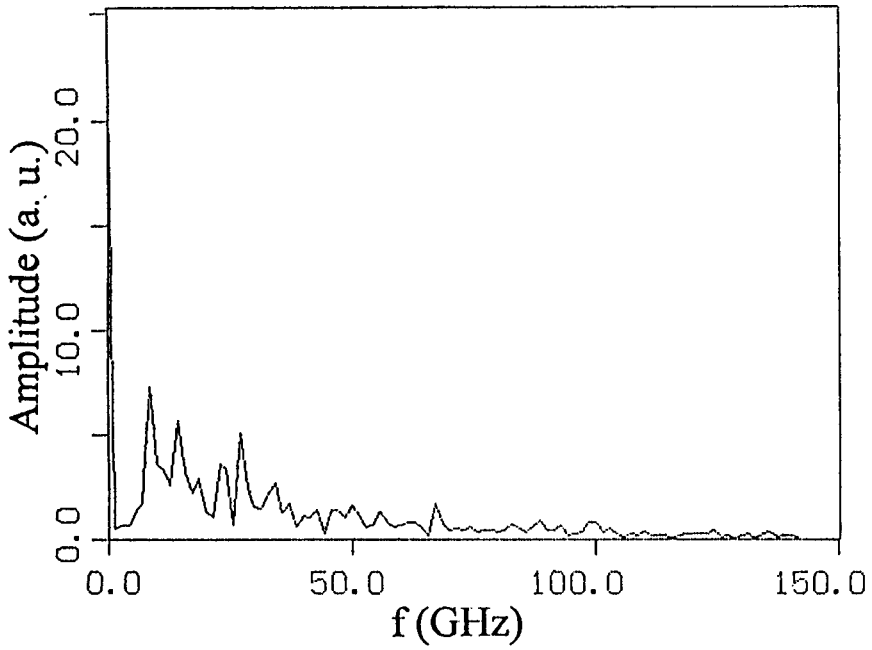


Figure 7. Fourier transform of the beam current through the anode foil for time range (0.4 - 2.1) ns.

transverse kinetic energy at the expense of their longitudinal kinetic energy ε. The

transit frequency of this part of the electrons becomes higher, because $\partial\omega/\partial\varepsilon < 0$ [6] and they form a new bunch. The second bunch is less efficient with respect to microwave generation, since it is deflected quickly to the waveguide wall, before a significant amount of power is extracted from it [7]. This explain why P_{av} in the first interval -(1.5 - 2.2) ns is larger than P_{av} in the second interval -(2.2 - 2.9) ns.

The efficiency of microwave generation in the hole 3 ns flat top of the pulse is 1.35 percent. In Table 1 are given the calculated efficiencies for corresponding intervals from the beginning of the constant voltage part of the TEM pulse. It is clearly seen that at shorter duration of the flat top, the efficiency is greater by 20 to 50 percent in comparison with the efficiency at the longer pulse (3 ns).

TABLE 1.

Interval (ns)	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
Efficiency %	2.0	1.83	2.0	1.92	1.72	1.71	1.74	1.67	1.67	1.62

In conclusion, this article investigates anaxial vircator with a solid cathode and a thin foil. The guiding magnetic field is absent. It is shown that the efficiency of the vircator at short pulses (0.5 - 1.0 ns duration in its flat top) is greater by a few tens percent in comparison with the efficiency at longer pulses (3 ns in the flat top). The performed numerical simulations would find an application in the design of axial vicator devices, driven by short pulse and high repetition accelerators.

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CIVILIAN APPLICABILITY OF PROJECTS FUNDED BY THE U.S. ARMY RESEARCH OFFICE

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A survey has been made of all active projects at the Army Research Office)(ARO) for the calendar year 1994. The database of projects was searched to find all those that were judged to have high potential for civilian applicability. It was found that of 919 total projects, 537 or 58.4% were included in this category. Furthermore, 180 (19.6%) were judged to have low potential, and only 200 (21.8%) were considered to have no potential for civilian applicability. Several high potential projects from the Chemical and biological Sciences Division are given as examples.

1. Introduction

The strategic vision of the Army Research Office is to conduct an aggressive basic research program on behalf of the Army so that cutting-edge scientific discoveries and the general store of scientific knowledge will be optimally used to develop and improve weapon systems to establish land force dominance. The overall strategy is to compliment research programs to greatly enhance emerging technologies impacting Army modernization objectives and related DoD Science and Technology thrusts. Programs are decided through joint coordination and planning through the basic research Tri-Service Reliance process.

Strategies to meet the vision:

Accelerate the transition of research results to applications in all stages of the R&D cycle. Strengthen the research infrastructure in the academic, industry, and non-profit labs which serve the Army.

Focus on those research topics that underpin the technologies and products which are vital to Army modernization plans and DoD S&T thrusts.

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Direct efforts in research areas relating to new opportunities for Army applications, **including those with dual-use**.

Leverage the science and technology of other defense and government labs, academia and industry, and appropriate organizations of our allies.

Foster the training of scientists and engineers in the disciplines critical to Army needs. Actively seek creative approaches to enhance education and research programs at Historically Black Colleges and Universities and at Minority Institutions.

2. Discussion and Results

In line with the third strategy above, a search of the ARO basic research projects database was undertaken to determine what portion of the program could be considered to be dual-use. Table 1 shows the overall results as well as a breakout by scientific discipline. As can be seen from the table the percentage of projects with high potential for civilian applicability ranges from a low of 25% in Engineering to a high of 100% in the Technology Integration Office. Over all disciplines the value is 58.4%. The high percentage for Technology Integration reflects the unique type of projects supported by that office. They are all Small Business Technology Transfer projects whose stated goals are commercially viable products, so they are obviously dual use.

TABLE 1. CY94 Active Projects with High Potential for Civilian Applicability

RESEARCH AREA	TOTAL PROJECTS	HIGH POTENTIAL PROJECTS	PERCENTAGE
Chemistry	95	60	63%
Engineering	109	27	25%
Electronics	164	116	71%
Geosciences	50	24	48%
Life Sciences	76	54	71%
Mathematics	157	70	45%
Material Sciences	128	91	71%
Physics	124	79	64%
Tech. Integration	16	16	100%
Total:	919	537	58.4%

In the area of Chemistry at ARO, the Army relevant technical objectives continue to be advances in our understanding of the basic principles underlying: improved elastomeric materials; ignition, detonation, and sensitivity of energetic materials; catalytic oxidation and hydrolysis; diffusion and transport; chemical sensors; dissolution and hydrolysis; supercritical fluid behavior; environmental beneficiation; and compact power sources. Through coordination with the other Services, we have decreased emphasis on the following areas: synthesis of energetic materials, non-linear optical polymers, semiconductor interfaces, and polymers stable at high temperatures.

The table reveals that 63% of the Chemistry projects are considered to have high potential for civilian applicability. In order to provide a flavor of the kinds of research that falls into this category, several projects are discussed below.

Professor Craig Hill of Emory University is developing redox systems that will catalytically decontaminate/degrade a host of toxic materials including chemical warfare agents and various components of toxic waste. The research involves a continuation of ongoing efforts in five related areas. The common theme of the work is the use of polyoxo-metallates such as polyoxomolybdate to catalyze the oxidation or dehalogenation of the target materials. There are two civilian spin-offs from this work. One is the discovery that certain polyoxometallates show activity in anti-HIV chemotherapy, and the other is that polyoxometallatess are being developed as replacements for chlorine in wood pulp bleaching processes.

Professor Warren Ford of Oklahoma State University is studying catalysis by polymer colloids in research that is relevant to chemical decontamination. Latexes of uniform size are synthesized by emulsion polymerization of functional styrene or methacrylic monomers. These are modified with trialkylamines to create anion exchange sites, purified by ultrafiltration, and characterized by light scattering and electron microscopy. Kinetics of four types of reactions are studied in detail and analyzed by the ion exchange model used for micellar catalysis. The cationic polymer colloids are highly active media for iodosobenzoate catalyzed hydrolysis of nerve agent stimulants. These systems could also be useful in the agrochemicals industry for pesticide or herbicide waste clean-up. Professor Ford's long term goal is to develop polymer-supported reagents and processes that would be useful to industry, and would be environmentally less polluting.

Professor Ken Klabunde at Kansas State University has developed the process to make nanoscale metal oxide particles as new materials for destructive adsorption of toxic chemicals. This again has relevance to chemical decontamination, as well as to environmental clean-up. The US Environmental Protection Agency is also funding this work because of the facility with which these metal oxides destroy chlorinated hydrocarbons. In recent work he has discovered that a monolayer of iron oxide on 4nm MgO crystallites is about 15 times as active as MgO alone for the destruction of carbon tetrachloride. He is currently investigating adsorption and reactions of chemical agent stimulants as well as halogen, sulfur, and nitrogen-containing environmental toxins.

Although this destructive absorption technology holds promise, in order to be used commercially, easier and less expensive methods for synthesis of the destructive adsorbents are necessary. Currently an aerogel preparation with supercritical drying is utilized.

Professor Dana Dlott of the University of Illinois is investigating the response of energetic materials to heat and shock pulses. He has developed a unique model for ultra-fast energy conversion (especially in hot spots). Using very fast, powerful "pump" lasers, he deposits large amounts of energy in materials and then with "probe" lasers he follows the energy pathways. Graphics Technology, a U.S. Printer has recognized that Dlott's work has applications to very high-speed printing of high resolution color images and is co-funding his research.

Professor Jeff Tester of the Massachusetts Institute of Technology is working with his colleagues in the URI Center for Chemical Reactors for Super-critical Water Oxidation of Army Toxic Wastes. He has carried out the hydrolysis and oxidation of glucose in supercritical water. Glucose is used as a model for cellulosic waste and is one of the more complex materials studied thus far. With a reactor residence time of only 6 seconds, even at the lowest temperature studied (425 C), and in the absence of Oxygen, glucose conversion was over 90%. In other efforts, the reactor design and materials are being studied. Minimization or control of the corrosion is the goal of these studies. Supercritical water oxidation is a very promising technology, and is already being commercialized for sewage sludge and other waste treatment.

The final example is the excellent fuel cell research and development that has been accomplished by Analytic Power. They have developed fuel cell power supplies which operate on hydrogen and air and produce electricity and water. The hydrogen can be supplied from regulated gas bottles or it can be generated from sodium borohydride fuel pacs. The power supplies can be operated between 40 F and 120 F. And the natural voltage regulation is about 37% from full to no load. The chemical hydride fuel pacs can give the fuel cell energy densities of 800 to 1400 watt hrs/pound. It has recently powered a three-wheeled scooter, and replaced lithium batteries to operate a microclimate cooler (it's intended Army use). These fuel cells could have many other uses in the civilian sector wherever small mobile electric power units are needed, such as golf carts, shopping carts, and electrified wheel-chairs.

3. Conclusion

This brief report gives a partial picture of the numbers and kinds of projects (of a dual use nature) that were supported by the ARO in Calendar year 1994. Further information about these projects may be obtained by contacting the author of this report.

CONVERSION PROBLEMS IN SCIENTIFIC RESEARCH

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The main principles of the conversion of defense research and development activities in Russia are published in [1]. I may give the example of conversion processes in Scientific Research Institute of Applied Mathematics and Mechanics (SRIAMM) which is one of the seven Scientific Research Institutes in Moscow State Technical University n.a.Bauman (well-known for many years as Moscow Higher Technical School). It is the oldest Russian Technical University (founded in 1830) and one of the leaders of engineering education in Russia. Such well known designers of aerospace technology as S.Korolev, A.Tupolev, as well as N.Dollezhal, the chief designer of the first nuclear power plant in Russia, the famous inventory V.Shoukhov (called "Russian Edison") were among the University graduates. Eight Russian cosmonauts are MSTU graduates as well.

If before 1990 more than half of scientific research in SRIAMM had been done to fulfill enterprises' orders, now we don't have such orders. The only financial sources now are the State Technical-Scientific Programs. That is why the number of scientists in SRIAMM decreased to a considerable extent. Another part of scientists applies their knowledge in different areas of science. Here are some examples.

Specialists in explosion processes have proposed the new original method of conversion used-up tires into rubber crumbs. This rubber crumbs can be used for manufacturing track coating and another purposes.

The scientists of SRIAMM take part in investigations of the problems of electrization and radiation stability of electronic devices on satellite's board. The created software package can calculate total radiation absorbed doses of protons, electrons and electron radiation emission in the satellite's on-board apparatuses and outer shell. The software package has been tested during several years and that gave a lot of experience in calculating radiation stability of apparatuses and time of satellite's active existence. The results of these calculations agree well with the results of satellites' in-flight tests.

Investigations of the passage of protons with energies in the 1-1000 MeV range through a quasicrystalline material have fundamental and applied characters. The quasicrystalline material consisted of specially oriented graphite crystallites measuring no more than 1000Å. The computer experiment was based on recognized models of the passage of protons through matter and the Monte Carlo method. It took into account energy-loss processes and multiple scattering of the protons and the microstructural features of material. A quantitative dependence of the characteristic of the passage of

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protons on the material's microstructural parameters and on the direction of propagation, and the protons' energy has been discovered. In some cases the mean range of protons' energy in the material decreased to 80% and the straggling range varied by more than two to three times at constant density of the material $p \approx 2.22$ g/cm^3 . The authenticity of the effect has been confirmed by experimental measurements. It is expediently to apply the detected effect and elaborated method to material treatment, acceleration techniques and producing radiation protection of spacecrafts [2].

In SRIAMM we continue investigating the methods producing diamond films. Diamond, one of allotropic forms of carbon, is characterized by valuable properties that make it useful in many areas. Diamond is chemically inactive and has very high hardness, corrosion resistance. Among all materials, diamond has the highest heat-conductivity at room temperature. A comparison of the properties of diamond to SiC, GaAs and Si allow us to draw a conclusion that diamond is the best semiconducting material for the potential applications in the future. We used direct current arc discharge and supersonic plasma flow for diamond film deposition. Diamond application in thermal management is most interesting for us.

We gave considerable attention to investigations of power-load complexes. The present stage of perspective power complex designing for space engineering or other complex technical systems is characterized by the fact that their formation, the determination of the technical and mass characteristics occur in conditions inadequate to elaboration of separate systems. Therefore, when creating mathematical models of main subsystems and elements, it is necessary to conduct extrapolation under the conditions of stochastic uncertainty.

The given circumstances impose restrictions on methodology of optimum design of power complexes or other complex engineering systems. Therefore, it is essential to elaborate conceptual and methodological basis for the development of such systems.

In our opinion, system engineering approach permits us to solve the problem of synthesis of optimum structures having stochastic initial data. Using this approach, a number of principles should be realized, the most important of which are the principle of the purpose (to be realized through the criterion of efficiency) and the principle of decomposition which is based on a number of systems representations: procedural, functional, "macroscopic", hierarchical and "microscopic". In terms of procedural representation, a technical system is considered dynamically as a process, the other system representations reflect its static aspect.

The procedural representation of a technical systems assumes considering it as a set of processes characterized by a sequence of their states in time. The main notion is time of life which is the time interval during which the given process is functioning. The life time T is broken into a number of states S_{t0}, S_{t1},..., S_{tn}. Analyzing the conditions of processes going on as well as their previous states in the technical system at the given time permit to proceed to functional description of the technical system.

The functional representation of a technical system is associated with understanding of this system as a set of functions to achieve a certain purpose. Each element of the technical system performs certain function; however, at the same time it can give the

system some undesirable features. For function representation it does not matter what materials the elements are made of. However, the functions without fail are associated with material elements which determine a method for decomposition the complex technical system into parts.

"Microscopic" representation is characterized by consideration of a complex technical system as a single unit. The most important concept here is the technical system's environment, i.e. A set of all objects, the change of properties of which influences the technical system and which are affected by changes in properties of the technical system. In developing any engineering object, it should be considered both as a part of a larger object and in relation to other objects surrounding and influencing it.

The hierarchical representation of a complex technical system is based on the notion of a subsystem, or unit, which should be distinguished from the notion of element. The unit has functional specific characteristic of the whole technical system. The technical system can be represented as a set of units making system hierarchy. The lower unit of the system hierarchy is formed by a limiting unit which still retains the main features of the given technical system but can only be decomposed into elements but not units. The set of units belonging to one horizontal row of the system hierarchy is the level of hierarchy. Another important notion of hierarchical representation of a technical system is the concept of "the analysis level" which characterizes the depth of system hierarchy form a technical system as a whole to its elements, and expresses the limit of divisibility of the given technical system into subsystems. It is possible to point out two types of functional relations between the units of system hierarchy, horizontal and vertical. Horizonal relations (or coordination relations) are established between units of one level of hierarchy and can be of two kinds: unidirectional and bi-directional. Vertical relations (or seniority relations) exist between units of various levels of hierarchy, penetrate one or several levels of a technical system, and are external in relations to units of a lower level of hierarchy and internal in relation to a higher level. A sequence of levels of hierarchy cannot be rigidly specified, it depends on the problem to be solved.

Figure 1 shows decomposition of power-load complex as an object of research in structure-redundancy-deficiency terms. Redundancy means that it is not necessary that all functional places in Fig. 1 should be filled in within the framework of "microscopic" representations and insufficiency means the fact that the ranking levels can be continued downward, and within the framework of the fourth ranking level the list of functional places can be continued. Besides, in this figure the most powerful flows of energy are indicated.

The manufacturing for space technology is considering as the main consumer, as a rule [3,4].

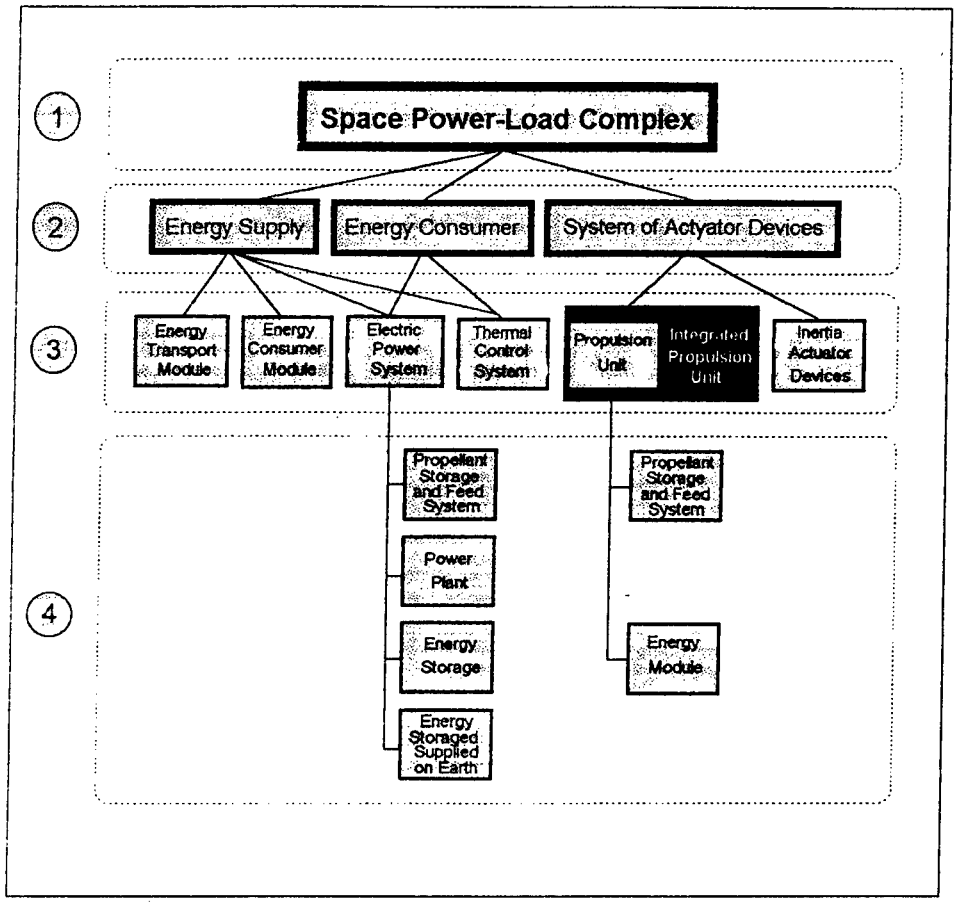


Figure 1.

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FILTER AND FILTER ELEMENTS FOR LIQUID AND GAS CLEANING FROM THE SOLID IMPURITIES

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1. Application

Filter and filter elements based on porous net metal and combined porous net metal (PSM and KPSM) for hydraulic and fuel systems of aircraft and special-purpose facilities were developed. The design engineering documentation for production-line items includes four engineering specifications for the porous media. These were issued in the course of designing. We have been providing the enterprises, manufacturing such filtering systems, with porous media and products, using these porous media, for several years.

In 1993 filters for cleaning the running water from solid impurities were under development (with delivering as a result). They could be used for the first and second loops of nuclear plants. Since 1992 there's been the activities to design and deliver filters and filter elements for hydraulic systems of metallurgical industries. We have provided a delivering of a number of filter sets to refine the oil in lubrication systems of centrifugal compressors and other industrial equipment.

To clean the foodstuff liquids mostly to prepare the water for the brewing industry a number of filters were under development in 1992....1993.

The aim of designing this type of filters is to replace filters used in imported equipment as well as in home one.

At the same time we together with co-designers solved the problem of joint of PSM and KPSM, in terms of processing technique, using laser welding.

We are ready to deliver the filter and filter elements according to your engineering specifications or represented sample, if imported, at least in 10 weeks after payment with or without the required tests.

2. Protection of Technological Process

A construction and methods for providing the porous media, being the filter basis, are protected by a number of certificates of authorship. Technical date on constructions, being worked out, is attached.

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3. Technical Data Gas and Liquid Filters

3.1 FORM

Set of filter elements (or one filter element) made of porous net metal.

3.2 APPLICATION

Gas and liquid cleaning of solid impurities.

3.3 POSSIBLE AREAS OF USE

Chemistry. Gas, oil-refining, machine-tool, aircraft, medical equipment, food and other industry enterprises.

3.4 TECHNICAL CHARACTERISTICS

- Method of filtration - mechanical
- Filtration rating - to 5 μm (liquid)
  - to 1 μm (gas)
- Permeability coefficient - 10^{-8} - 10^{-11} m^2
- Operating differential pressure - from 0.005 to 1 MPa
- Permissible differential pressure - to 40 MPa
- Service life (with a period of regeneration) in non-aggressive medium - not less than 10 years
- Regeneration by ultrasound. Mechanical regeneration or regeneration by back-wash, blow.

3.5 ADVANTAGES FOR THE FILTER

High durability.
Operation in a wide temperature range.
High reliability.
Workability.
Simple maintenance.

3.6 POSSIBLE COOPERATION

Joint development and manufacture of new filter materials and filter elements to be sold in the Russia and abroad. There is strong shortage of this product in the Russia market.

3.7 POSSIBLE COOPERATION

There are three areas inwhich cooperation is possible:

- calculations, design, testing;
- manufacture, delivery, installation and maintenance during the guarantee period;
- offers organization of a joint venture on a mutually advantageous basis.

4. Examples

The experimental data are presented in Fig. 1. KPSM has some porous nets metal. Experimental data (line 1) have value not more than 15...20% less than experimental date for porous net metal (line 2), which have the best filtration rating of this KPSM.

The such filter elements have were good weight data: because there is not special support turn frame work. As result the weight of filter element considerable decreases (to 20...40%: sometimes to 50%).

Such combination of technical data for filter elements of KPSM (PSM) was not accessible before (the samples of filter elements are demonstrated).

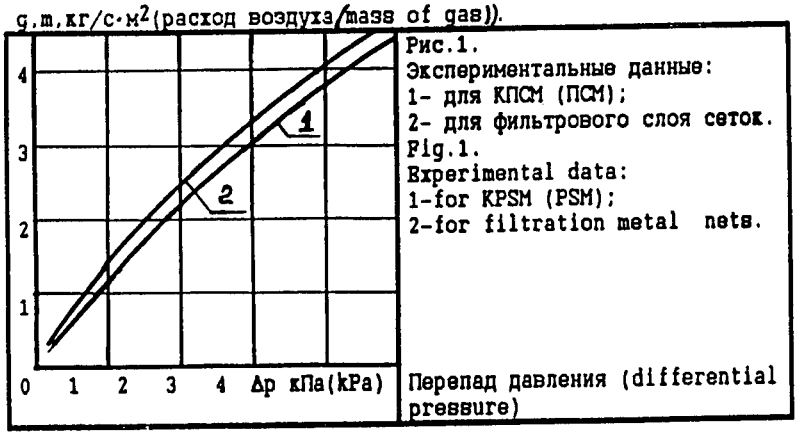


Figure 1. Experimental data

SETTING UP SUCCESSFUL STRATEGIC ALLIANCES

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1. Current Concepts and Applications

Strategic alliances may be viewed as an innovation or value "chain" for the successful commercialization of new technology requirements. These requirements consist of "forging links" with scientific, engineering, entrepreneurial, manufacturing, and marketing skills. If any of these links are missing or broken, the chain for successful innovation will not be forged. Forrest et al. [4] has identified and defined several types of strategic alliances.

The changed competitive environment means that organizations must find more innovative ways to compete and survive. Strategic alliances provide one option, particularly for technology-based firms. [4] The rising costs of developing technology as a globally competitive weapon are encouraging more and more firms to enter strategic alliances. In sectors with converging technologies, firms which have aggressively networked themselves have a major advantage over firms which traditionally have followed a more solitary path toward innovations. [14]

1.1 NETWORKS OF COMPANIES

One form of strategic alliance is the network of firms. These firms can be either totally domestic or include foreign firms as well. Many articles have appeared in the popular press discussing the virtue of cooperative relationships between large and small firms in high technology. These relationships have been termed strategic partnerships. The thrust of these articles is that synergy develops in these relationships because the small firm brings its strength - innovative technology - while the large firm brings its strength - downstream resources such as marketing. In theory, this merger of complementary strengths enhances the competitive position of the partnership relative to others in the marketplace and results in higher performance than either firm could have achieved alone. [7] Such partnerships are usually focused on a particular technology and involve joint efforts in many aspects of venture development. This distinguishes partnerships from contract R&D and venture capital investments. [4]

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Alliances are coalignments between two or more firms in which the partners hope to learn and acquire for each other the technologies, products, skills and knowledge that are not otherwise available to their competitors.[8] The network of firms has been described as a grid of firms or value-chain of elements.

TABLE 1. Types and Definitions of Strategic Alliances

Technology Development Alliances:	
UNIVERSITY AGREEMENT	an agreement whereby the company pays the university to conduct research on its behalf.
RESEARCH INSTITUTE	similar to the above.
COLLABORATIVE R&D	an agreement between two companies to collaborate on the development of specific products or processes.
RESEARCH AND DEVELOPMENT LIMITED PARTNERSHIPS	a tax advantaged investment vehicle which provides funding for specific projects.
TECHNOLOGY LICENSING (INWARD)	payment to another company for the use of its technology.
CLIENT SPONSORED RESEARCH	a company is paid to conduct research on particular products of processes for another company.
Commercialization Alliances:	
MARKETING/DISTRIBUTION AGREEMENTS	an agreement whereby another company markets and distributes a company's products.
MANUFACTURING AGREEMENT	an agreement whereby a company agrees to manufacture products developed by another company.
Financial Alliances:	
OPERATING JOINT VENTURE	an independent third enterprise formed between the firms. Assets are contributed by both parties who share risks and involvement.
EQUITY INVESTMENT	an investment by one firm in another, usually a large firm in a smaller firm.
TECHNOLOGY LICENSING (OUTWARD)	receipt of fees or royalties from another company for allowing use of its technology.

The critical factor is that all firms recognize that they are part of the grid and are at least minimally committed to supporting it. [15]. Coalitions are characterized as "quasimarkets", or "settings in which groups and individuals with varying interests and preferences come together to engage in exchanges, and engage in exchanging contributions for inducements." "The organization is the setting in which exchanges of inducements and contributions occur. Participants enter and leave the organization depending upon both their assessment of the relative value to be gained by continuing the exchange and the organization's assessment - the assessment of others in the coalition of the same issue." [1] By using a network structure, a firm can operate an ongoing business both efficiently and innovatively, focusing on those things it does well and contracting with other firms for the remaining resources. In many networks, firms create and assemble resources controlled by outside parties. [15] Also, networks may be formed between supplier and customers because alliances with customers are more dependable than open market transactions. [9]

Networking with firms in other industries enhances access to their technological expertise. External partners can provide complementary technology and may participate in strategic alliances to implement innovations spanning multiple technologies. Networking like technological skills, is subject to learning: a firm's experience in dealing with external partners is an integral component of its stock of skills. [14]

Snow et al. [15] breaks these networks into two categories: stable and dynamic networks. A stable network spreads asset ownership and risk across independent firms. In bad times, however, the parent firm may have to protect the health of smaller family members. The benefits of stability are the dependability of supply or distribution, as well as close cooperation on scheduling and quality requirements. The "costs" of stability are mutual dependence and some loss of flexibility. [15]

Dynamic networks can provide both specialization and flexibility. Each network node practices its particular expertise, and, if brokers are able to package resources quickly, the company achieves maximum responsiveness. However, dynamic networks run the risk of quality variation across firms, of needed expertise being temporarily unavailable, and of possible exploitation of proprietary knowledge or technology. The dynamic network operates best in competitive situations where there are a myriad of players, each guided by market pressures to be reliable and to stay at the leading edge of its specialty. The dynamic network is also appropriate in settings where design and production cycles are short enough to prevent knockoffs or where proprietary rights can be protected by law or by outsourcing only standard parts and assemblies. [15]

In comparison, Forrest et al. [14] has grouped alliances into three types:

Technology development alliances - designed to expand R&D expertise to keep abreast of the state of the art.

Commercialization alliances - designed to provide and/or expand manufacturing and marketing capabilities.

Financial alliances - designed to help provide the funds needed to support technology acquisition and commercialization strategies.

Snow et al. [15] lists several reasons why managers who want their companies to be strong competitors in the 21st century are frequently deciding to form networks. These managers are urged to:

- Search globally for opportunities and resources.
- Maximize returns on all the assets dedicated to a business-whether owned by the manager's firm or by other firms.
- Perform only those functions for which the company has, or can develop, expert skill.
- Out source those activities that can be performed quicker, more effectively, or at lower cost, by others.

These reasons become the basis for many of the networks that exist today.

1.2 UNIVERSITY-INDUSTRY ALLIANCES

Technological advances have made the world's universities an increasingly critical supplier of useful knowledge for industry. American universities perform about 60% of all U.S. basic research, and a much smaller but still significant amount of applied research. In the not-too-distant past, there was ample time for the results of this work to slowly trickle into use. Today, the time between the creation of new knowledge and its practical application is shrinking rapidly. Universities are consequently playing an increasingly direct role in shaping the ideas industry turns into new goods, but universities cannot always be expected to meet industry needs on their own initiative. [4]

The changing global economy and the changing nature of scientific research are bringing about the intensification of university/industry cooperative ventures. The university-industry's interaction in R&D has been attributed to industry's desire to maintain a window to new technologies, a first hand in selecting future scientific employees, and to compensate for lagging federal support in R&D. In the continuum of experiments, university-based expertise is utilized to develop technologies that undergrid marketplace successes and promote regional economic development. [5]

Typically the alliance has a hybrid form, somewhere between a university department research unit and a semi-independent "stand alone" consortium. Member companies are also entitled to review any scholarly publications/outputs generated by the alliance prior to publication. Usually, semi-annual meetings are held in which alliance personnel, academic scientists and technicians have an opportunity to interact with representatives of industrial sponsors about policy issues and research agenda. Member companies enjoy first rights to research findings and a first hand access to graduating students. Some companies support research tailored to their specific needs. [5]

Company recruiting is a critical side benefit to having college ties. For any firm the quality of its own R&D depends on the quality of the people doing the work. Universities provide a crucial input because new graduates have been exposed to the latest frontiers. [4]

Unfortunately, the focus in university-industry interaction has been mostly on the precariousness of alliances based on expediency rather than trust and on the possibility that they might abridge the principles of free inquiry, open dissemination of ideas, collegiality and primary commitment to the general mission of the university. Managers/directors of alliances should be aware of the fact that these alliances face similar managerial problems across disciplines and universities. Thus an exchange of information and mutual consultation in sharing experiences among managers would greatly benefit management in these type alliances. [5]

2. Issues in Collaborative and Alliance Ventures

Joint ventures or alliances are often too inviting. The lure of entering a new arena while side-stepping one's own limitations is heady stuff. In practice, mere survival calls for patience and care because joint ventures are inherently fragile. Managers turning to this form of alliance need a keen appreciation of the diverse issues involved in each specific opportunity. [12] This section will examine the issues associated with strategic alliances and collaborative organizations. Most of the issues are addressed in general terms that do not differentiate between the type of collaborative or strategic alliance.

Strategic alliances hold vast potential for reshaping firms and industries. Today, it isn't enough to use alliances to strengthen an individual company. Growing interdependence i these s giving links to key partners new importance. Alliances also have to be used to fortify links. [9] Success depends on effectively negotiating, planning, and controlling the alliance. Forrest et al. [4] lists several reasons they found for establishing alliances in Table 2.

2.1 DETERMINING WHETHER TO FORM AN ALLIANCE

An organization must determine the type of alliance it seeks. Alliances can be formed to share costs, reduce risks, obtain economics of scale or gain access to new markets. ([8] One challenge is to recognize and respond to the fact that alliances force a redefinition of the strategic playing field. [4] Domestic firms often believe that alliances serve ultimately as outsourcing or long-term supply agreements to free up capital for R&D, new products, or higher dividends. However, the alliances may actually be creating new competitors in those fields. Conventional wisdom and strategic analytic tools used by senior managers today actually encourage impulsive alliance formation. Some strategic tools create the illusion of building a competitive advantage, but they may actually encourage managers to enter into alliances too quickly. These can undermine corporate efforts to focus on and renew core competencies, while discouraging careful thinking and

strategizing of prospective partners' intentions. Managers must determine if they are prepared to satisfy the needs of an alliance. [8]

TABLE 2. Principal Reasons Why Strategic Alliances Were Established, Ranked in Order of Importance

RANKING	REASONS
1.	Facilitate rapid exploitation of technology
2.	Generate short term revenues
3.	Share the risks of new product development
4.	Gain access to financing
5.	Gain credibility
6.	Gain access to partner's R&D facilities and expertise
7.	Link into partner's established marketing/distribution network
8.	Give credibility to new products
9.	Develop products for specific market niches
10.	Access export markets
11.	Benefit from partner's clinical testing experience
12.	Benefit from partner's expertise in regulatory approval
13.	Benefit from economies of scale in manufacturing
14.	Pre-empt potential competition
15.	Expand competitive intelligence
16.	Be a low cost producer
17.	Benefit from partner's manufacturing facilities and expertise
18.	Benefit from partner's pilot production facilities
19	Access partner's scale-up facilities
20.	Gain access to general management skills
21.	Ward off acquisition

One of the first concerns about alliances regards sharing control. [9] Organizations often face the vexing choice of implementing innovation internally or through some external form. There is a profound tension between these alternatives. A firm might be reluctant to relinquish control over innovative activities that are central to the maintenance of its competitive edge. External implementation raises the danger of appropriability and provokes issues of ownership, management structure and equity in the sharing of costs and benefits among the participating partners. In fact, internal implementation has been the rule and forms the basis of virtually all innovation research and theory. The choice between internal versus external forms acquires additional significance when compared against the history of interorganizational skill building.[14] Partnerships also require managerial intensity from large corporations because collaboration involves more shared decision-making than in-house development.[7] The time and human resources necessary to manage a partnership can be high, and venture organizers must be prepared to make commitments to the relationship as well as the operational aspects of the venture.[10]

One key step is to be sure an arrangement is really an alliance: partners have a mutual objective, need each other to get there, and share the risks. Cooperative arrangements facilitate transfer, but they require the innovative allotment of resources and

outcomes with other organizations, together with the formation of precarious management structures. Given the widespread experimentation with internal entrepreneurships, there are many organizations which follow a solitary route to new technology rather that to externalize their innovative efforts. Whatever an organization's skills in building internal or joint ventures, some of these skills are as critical for successful implementation as are available technological skills. There is a disinclination to partner with other firms that have comparatively few skills in implementing innovation externally. [14].

Thus far the results of joint ventures in transforming economies have been disappointing. Industrial ventures involving complex technology have encountered tough hurdles. A majority of the early hasty agreements have been abandoned or sharply revised when operating realities were faced. As a result of unfavorable publicity, many foreign companies are now unwilling to spend time exploring possibilities. [12] In contrast, successful alliance practitioners share key relationship-building attributes regardless of cultural challenges. Managers in these firms go out of their way to get to know their partners as individual and as functioning organizations. Representatives from both firms take time together doing things. Formal talks with partners are complemented by off-the-record conversations by people who have become comfortable with one another. By complementing a firm's internal resources, strategic alliances ease its access to other markets. By reducing entry barriers, alliances thus bring new competition to every sector. In this process, a firm must preserve and protect its core strengths, those hard-to-duplicate abilities that bring unique value to its customer and sustain the firm. Alliances can be used to reinforce core strengths without compromising them. Other less central functions may be spun off into alliances with various partners. [9]

If the alliance is to collaborate on new technological ventures, Hull and Slowinski [7] maintain that alliances should be established with a partner that provides "technology - plus". Traditional theory states the principal reason major corporations partner with entrepreneurs is their innovative efficiency. Large corporations often contribute the technical expertise to incubate new technologies faster and more efficiently in entrepreneurial firms. Partnerships enable large corporations to enter new market segments or enlarge their share of existing ones quickly and at low cost. Large corporations enlarge their potential domain by gaining a window on new technologies or obtaining an option to participate in their development through cooperative ventures. Risk is reduced because the damage to the corporations from failure is less than for inhouse development. Usually large and small firms are interested in the same technologies but instead of competing, they collaborate by exchanging complementary resources to achieve synergy in an ongoing relationship. "Strategic fit " between small and large companies is most likely to occur when the resources contributed by each are complementary. The partner should give technology, a significant proportion of the financing, manufacturing, marketing and management. Large corporations that partner with technological entrepreneurs should be prepared to devote considerable managerial talent to the relationship because the managerial requirements on the large firm will likely need to be significant.

A number of factors influence management to search for technology outside the firm. Many of these reflect time pressures and/or the need to reduce uncertainty in cost, timing and performance of new (or improved) products and manufacturing technology. Other reasons to search for technology outside the firm include the lack of specific internal ability to carry out a given program, preoccupation with maintenance R&D and incremental improvements and disappointment with the track record of the firm's existing R&D. Managers should take the initiative in helping their companies develop a strategy for acquiring outside technology and in building bridges from the company's R&D community to the business operations sector. The R&D team is in closest contact with the world of technology, and has the primary role in serving as "hunter/gatherers" of technology opportunity. Some of the reasons for using an alliance to achieve technology transfer is that an alliance forces an organization to deal with the main issues of technology transfer; basically that:

1) Technology transfer must be seen as a process requiring continuous and complex human interaction;
2) Face-to-face methods of transferring technology are more effective than reports and publications-publication of research results is neither a necessary nor sufficient condition for technology transfer;
3) the movement of people is one of the most effective forms of technology transfer; and
4) User participation in the development of the technology motivates buy-in.

Perhaps the greatest barrier to technology transfer is NIH - Not Invented Here. Technology transfer implies the need for new management philosophy and tools. Hierarchical management from the top down does not enhance, and may even impede, the process of technology transfer. American institutional biases strongly favor the technology-push phenomenon where ideas originate with external sources. Today's international competitive economic environment is forcing a far more complementary push/pull process which mediates laboratory capabilities to meet market needs. [4] By using a strategic alliance some of the prejudices against technology transfer may be overcome.

However, care should be taken in forming technology exchange alliances. One of the partners may find that the costs of sharing technology or skills significantly outweighs the potential benefits. Sharing risks or improving cost position usually requires that both partners share their knowledge and technological skills concerning the immediate product or manufacturing process under development. The growing levels of technological or production interrelationships between once disparate industries mean that collaboration on one specific product often opens up the firm's entire array of related skills and technologies that may have direct application to other fields. Because highly interwoven production and technological relationships are based on core competencies, and can provide the means for entering new and different markets, a technology sharing alliance can undermine a firm's long-term potential in a particular industry. [8]

The university-industry alliance faces some additional problems. The university researcher turned entrepreneur confronts such critical factors as: support from university officials; initial support from industry; economic conditions in the target industries, disinterest on the part of the university administrators and colleagues, and lack of prior experience. The ability of the university to mold from academic environment a viable and accessible technical/scientific pool of quality faculty and students is another vital concern. In addition, another potential pitfall is the university's ability to translate the needs of the academic and industrial culture in a manner acceptable and satisfactory to both. Industrial representatives advocate more "cutting edge" research, but indicate a desire for "relevancy" to support industry funding. The alliance can become trapped into being more concerned with modes of communication and assuring industry's continued support and less concerned for technology transfer. [5]

2.2 NEGOTIATING THE ORGANIZATION

The first step in forming an alliance involves choosing a partner. Expectations must mesh and partners must be on the same wavelength. At the same time an equality of partners must exist; one-sided alliances are more likely to fail. [4] Alliances have to be found, and commitments made by people close to the action. They are in the best position to sense, understand and respond to the needs of the partner. Successful alliance practitioners share key relationship-building attributes. One is a deep belief that to work together, people must really understand one another. Experienced alliance practitioners recognize that coercion or submission defeat the mutual effectiveness. [9] Instead, a successful exchange process must be established. To make the exchange process effective, the partners need to think of the other organization as an ally, know the world of the partner, including the pressures as well as the partner's needs and goals, be aware of key goals and available resources that may be valued by the partner and understand the exchange transaction itself so that win-win outcomes are achieved. [2] Each of these factors is necessary to establish an effective alliance.

Managers must take steps to better understand competitor/partner motives. Alliances in themselves represent a temporary coalignment of current interests. Each alliance mirrors the other partner's options and capabilities at a point in time. The most attractive partner in the short run is likely to be a company that has a leading share of the market, but needs to learn some new technological skills. In the long run however the best partner might be the one that does not have a dominant share of the market or isn't even in the industry. The latter case offers much greater opportunity for both partners to maintain a healthy balance of contribution and dependency. [8]

One of the first steps is to establish an external "friendly" relationship with the partner. In most cases the only way for two companies to avoid the shifts of balance in this relationship is to commit all the managerial resources to the establishment of a new venture. The second step is to help build up the partner for a period of time without "giving away the store". The third step is to complete a specific task such as penetrate a new market or share the risks of a technological development. Successful alliance

strategy is based on its managements careful understanding of each partner's motives, their technological scope, and the alliances' implications for a two-way knowledge flow. [8]

Developing alliances often involves tradeoffs. It is necessary to recognize that firms from different cultures may not subscribe to the same business practices. Time is recognized as an important element in negotiating and running the alliance. A large amount of time is needed for the negotiating stage (6 months to a year depending on the type of agreement being negotiated and the parties involved). Often most of the agreement can be resolved quickly, but issues that could result in legal complications take the longest to resolve. No set formula can be established for developing and negotiating alliances, for each is unique. Those who are involved in the negotiations must be tenacious in working out the agreement and the details with depth and precision. [4]

The alliance agreement is the outcome of the negotiating process and involves a large amount of planning. It is imperative to try to determine all the possible permutations and combinations of what could emerge during the alliance process. This foresight is particularly important for research alliances where ownership of intellectual property is at stake. ([4] An agreement on a mutually beneficial win-win concept is a necessary but insufficient basis for a successful joint venture. More specific terms for the cooperative effort need to be spelled out. [12] Forrest et al. [4] identified certain items that should be included in the agreement. These were: who is to manage the alliance and who has the necessary authority to mobilize resources when needed, milestone points, non-disclosure agreements, built-in renegotiation points, and clearly defined goals. For successful university alliances, the agreement requires particular care. University alliances must be based on mutual interest, remembering that universities' prime function is to advance science while the firms' is profitability. Patenting and publishing policies should be included in the agreement. Exit terms must also be included. It must be recognized that each alliance is different, and each one should be negotiated contingent on the situation. [4]

Among the challenges that face an alliance are the need for substantial delegation and an unprecedented emphasis on organizational learning. Alliances cannot function with top down management. [9] To maximize effectiveness and to deal with what Lynch [10] calls "the variables of the ambiguity-certainty continuum", the management style of most alliance organizations will be some combination of the hierarchical and the collaborative styles. There should be a mix for the alliance to have enough power to function. In addition, it may be advisable to plan a change of venture managers and sponsor liaisons if the venture goes through distinct and highly differentiated phases. It is much like having a "lateral promotion" to provide a broader perspective and understanding of the nature of the alliance and to introduce a fresh perspective on the needs of the alliance.[10]

If the alliance is primarily to foster technology transfer, it can be facilitated by the presence of special liaison agents. These agents are also referred to as gatekeepers or boundary spanners. Other descriptions and classifications for this coordinating role also

exist, but the underlying idea is generally the same; there is a need to integrate the values, roles, and perspectives of different functional divisions through some formal or informal mechanisms to resolve differences and conflicts between them. The typical gatekeeper is a highly technical performer who connects an organization with outside sources of technology. He keeps up with new technical developments outside the organization by reading the more technically sophisticated literature and by communicating with external technical experts. Further, because of his proven technical competence he is frequently consulted on technical matters. As a result, the gatekeeper is a very effective channel for transferring technical information into an organization from external sources. M. L. Tushman extended the gatekeeper concept by showing there are key individuals who span boundaries within an organization. These individuals perform the very important role of integrating differentiated functional or departmental units. [13]

Many firms have concentrated their efforts on designing, distributing and marketing new ideas only to have them actually produced in a partner's manufacturing facility. In numerous cases, this division of labor results in a steady deterioration of the firm's production skills and technologies that are important sources or organizational learning. Because alliance implementation depends upon frequent day-to-day contact between employees and managers, it is difficult to seal off the many unforeseen gateways and opportunities for a partner to learn about a firm's technologies. One-time technology transfers, such as exchanging blueprints and design sketches, are not nearly as effective or dangerous. [8]

Once an alliance has been formed, managers can design a structure to implement the alliance's strategy. Group headquarters become meaningless. Since managers in the alliance are responsible for manufacturing/marketing strategy and coordination with other responsible departments, there is little value-added potential for another structural layer. Value-driven superstructures rather than bloated corporate headquarters should oversee the day-to-day operation of the alliance. Where necessary, shared resources should be organized as profit or cost centers. A type of structure that is replacing the traditional functional-based form is the horizontal organization. Work is primarily structured around business processes such as new product development, manufacturing technologies, or integrated logistics, as opposed to areas of functional expertise. It is these processes that link employees to the needs and capabilities of suppliers and customers in a way that improves performance. In horizontal organizations, alliance's core processes are owned by teams. Each team is responsible for a process' performance and ensures that its performance objectives are congruent with other processes and with the strategy of the alliance. The technical expertise to support these teams is housed in each parent. Many organizations have been able to make these teams self-managing. To be effective, the teams must have the authority, information, resources and motivation to evaluate and to change when, how, and with whom they do work. Team members must hold themselves accountable for agreed-on goals and be rewarded for the attainment of them. [8]

A venture designer seldom has a clear or complete vision of all the specific operating networks that may ultimately emerge from his or her efforts. The architect has in mind only a vague concept of the product and of the value-added chain required to produce it. [15]

3. Common Causes Of Failure

Throughout the 1980s, organizations around the world responded to an increasingly competitive global business environment by moving away from centrally coordinated, multilevel hierarchies and toward a variety of more flexible structures that closely resembled networks rather than traditional pyramids. These networks, clusters of firms or specialty units, are viewed by both their members and management scholars as better suited than other forms to many of today's demanding environments. The various components of the network recognize their interdependence and are willing to share information, cooperate with each other, and customize their product or service, all to maintain their position within the network. Recently designed networks expect a more proactive role among participants, voluntary behavior that improves the final product or service rather than simply fulfills a contractual obligation. This results in an organization collectively based on cooperation and mutual shareholding among a group of manufacturers, suppliers, and trading and finance companies.

Two types of subtle managerial "mistakes" that can be made in ventures are: making individually logical extensions of the form which in the aggregate push the form beyond the limits of its capability; and modifying of the form which, while reasonable on the surface, nevertheless violates the form's operating logic. [11] A third proposed by Lei and Slocum [10] is allowing a firm's capability to be "hollowed out." Other factors that can affect the success of an alliance are overcommitting resources to the alliance, failing to ensure that the underlying concept of the alliance is viable, misreading the marketplace, and misrepresenting capabilities. The following is a ranked set of reasons for alliance failures uncovered by Forrest et al.[4] and a list of causes of failure in network organizations by Miles and Snow [11].

3.1 LOGICAL EXTENSIONS TO ORIGINAL ORGANIZATION

If managers of functional departments have full say over assignments to project teams, the needs of the stable portion of the organization will dominate those of the flexible side, making it difficult for project team managers to meet customer needs for both technical sophistication and timeliness. The stable portion is designed to serve a mostly predictable market by linking together independently owned specialized assets along a given product or service value chain. The stable network substitutes a set of component firms, each tied closely to a core firm by contractual arrangements, but each maintaining its competitive fitness by serving firms outside the network for the open market. If the several suppliers and distributors in the stable network focus their assets solely on the

needs of a single core firm, the benefits of broader participation in the marketplace are lost because the price and quality of their output is not subject to market test. Unless multiple outlets are used, the value actually added by distributors must be set by judgement rather than by market-driven margins. This can ultimately result in the inability of the supplier to compete in other markets and an obligation on the part of the core firm to use all of the supplier's output. For maximum effectiveness, they must explicitly consider the limits of allowable dedication, forcing themselves to set restrictions on the proportion of component assets that can be utilized. [11]

3.2 VIOLATION OF THE ORIGINAL PURPOSE

When managers "dream different dreams", a lack of mutual understanding can develop, which can then result in the demise of the joint venture. [8] Henderson [6] found several cases where investments in technology yielded no measurable impact. In many cases, this failure appears to stem not from an inappropriate vision but from the inability of the organization to integrate the use and the management of the technology infrastructure into the mainstream of the firm. [6] Miles and Snow [11] supported these findings. One reason for network members to participate in the market outside their relationship with the core firm is to force these components to maintain their technological expertise and flexibility. They must develop their adaptive skills by serving various clients. In the search for assurance that suppliers can meet quality standards and delivery dates, some core firms attempt to specify the processes that the network member must use. The core firm can ultimately find itself "managing" the assets of its partners and accepting responsibility for their output. When the operating independence of the network member is severely constrained, any creativity that might flow from its managers or staff is curtailed and the firm is not getting the full benefit of the component's assets.

Dynamic networks are designed for independent firms to be linked together for the one-time (or short-term) production of a particular good or service. The availability of numerous potential partners eager to apply their skills and assets to the upstream or downstream needs of a given firm is not only the key to success of the dynamic network, it is also a possible source of trouble. Firms with a contribution base that is either too narrow or weakly defined are easily overrun by their upstream and/or downstream neighbors. There is a constant temptation for firms to go beyond the development of their own competence as the means of insuring their viability. They may seek to add protection through an excessive concern for secrecy, heavy emphasis on legalism in contractual relations, a search for preferential relationships with particular partners. Such protective modifications can constrain the primary strength of the dynamic network, its ability to efficiently allocate member firms, uncoupling and recoupling them with minimum cost and minimum loss of operating time.

TABLE 3. Reasons for Unsuccesful Alliances

RANKING	REASONS
1.	Not enough attention was paid to detail
2.	Differing strategic goals
3.	There was a lack of significant top executive time and commitment
4.	Mutual trust between the two parties did not develop
5.	Alliance details were not well thought out
6.	Problems with managing the alliance
7.	Partners unwilling to keep to the terms of the agreement
8.	Organizational cultural differences
9.	Incompatibility of partners
10.	Changes in partner's objectives
11.	Problems of give and take
12.	Partner reneged on promises
13.	Failure to agree in advance how to manage the alliance
14.	Partnering politics could not be mastered
15.	Problems with royalty payments
16.	Changes in top management of either partner

The possibility that firms adopting network structures will improve their self-renewal competence flows from two unique characteristics of the network form: the essential relationships among components are external (and thus highly visible to all parties) and these relationships are voluntary (and thus must reflect explicit commitments). Even when a network's components are common, the essential structure of the organization is external, an exoskeleton of clearly specificed, objectively structured contracts and by-and-sell agreements that guide interactions, rather than internal schedules, procedures, and routines. With external linkages, attempts at personal gain may be made, but the behavior will be much more transparent. These contracts or agreements specify the performance that is expected from each partner and how that performance will be measured and compensated. The fact that network relationships are explicit does not mean that they are dictated by one party or another. If voluntarism is not present, if partners are not free to withdraw from relationships they believe are unfairly structured, then the value of openness and explicitness is compromised. [11]

3.3 HOLLOW ORGANIZATIONS

Companies must learn how to utilize strategic alliances without becoming "deskilled" and "hollowed out." Deskilling creates a dependance on other firms for components, supplies, and new designs and technologies. Firms that rely on strategic alliances as an outsourcing mechanism to secure access to competitive products may find their own skills sets deteriorating as they become "locked out" from learning new skills and technologies critical to participating in future industries. Joint ventures, outsourcing agreements and co-production arrangements can effectively transfer away initiative and learning from the firm to its alliance partner if managers are not cognizant of the different goals held by their alliance partners or if they are not careful about the interrelationships

that involve technologies with a variety of applications. Alliances pose fundamental risks to firms regarding the flow of information and technologies. By their very nature, alliances create direct and indirect "windows of opportunity" for gaining access to a partner's skills, technologies, core competencies and even strategic direction. Outsourcing may actually accelerate the "hollowing out" of a domestic industry because foreign partners are able to develop the kinds of human resource skills and technologies that are needed to eventually enter into the industry on their own. [8]

Alliances that are based on developing and producing component parts or a broad-based generic technology are particularly susceptible to applications in various different markets that are beyond the current alliance's scope. The problem is greatly magnified by the varied applicability of technologies now occurring in a wide range of different industries. The loss of tacit skills and core competencies may not only affect the immediate industry, but may have damaging collateral effects in related sectors as well. Various stages of dependency emanate from a poor understanding of core competencies and of alliance partner's motives. The seven stages of growing dependency listed in Table 8 reveal the dangerous role alliances can play for those firms that do not understand their partner's dreams. [8]

The single biggest cost may be one partner's loss of skills and other sources of competitive advantage to a partner who then becomes a more direct and more potent competitor. Ignorance and lack of experience are often at the root of alliance problems and failures. Once they realize how dangerous alliances can be if they don't understand their partners' motives, firms can avoid becoming "hollowed out". [8]

TABLE 4. Stages in Dependency on Partnerships

STAGE ONE:	Outsourcing of assembly for inexpensive labor
STAGE TWO:	Outsourcing of low value components to reduce produce price
STAGE THREE:	Growing levels of value-added components move abroad
STAGE FOUR:	Manufacturing skills, designs and functionally related technologies move abroad
STAGE FIVE:	Disciplines related to quality, precision-manufacturing, testing, and future avenues of product derivatives leave
STAGE SIX:	Core skills surrounding components, miniaturization, and complex sywtems integration move abroad
STAGE SEVEN:	Competitor learns the entire spectrum of products and skills related to the underlying core competence

4. Future Challenges

Alliances clearly play a major part in today's competitive business strategy. What is much less clear, however, is how networks are going to be designed and operated and where their future applications lie. Researchers and managers alike need to review the progress of the network form and the factors affecting its deployment.

Management of the knowledge assets needs to be a prime consideration of every company. Information specialists who are creative and who have a special ability to recognize new and significant technologies are needed by U. S. industry; universities need to develop curricula to help train such specialists. Companies also need to plan for effective research by developing long-range research plans. Effective technology acquisition and implementation requires a long-range technology transfer plan as well. The time has come to get serious about technology transfer. Alliances have been shown to help with the process.

One of the major sources of competitive advantage for any alliance is its ability to attract talent from anywhere in the world. The question of how the managers of tomorrow's network organizations should be selected and trained needs to be addressed. In the future, strong interpersonal linkages will be required to sustain learning and to provide the glue for keeping an alliance together. Thus a systemic international management development system is vital. Companies are experimenting with various human resource activities as a means of developing sources of competitive advantage. Some common practices in these programs are: to give newcomers early assignments outside their home country; assign them to international alliances; and make them manager of an alliance outside their home country in the first five years. In addition, faculty and research staff are familiar with industry needs. They were able to gain industrial knowledge and experience through consulting, short courses and conference activities and participation in professing society activities which attract industry personnel. This knowledge needs to be passed on to the students.

A systematic approach to developing human resources usually takes ten years or more to come to fruition. Firms need to begin today to train tomorrow's alliance managers.

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TWO-BEAM ACCELERATOR BASED ON A VIRCATOR-GENERATOR AND A PERIODICAL MAGNETIC FIELD

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Abstract. *A two-stage scheme of ion collective acceleration in investigated on the basin of simultaneous space and time modulation of the REB. At the first stage the REB time modulation is realized via ions accelerated by a virtual cathode (VC) field. At the second stage, the REB modulated at a frequency of about 20MHz, is injected to the drift chamber placed in the space-periodic magnetic field, where space modulation of the beam takes place. In the drift chamber, the ions from the VC are accelerated by a slow travelling wave of REB, originated from space and time REB modulation.*

1. Introduction

The solving of the problems of ecology, economy and conversion in Ukraine is interdependent. The overcoming of the consequences of the negative influence on the environment of various antropogeneous and technogeneous factors, especially of the consequences of the Chernobil disaster, requires not only financial and material-technical means but using of new ecophil technologies. In the wide extent the conversion can promote the solution of this problem. Machine-building and military-industry complex is the essential part of the industry potential of Ukraine that is organized in Ministry "Minmashprom". Minister of the department V. Petrov at the first Congress informed the following [1]. The volume of enterprises production in a total volume of industry production in a total volume of industry production in Ukraine is 15-18% in existing prices and 20-25% in comparative prices.

The scientific-technical potential of this department consist of 379 scientific-researching, design and planning organizations, numerous design and technical offices. It accounts for 40% of the total scientific-technical potential of the Ukraine. In these organizations above 150 thousands people including almost 30 thousands of scientific researchers, between them about 3 thousand of Professors and Ph.D., that personify the future of the department. That is why during realization of the deep economical and social reforms, initiated by President of the Ukraine L. Kuchma, the great hopes entrust on the machine industry and military-industry complex.

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But avalanche conversion in "Minmashprom" is the essential factor of negative economical situation and social strengthening. During 1991-1994 years the proportion gravity of the commodity production of the military application decreased from 22.7% to 4.0% in the total volume of industry production. At the 218 enterprises of the department the proportion gravity of the defence and special production was above 20%. At the 100 enterprises military production was equal more than 40% in the total volume of production. As a result of such unprecedented in the would practice one moment curtailing of the military and special production, the progressive technologies and high scientific and technical potential of defence industry are turned out under the threat of destruction.

The main problem of conversion became adequate substitution of the special production by the production of the civil predestination equivalent by scientific capacity and competitiveness. To give the conversion process the controlled character the aimed scientific and technical programmed of gradual, raising of the civil production in the 22 priority directions of the scientific and technical progress. Between the main one's are the elaboration and manufacturing resources economy equipment, machines for fuel energy complex, creation of the machine and equipment complex for agriculture, food and manufacturing industry, complex domestic and radio-electronic technics, medical equipment, instruments etc.

President of the Ukraine Academy of Science B. Paton underlined [2] that at present some great problems of the Fundamental science and their application are solving together with other countries, namely cosmic welding, monocrystals growing in space etc. A special attention is paid to the global problem of space cleaning from the debris and waste, because cosmic launching in various countries are intensificating approximately about 10% per year, that leads to space debris accumulation.

As an example of conversion of scientific researches is the activity of Ukrainian Scientific Technological Center, created by USA, Canada, Sweden and Ukraine to divert military activity of scientists to civil investigations.

Now we represent the transformation the scientific investigations of generators and accelerators, that can be considered as Star war weapons to the elaboration of the accelerators for the technological and fundamental applications. Namely, the problem of electrical nuclear method of energy producing can not be solved without accelerators of the energy about 1GeV and ion beam current of 10-100 mA. As an unit of such accelerator the following theoretical and experimental elaboration of two-beam accelerator can be considered. As a HF-source it uses the power generator called vircator.

2. Theory

Ion acceleration in the field of a slow REB wave excited with a simultaneous space and time beam modulation [3] is one of the most promising methods of collective ion acceleration. This acceleration method allows one to obtain on the one hand, a high acceleration rate unattainable with the traditional accelerators, and on the other hand, a

resonant character of acceleration, that makes it analogous to the traditional methods. The wave phase velocity can be governed either by changing the space modulation period [3] or by changing the time modulation frequency of the REB [4].

The temporal particle-density modulation of the REB at a frequency of several tens MHz is one of the most difficult problems arising during development of the collective ion acceleration method under consideration. Here we discuss the possibility of a low frequency (LF) REB current modulation ion the regime of ion acceleration by the VC. So, two aims are achieved in this scheme: (i) ion acceleration up to the energy of order of the initial REB particle energy, and (ii) LF-modulation of the REB current, that is necessary for slow wave excitation when the modulated beam is injected into the space-periodic manager field.

To determine the mechanism of LF-modulation and its typical frequencies, a simulation code adequately fitting the experimental conditions was worked out, in which the self-consistent two-dimensional ion flow dynamics with the VC of the magnetized REB was investigated by means of the CIC model in the potential approximation. The typical model parameters were: electron current 50-500 A/cm, ion current 0-50 A/cm, initial electron energy 200-500 keV, initial ion energy 50-100 keV, ion-electron mass ratio 25-30 beam diameter 0-3 cm, system length 7 cm. When ions were absent, the C-formation and the accompanying HF-modulation of reflected and transit currents were observed. The HF-modulation of transit currents is presented in Fig. 1a. For the second case of ion presence, the LF-modulation took place even for the ion-electron current ratio equal to $l_i / l_e = 0.1$, Fig. 2a, 2b show the ion distribution in the interaction region for the cases of ion injection near the beam axis and from the outside of the electron beam, respectively. It is seen, that in the $r_i / r_e = 3.5$ case when the LF-modulation of the REB takes place, the transverse ion motion plays an essential role in the VC dynamics. Moving in the two-dimensional potential well of the electron beam, the ions accelerated in the longitudinal direction and are displaced to the system axis, forming a focus behind the VC. As a result, the ion beam takes the form of a ripple. With a sufficient quantity of ions stored, the REB space-charge compensation leads to the displacement of the VC into the chamber and then to its disappearance. In this case, the total electron beam transits through the system, acceleration of ions in the VC field and hence, their arrival to the electron beam region stop. Then, the previously stored ions drift into the chamber and the VC is restored near the entrance of the chamber. This process periodically recurs, giving LF-oscillations with a frequency of the order of the ion transverse oscillation frequency in the VC field.

At the second stage of the accelerator, the LF density-modulated REB enters the space periodical magnetic field region, where the space modulation of the beam takes place along the drift chamber. The combined space and temporal modulation form a beam slow wave with a phase velocity $\upsilon_{ph} = \omega_m / k_m$, where ω_m = frequency of temporal modulation, $k_m = 2\pi / L$ - wave number of space modulation of the beam (L-period of the external magnetic field). For the magnetic field of type: $H_r = hI_a (k_m r) \sin(k_m r)$, $H_x = H_o + hI_o (k_m r) \cos(k_m z)$ and the annular beam with a harmonic

modulation of current in time at the system entrance, the accelerating field near the axis has the form: $E_z = (I_b \alpha k_m h) / (2_{vh} H_o) \cos(\omega_m l - k_m z)$, where I_b - electron beam current, $_{vh}$- beam velocity. α - depth of temporal modulation. The accelerating field amplitude, as it follows from this relation, is proportional to the depth of the magnetic field modulation times the beam current modulation depth and linearly depends on this beam current.

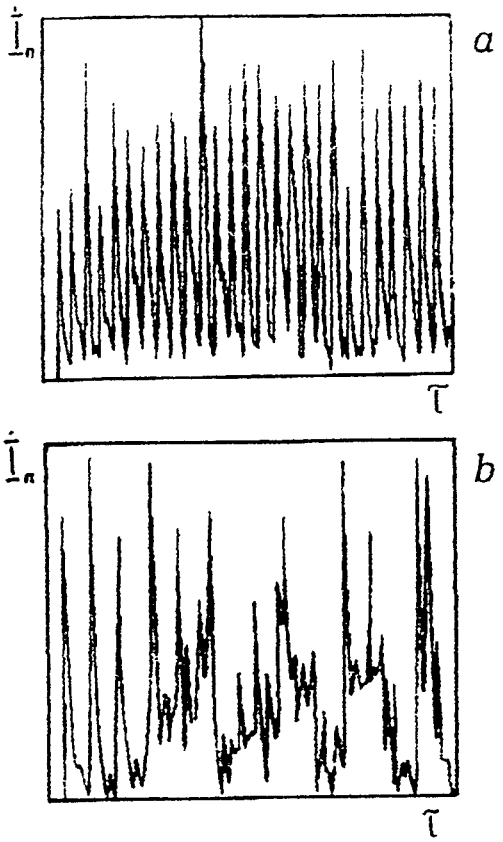


Figure 1. (a) HF Modulation of Transit Currents
(b) LF Modulation of Transit Currents

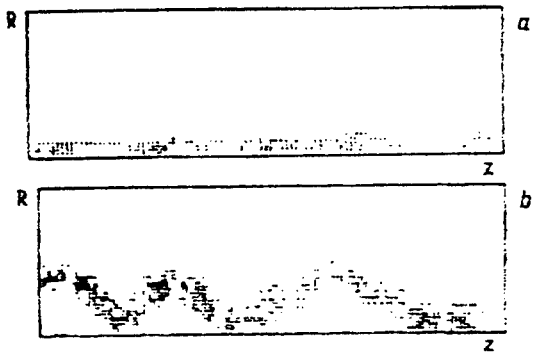


Figure 2. Ion Distribution on the Interaction Region:
(a) Ion Injection Near the Beam Axis, and (b) From the Outside of the Electron Beam

3. Experiments

The experiments were conducted on the accelerator "AGAT", which was a microsecond diode with a magnetic isolation [5]. The accelerator formed the annular electron beam with the parameters: E = 280 keV, I = 3.5 kA, r = 1μs and the beam pulse energy 350 J. The beam was injected to the drift chamber, 4.9 cm in diameter, placed in the external magnetic field of 4-4.5 kOe intensity. It is shown that the REB injection (with its current obviously greater than the vacuum limiting current) into the drift chamber filled with neutral gas at a pressure of $2x10^{-5}$ - $3x10^{-4}$ torr and under beam magnetization is accompanied by the formation of the VC in the near anode region. The measurements during one pulse of the installation were made by a set of capacitive probes located along the length of the drift chamber.

The dimensions of the region, occupied by the VC, were defined by comparison of the signals, picked off the probes. The measurements have shown, that at a distance of 3 cm from the cathode, the measured potential exceeds the voltage applied to the diode, then a sharp fall of potential value takes place along the length of the drift chamber and at a distance of more than 10 cm it becomes constant. The magnetic field value in the region of REB injection was chosen such that the part of the beam should get on the chamber walls, forming as a result of the stimulated desorption, a plasma I the anode region which was a source of ions. The experiments show that the dependence of the ion current on the REB current has a threshold character, i.e., the ion current sharply increases when the injected electron current achieves a certain critical value of l- and the ion current reaches 200 A. And the major portion of nitrogen ions of the near-wall plasma, accelerated by the VC potential well, had the energy of about 300 keV. In some experiments ions with an energy up to 900 keV were measured. Energy spectra measurements and potential

distributions allow us to draw a conclusion that the ion energy is determined by the depth of the VC potential well. In the VC regime, DF modulation of the electron beam was also observed. Its characteristics were defined from measurements of X-ray bremsstrahlung signals from the beam collector and loop probes, placed along the drift chamber. It can be seen from the signal patterns and frequency spectra from the loop probe and the collector, that DF oscillations of the electron current are of regular nature. The peak of the frequency spectrum is at 20 MHz, the modulation depth reaches 40%. As it follows from the above-given theoretical consideration, the ion transverse oscillations in the VC field are the reason of the excitation of this LF modulation.

The beam space modulation was carried out by a periodic magnetic field at a second stage of the accelerator. The period of the space modulation was chosen so as to ensure synchronism of a slow wave of the REB and the accelerated ions ($\upsilon_{ph} = \upsilon_i$). The space modulation of the REB occurred as it passed in the external magnetic field through the system of ion and aluminum rings put on a round waveguide. The modulation depth depended on the ring thickness and could vary within the experimental limits of 12-40 %.

The experiments were carried out in the systems both with a constant period of modulation and with the period growing along the length, chosen to carry out a continuous synchronous acceleration of ions. Pot acceleration of the ion beam obtained at the first stage by the field of a slow space-charge wave of the REB, formed at the second stage of the accelerator, was investigated experimentally. The highest energy of nitrogen ions after five periods of space modulation, when the period of modulation changed in the limits of 6 cm to 7.8 cm, was 1.5 meV. The current of trapped ions was 20 A for the pulse duration 400 μs. It was found that the stable acceleration of ions is observed at an 8% increase of the length of the following period.

Experimental investigations of current space modulation of the REB revealed the peculiarity that the maximum of the frequency spectrum of LF oscillations of the REB current shifts to the region of higher frequencies (from 20 Mhz) (see Fig. 3) as the beam passes through the section with space modulation of the magnetic field. This phenomenon of space modulation frequency increase in the process of acceleration may be connected with the change of the Doppler shift of the radial ion oscillation frequency as the ion velocity increases. This effect causes self-consistent increase in the phase velocity of the wave and ensures ion acceleration even at a constant period of space modulation.

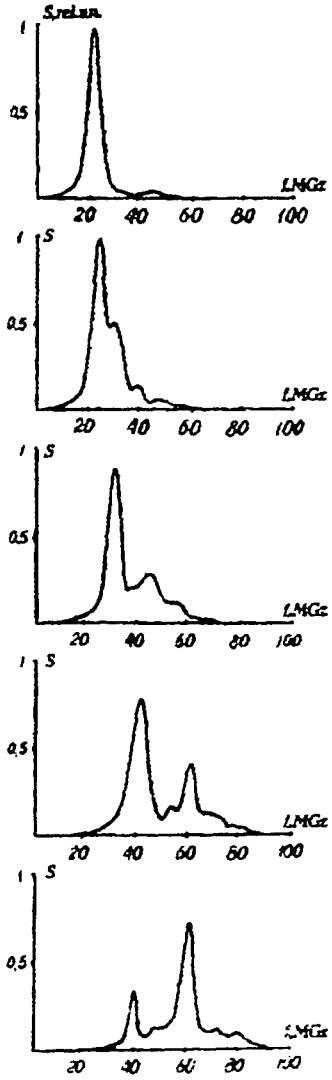


Figure 3. Shift of LF oscillations of the REB

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DEVELOPMENT OF A PROJECT AND THEORETICAL SUBSTANTIATIONS OF A TWO-BEAM ELECTRON-ION ACCELERATOR BASED ON DOPPLER EFFECT

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1. Introduction

Two-beam electron accelerators suggested and designed at the Lawrence Berkeley laboratory [1, 2] are mainly intended for research in high energy physics. This paper studies the "two-beam concept" in order to make high current ion accelerators. As is known, one basic setback hinders the current enhancement in existing linear accelerators. Indeed, if special measures are not taken the accelerating RF field is defocusing in the radial direction. In a two-beam ion accelerator it is possible for the driver electron beam to excite RF fields in an ion linear accelerator that are accelerating and focusing at the same time. A considerable gain may be obtained in the current of accelerated ions and in the acceleration rate.

Reference [3] outlines the concept of a two-beam high current ion accelerator based on the Doppler effect. According to this concept an intense electron beam injected along the accelerator axis together with the accelerated ion beam generates accelerating and focusing RF fields in the spatially periodic accelerating structure of a linear accelerator. RF fields are excited by the interaction of E-beam with transverse fields of any spatial harmonic due to cyclotron instability under anomalous doppler effect (ADE) or normal Doppler effect (NDE) whereas the ions are accelerated by the longitudinal field of the same harmonics or another one, corresponding Cherenkov resonance (CR). (Note that a similar instability, regarded as an undesirable effect, has been considered when determining the limiting currents in cyclic accelerators [4].

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Such acceleration schemes are the intermediate or hybrid ones between conventual and collective accelerators, using well investigated and technologically elaborated electrodynamic structures of the former and accelerating/focusing high gradient RF fields of the latter. The following properties are of advantage:

- with the resonant excitation the wave field near the axis i.e. In the region occupied by E-beam with the cyclotron wave excited in it possesses the volume pattern ($E=E_oJ_o(\chi R)$, χ is a transverse wave number, R is a radius of a drift tube) provided for radial and phase stability of the accelerated ion beam (as in a plasma waveguide [5]);
- the accelerating field intensity is $J_o(\chi R)$ times higher at the axis that at faces of drift tube whereas in conventional accelerators it is $I_o(\chi R)$ times lower.
- the excitation of RF fields due to ADE is possible without changes in the frequency and phase velocity of the wave. This circumstance makes it easier to calculate and sustain the parameters of such accelerators;
- the coordinated changes of the wave phase velocity and the external magnetic field strength provide for the resonant excitation of the required type of oscillations and for the suppression of other instabilities (due to nonuniform conditions for the latter ones);
- the possibility to obtain a low phase velocity wave by means of an intense relativistic electron beam. Then nonlinear effects involved with beam electrons trapped by the wave can be neglected at accelerating fields about 10^5 -10^6 V/cm.

The treatment of the problem given is performed with H-type interdigital accelerating structure as an example [about these structures see 6, 7]. In these structures the amplitudes of the +1-st and -1-st spatial garmonics exceed amplitudes of other ones zero one including. The + 1st spatial harmonic is assumed to accelerate ions, and E-beam excites the RF field at the + 1st harmonic due to ADE or at the -1st harmonic due to NDE. In a broad range of parameters of interest for acceleration problem the excitation time of the resonator is sufficiently small (~10^{-8}-10^{-7} s). Generation due to ADE is accompanied by decreasing longitudinal and increasing transverse momenta of electrons [8]. For generating due to NDE (when the waves moves to meet the beam), on the opposite, there occurs the transformation of transverse momenta of electrons to longitudinal ones. To increase the total efficiency the sections of the accelerator with field excited due to ADE (n=1) alternate with sections with field excited due to NDE (n= -1). The resonant magnetic field is somewhat changed in value but not in direction. When E-beam leaves the accelerator it goes into the RF recuperator to increase total efficiency [3].

The preliminary calculations [3] show the new type of accelerators to be promising due to expected considerable accelerating fields (10^5 - 10^6 V/cm) and simultaneous phase and radial stability of accelerated ions. (Fields of order of 10^5 V/cm were obtained in suitable experiments [9]. This concept may perhaps provide the ground for creation of ion accelerators with 10-100 MeV energy and 1 - 10 A current. The tolerance system for

them may be conceptually similar to one for classic accelerators and powerful electron RF devices (i.e., practically feasible).

To begin the realization of such accelerators we provide research and development activities including theoretical and experimental investigations, and construction of an accelerating installation.

2. Engineering Development of a Detailed Design of the Experimental Accelerating Stand (EAS)

2.1 DESIGN PROJECT OF THE EXPERIMENTAL ACCELERATING STAND (EAS)

The Experimental Accelerating Stand (EAS) is intended to prove the workability of a new promising type of ion accelerators and to optimize their parameters. The intense electron beam propagating along the system axis in the resonant magnetic field with the given value and distribution over the length will excite focusing and accelerating fields in EAS due to the anomalous Doppler effect. To save money one intends to use the operating linear proton accelerator (e.g., the "Ural-5" accelerator of 5 MeV energy ad 30 mA current) as na injector. If a more powerful injector is available the current in EAS may approach 1 A. Table 1 gives the main EAS parameters calculated to accelerate protons from 5 MeV initial energy to 8 MeV final energy. Fig. 1 shows the EAS scheme.

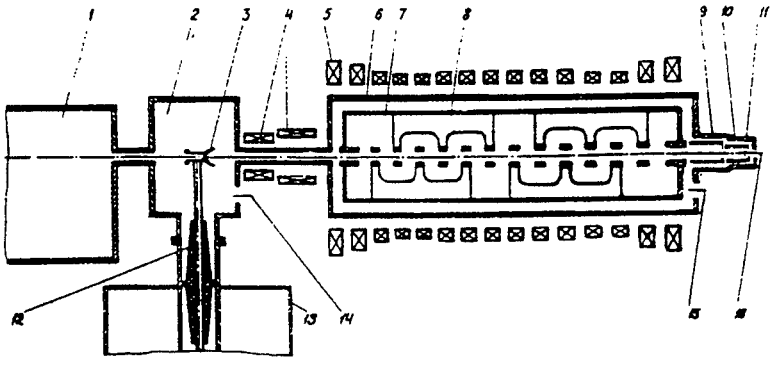


Figure 1. The EAS setup. 1- accelerator-injector, 2 - vacuum chamber, 3 - electron gun, 4, 5 - magnetic coils, 6 - vacuum chamber, 7 - H-type resonator, 8 - support "combs" with drift tubes, 9 - electron collector, 10 - ion collector, 11 - collector bottom, 12 - high-voltage input, 13 - high voltage pulse transformer, 14, 15 - vacuum pumping, 16 - ion outlet.

Table 1. The Main Parameters of the Experimental Accelerating Stand (preliminary data)

1.	Input proton energy	5 Mev
2.	Output proton energy	8 Mev
3.	Proton current	30 mA
4.	Electron beam energy	350 keV
5.	Electron beam current	150 A
6.	Pulse duration	2.5 mk sec
7.	Pulse frequency	1 pps
8.	Electron beam initial radius	2.6 cm
9.	Electron beam final radius	4.8 cm
10.	Magnetic field intensity	
	for EAS input	609 Oc
	for EAS output	439 Oc
11.	Resonator length	161 cm
12.	Operating frequency	148.5 MHz
13.	Accelerating field intensity	56 kV cm
14.	Synchronous phase	30 °
15.	Shunt impedance	35 MOhms/m

The accelerating section is designed on the basis of the H-type resonator with drift tubes on meeting suspenders (such accelerators are designed successfully at KFTI) [see also 6,7]. Electron injector utilizes the electron gun with the transverse compression of the beam and the supply unit of a powerful clystron of industrial production. Energy and current of the electron beam are chosen to be sufficiently large (up to 350 keV and 200 A respectively) to present excessive longitudinal deceleration and beam radius increase (due to longitudinal-transverse momentum transformation of beam electrons that is inherent in RF generation due to anomalous Doppler effect [8]. At this stage of research the conditions are chosen when energy losses of the electron beam are small in order to simplify calculations and increase their reliability as well as to simplify the experimental adjustment of the accelerator. Because of that the efficiency of the energy transfer from the electron beam to the ion one is small (<1%). Reference [3] discusses the ways enhance the efficiency considerably and they will be studied in later developments. (In particular, it will be suitable a method similar to the FEL efficiency increasing method, by tapering of wiggler magnetic field, as it is used in the work of the LLNL and LBL [10]. The magnitude of the resonant magnetic field H(z) determined from the conditions of RF fields excitation due to the anomalous Doppler effect is:

$$H_z(z) = \frac{\gamma mc}{e}\left[k_z(z)\cdot v_z - \omega\right], \qquad \omega_b << \omega_H = eH_z/\gamma mc \tag{1}$$

where z is the longitudinal coordinate, e and m are the charge and mass of an electron, c is the speed of light, γ is the Lorentz factor, k_z is the longitudinal propagation constant, γ_z is the velocity of beam electrons, ω is the frequency of excited oscillations that is equal to the natural frequency of the resonator at the basic (π) type of oscillations, ω_H is the electron cyclotron frequency, ω_b is the beam Langmuir frequency.

In finding $H_z(z)$ we assume for simplicity the frequency of the hollow resonator to be equal to one for the beam-loaded resonator. This approximation is justified in this case because for the cyclotron instability due to the anomalous Doppler effect one can choose the conditions when $\Gamma = \mathrm{Im}\omega > 0$, $\Delta\omega = \mathrm{Re}\omega = 0$ for $\omega = k_z \gamma_z - \omega_H$ and $\omega - \omega_b$ (where Γ is the instability growth rate, $\Delta\omega$ is the resonator frequency shift).

The generation of the RF oscillations by the electron beam due to the anomalous Doppler effect is accompanied by the increase of Larmor radii of beam electrons (it was studied in the experiment in [8]). To determine the Larmor radius of every electron (r_l) and of the electron beam as a whole (r_b) one may employ the energy relation for the anomalous and normal Doppler effects [8]:

$$\frac{\pm\Delta P_\perp}{P_{RF}} = \frac{\beta - \beta_{ph}}{\beta_{ph}}, \qquad \Delta P_\perp = \frac{1}{2}\gamma mc^2\left(\beta_\perp^2 - \beta_{\perp 0}^2\right) Ie^{-1}, \tag{2}$$
$$\beta = v/c, \qquad \beta_{||} = \beta\cos\Theta, \qquad \beta_\perp = \beta\sin\Theta, \qquad \beta_{\perp 0} = \beta\sin\Theta_0,$$

where P_{RF} is the RF power radiated due to the anomalous (the sign "+") or normal (the sign "-") Doppler effect; $\pm\Delta P_\perp$ is the change in the power (energy flux) associated with the transverse motion (rotation) of the electrons: β_{ph} is the phase velocity of the wave, divided by light velocity; Θ is the angle between the electron velocity and the magnetic field, Θ_0 is the initial one.

From formula (2) we have for the case of the anomalous Doppler effect:

$$P_{RF}\,\frac{\sqrt{1-\gamma^2}\cos\Theta - \langle\beta_{ph}\rangle}{\langle\beta_{ph}\rangle} = \frac{1}{2}mc^2\,\frac{\gamma^2-1}{\gamma}\left(\cos^2\Theta_0 - \cos^2\Theta\right) \tag{3}$$

where $\gamma = \gamma_0 - \frac{eP_{RF}}{I\cdot mc^2}$ and $\langle\beta_{ph}\rangle$ is the mean value of the phase velocity.

From equation (3) the value of $\cos\Theta$ and then the Larmor radius and the electron beam radius are determined:

$$r_L = \beta c\,\omega_H^{-1}\sin\Theta, \qquad r_b = r_{b0} + r_L - r_{L0} \tag{4}$$

where the subindex "0" corresponds to initial values.

The diameter of drift tubes is also increased in correspondence with the electron beam radius increase as the beam propagates in the resonator. Simultaneous increase of drift tubes diameter and accelerating structure period from the beginning to the end of the resonator makes it easier to adjust the constant accelerating rate along the resonator length.

2.2 DESCRIPTION OF THE EXPERIMENTAL ACCELERATING STAND (EAS)

The Experimental Accelerating Stand (EAS) is created as an operating model of a two-beam ion accelerator based on the Doppler effect.

EAS possesses the following main parts: i) the accelerating section based on an H-type resonator with the spatially periodic accelerating structure; ii) the solenoid crating the resonant magnetic field at the resonator axis; iii) the electron injector to crate the intense electron beam generating the accelerating and focusing RF-field in the resonator; iv) vacuum, adjusting and other systems. (Assembly drawings and specifications are given in the Report for LBL, 1993).

The EAS setup is shown in Fig. 1. The H-type resonator 7 is excited by n electron beam created by the electron gun 3. The electron beam is focused by the magnetic coils 4 and the solenoid 5. The electron gun is supplied by high-voltage pulse transformer 13. A proton beam from accelerator 1 is injected along the axis through a central hole in a cathode of the electron gun 3, and pass in the H-type resonator 7 to have an additional acceleration. Accelerating and focusing RF fields are excited by the electron beam upon anomalous Doppler resonance conditions. The solenoid 5 (consisted of 15 coils) creates a resonance space-changed magnetic field. (Calculation of the solenoid with required spatial distribution of magnetic field is realized by the regularization developed by A.N. Tikhonov for solution of incorrect inverse problems).

Vacuum in chambers 2 and 6 is provided by magneto-discharge and turbomolecular pumps at the level of 10^{-7} mm Hg. On the output end of chamber 9 there are located the electron collector 9, the ion collector 10 with a moving bottom 11, and branch pipes 15 for vacuum line coupling.

Now the EAS is being manufactured at the KFTI.

2.3 TECHNICAL DATA OF THE H-TYPE RESONATOR

The resonator is constructed for the 148.5 MHz operating frequency. The total resonator length is 161 cm, its diameter is 45 cm. The accelerating structure is calculated for acceleration of protons from 5 to 8 MeV. It comprises the inlet and outlet pipes located on resonator ends and 12 drift tubes fixed by three on two pairs of "combs" (see Fig. 1). Two types of adjusting elements with mechanic drives are available to tune the resonator to the required frequency 148.5 MHz and to obtain the required distribution of RF field between gaps. Besides, precision adjusting and fixing (by special captures) of the "combs" with their drift tubes are foreseen. This construction allows one take off, alternates and places again these "combs" rather operationally.

There are two high-frequency inputs with moving loops for H-resonator excitation, several high-frequency measuring loop and diagnostic windows also. The H-resonator is placed in a vacuum chamber evacuated by three high-vacuum pumps.

Structure of the resonator. The resonator consists of two sections connected between themselves such that they may be rotated one relative to another keeping safe the contact between sections and the alignment of drift tubes. In this case the accelerating

structure is calculated for proton acceleration from 5 to 8 MeV and it consists of 12 drift tubes each three of which are carried by four "combs" made of copper sheet. When the proton energy needs to be changed one may change the accelerating structure.

Each section possesses a bearing frame made of end rings connected between themselves by bearing upper and lower bars. The combs with drift tubes are positioned on energy bar with a special clamp. The drift tubes are aligned relative to one another with the help of a special rod-adjuster centered in aperture holes of drift half-tubes fixed on inlet and outlet ends of the resonator. The half-tubes are fixed on ends with a possibility to adjust the angle with respect to the axis. On the outer surface of drift tubes and half-tubes the rings are fixed leveling the RF-field along the resonator. Side half-cylindrical jackets made of copper sheets 2 mm thick with stiffening ribs form the current-conducting cylindrical surface of sections. On jackets there are mounted adjustable side regulators in the form of rectangular plates intended to correct the field value or resonator frequency. The corresponding brass spring lobes are installed on jackets and regulator plates where the electric contact must be effected. Resonator ends (inlet and outlet) are installed and fixed in corresponding recesses in end rings of the frame.

To decrease the weight the ends are made of duraluminum together with a copper sheet 1 mm thick and they are perforated to provide for vacuum pumping. Along the end circumference there are lobe contacts to ensure electric contact with jackets.

Contact flanges for RF coupling are placed on the inlet and outlet ends and those for measuring loops are on the jackets of each section. The resonator possesses four supports adjustable in vertical and horizontal planes. The supports are mounted on elements fixed on end rings of resonator sections.

Now the resonator is being manufactured in the KFTI.

3. Theoretical Investigation of Accelerating Field Excitation in H-Type Resonators in The Cases of Anomalous and Normal Doppler Effect

3.1 FIELD STRUCTURE IN H-TYPE RESONATOR

In the present part the excitation processes of axially symmetrical, slow electromagnetic waves (EMW) of E-type by an electron beam in accelerating structures are investigated, in the case of anomalous and normal Doppler effect. The structures are based on H-type resonators with drift tubes on meeting suspenders used in conventional ion accelerators [6, 7] (Fig. 1). Anomalous Doppler effect (ADE) has been theoretically predicted and investigated in [11, 12]. Some problems of slow wave excitation by electron beam at anomalous and normal Doppler effects (connected with excitation of slow and fast electron cyclotron waves) have been investigated earlier, in [13-24]. In our case, an essential peculiarity is a necessity to take into account the radial dependence of longitudinal electrical field component that leads to beam instability due to anomalous

and normal Doppler effects. An another peculiarity of E-wave excitation is the new mechanism of instability saturation due to competition of the terms in the excitation equation (see below Eq. 10d).

The accelerating system considered here is a complicated periodic stgructure, and in general the excited field structure is not simple. However, the problem is not so difficult for the field structure in a drift tubes region. where ions should be accelerated. Here the fields can be presented as a superposition of space harmonics (see, e.g., [7, 25]):

$$\bar{E}(\bar{r},t) = \mathrm{Re}\sum_{m=1}^{\infty}\left\{\left[C_m\bar{E}^{(m)} + C_{-m}\bar{E}^{(-m)}\right]e^{-i\omega t}\right\} \tag{1}$$

$$\bar{H}(\bar{r},t) = \mathrm{Re}\sum_{m=1}^{\infty}\left\{\left[C_m\bar{H}^{(m)} + C_{-m}\bar{H}^{(-m)}\right]e^{-i\omega t}\right\} \tag{2}$$

where $E\ (r\ ,\ t\ )$ and $H\ (r,\ t\ )$ are electric and magnetic fields, correspondingly; $r\ ,\ t$ are space coordinate and time: $r \equiv \{r\ ,\ \varphi, z\ \}$ and z is directed along the waveguide axis; C_m and C_m are wave amplitudes; $E^{(m)}\ ,\ H^{(m)}$ - space structure of the waves propagated along z-axis, $E^{(-m)}\ ,\ H^{(-m)}$ the ones propagated in opposite direction:

$$\bar{E}^{(\pm m)} = \bar{\varepsilon}^{(\pm m)}(r)\,e^{\pm ik_m z}; \qquad \bar{H}^{(\pm m)} = \bar{h}^{(\pm m)}(r)\,e^{\pm ik_m z}; \tag{3}$$

As ions should be accelerated in vicinity of the resonator axis by the longitudinal electric field, we consider the excitation of the only fixed eigen wave with nonzero longitudinal field on the axis. Space components of this field can be represented by the following form $(\mu_m^2 = k_m^2 - \omega^2/c^2$, k_m and μ_m are longitudinal and transverse wave numbers):

$$\varepsilon_z^{(\pm m)} = I_0(\mu_m r);\quad \varepsilon_r^{(\pm m)} = \mp\frac{ik_m}{\mu_m}I_1(\mu_m r);\quad h_\varphi^{(\pm m)} = -\frac{ik_m}{\mu_m}I_1(\mu_m r) \tag{4}$$

3.2 EXCITATION OF H-TYPE RESONATOR (THE GENERAL SYSTEM OF EQUATIONS)

Suppose that E-beam is injected into resonator at $z = 0$ along the homogeneous axial magnetic field H. In the first section $(0 \le z \le L\ )$ E-beam excites a slow EMW at ADE condition:

$$\omega = k_m v_0 - \omega_{ll} \tag{5}$$

Here v_0 is initial longitudinal velocity of the beam electrons at the entrance of the sections $(z = 0)$; $\omega_{H_0} = \frac{|e|H_0}{mc}$ is the cyclotron frequency; $\omega_H \equiv \omega_{H_0}/\gamma_0$; e and m are charge and mass of electron, correspondingly; c is light velocity;

$\gamma_0 = \left(1 - v_0^2/c^2\right)^{-1/2}$ is relativistic factor.

The wave amplitude is considered as a slow changing function over longitudinal coordinate z and time t. Then, according to general theory of waveguide (resonator) excitation [25], the equation, describing the change of this wave amplitude in the resonator, has the form:

$$\frac{1}{v_g}\frac{\partial C_m}{\partial t} + \frac{\partial C_m}{\partial z} = \frac{1}{N_m}\int_{S_\perp} ds \bar{E}^{(-m)} \bar{j}_\omega \tag{6a}$$

$$N_m = \frac{c}{4\pi}\int_{S_\perp} ds \bar{e}_z \left\{\left[\bar{E}^{(m)}\bar{H}^{(-m)}\right] - \left[\bar{E}^{(-m)}\bar{H}^{(m)}\right]\right\} \tag{6b}$$

Here N_m is the norm of the wave proportional four times the power carried by this wave through cross-section of the waveguide; v_g is the group velocity; e_z is the unit vector along z-axis; in the equation [16] integration is carried out over the cross-section of the waveguide;

$$\bar{j}_\omega = \frac{\omega}{\pi}\int_0^{2\pi} dt\, \bar{j} e^{i\omega t}$$

The fourier component of the current density is $\bar{j}(\bar{r},t) = en_b(r)\int d\bar{v}\cdot\bar{v}\, f(\bar{v},\bar{r},t)$

The equation of the motion of beam electrons in fields [1,2] and in magnetic field H_o in Language variables has the form:

$$\frac{dp_+}{dz} - i\frac{\omega_H}{\gamma}\frac{p_+}{v_z} = \frac{e}{v_z}\left(E_r - \beta_z H_\varphi\right)e^{i\varphi}$$

$$\frac{dp_z}{dz} = \frac{e}{v_z}\left(E_z + \beta_r H_\varphi\right) \tag{7}$$

$$\frac{dt_1}{dz} = \frac{1}{v_z}$$

$$v_z(z = 0, q_0) = v_0, \quad p_+(0, q_0) = 0;$$

Here $P + = m\gamma v_+$, $v_+ = v_x + iv_y$, $\beta_i = v_{i/c}$, $v_i = v_i(z, q_o)$ is I-th component of electron velocity; $q_0 \equiv \{r_{\perp 0}, \tau_0\}$, $r_{\perp 0}$ is initial transversal coordinates of electron injected in moment t_0 at the entrance of the frist section $z = 0$. As an independent variable in equation (7), the longitudinal coordinate z is chosen.

The set of nonlinear equations (6, 7) describes the excitation of slow E-wave (with index m) by relativistic E-beam in H-type resonator. In general case the solution of this equation is attended by considerable difficulties. It is conditioned by the fact, that considered ADE resonance is not separated in the equation of motion (7) and correspondingly in field equation (6). Besides, the equation (6a) takes into account both spatial (along axis z) and temporal changing of field amplitude in resonator. For more detailed study of wave excitation process at ADE we below investigate separately two types of resonators - with the low and high Q-factor. In the first case only space changing of amplitude will be accounted, in the second case the field structure will be considered as fixed (given) one.

3.3 WAVE AMPLIFICATION AT ANOMALOUS DOPPLER EFFECT

In the limit of the strong amplification the equation of the slowly variating wave amplitude (5a) in the waveguide takes the form:

$$\frac{\partial C_m}{\partial z} = \frac{1}{N_m} \int_{S_\perp} \mathrm{d}s \bar{E}^{(-m)} \bar{j}_\omega \tag{8}$$

At the excitation of the oscillations under ADE resonance conditions it is convenient to pass from cylindrical transversal coordinates (r, φ) and momentum ($\rho_\perp$) to Cartesian ones (x, y). Current transversal coordinates we describe in the form:

$$x(z, q_0) = x_0 + \frac{v_\perp}{\omega_H} \sin\left(\frac{\omega_H}{v_0} z + \vartheta\right) \tag{9a}$$

$$y(z, q_0) = y_0 + \frac{v_\perp}{\omega_H} \cos\left(\frac{\omega_H}{v_0} z + \vartheta\right) \tag{9b}$$

where x_0, y_0 are transversal coordinates of an electron at the time t_0 in the cross-section $z = 0$; $v_\perp$ φ - amplitude and phase of transversal velocity, $v_\perp = \left(v_x^2 + v_y^2\right)^{1/2}$.

Below we suppose that at the resonator entrance ($z = 0$) REB is monoenergetic:

$$f(q_0) = \frac{\delta(p_\perp)}{2\pi\, p_{\perp 0}} \delta(p_z - p_{z0})$$

Keeping in the equations (6), (7) only terms satisfying resonance condition (5), taking into account the relation (9), resulting from it the expression for transversal velocities, and supposing that condition $\mu_m r_1 = \mu v_\perp / \omega_H << 1$ is satisfied, the set of

nonlinear selfconsistent equations, describing space amplification of cyclotron wave by E-beam at ADE takes the form (in the dimensionless variables):

$$\frac{d\rho_z}{d\varsigma} = -\Gamma \operatorname{Re}\left(a\rho_\perp^*\right) \tag{10a}$$

$$\frac{d\rho_\perp}{d\varsigma} + ig\rho_\perp = (1+h_1)a \tag{10b}$$

$$\frac{d\tau}{d\varsigma} = \frac{\gamma_0^2}{2\pi\lambda}(1-\nu) \tag{10c}$$

$$\frac{da}{d\varsigma} = \int_0^1 d\tau_0 \Gamma\rho_\perp(1+h_2) \tag{10d}$$

$$\rho_z(0) = \rho_\perp(0) = 0; a(0) = a_0$$

Here: $a = i\frac{C_m}{2}\frac{|e|I_1(\mu_m\bar{r})}{m\nu_0^2\gamma_0^2\mu_m}\left(\frac{k_m^3}{\chi^3}\frac{\omega}{\omega_H}\right)^{1/2}(\alpha_1\alpha_2)^{1/2}$

$$\rho_z = (p_z - p_{z0})/\lambda\rho_{z0}; \rho_\perp = p_\perp/mc\,\lambda_\perp; \Gamma = 1/(1+\lambda\rho_z);$$

$$g = \Delta/\chi + \left[1 - \Gamma + \frac{\omega}{\omega_H}(1-V)\right]/\mu; V = \gamma/\gamma_0(1+\lambda\rho_z);$$

$$\mu = \chi v_0/\omega_H; \tau = \frac{\omega}{2\pi}\left[z/v_0 - t_1(z,\tau_0)\right]; \varsigma = \chi z; \Delta = k_m - (\omega+\omega_H)/v_0;$$

$$h_1 = -\frac{\chi v_0}{\omega\alpha_2}\left(\Delta/\chi + 2\pi\frac{d\tau}{d\varsigma}\right); h_2 = \frac{\chi}{k_m\alpha_2}\left(\frac{\mu_m v_0}{\omega}\right)^2\frac{2\pi}{V}\frac{d\tau}{d\varsigma};$$

$$p_\perp = p_+ e^{i(\omega t - k_m z - \bar{\varphi})}; \lambda = \gamma_0^2\chi v_0/\omega;$$

$$\lambda_\perp = \beta_0\gamma_0^2\left[\frac{\chi}{k_m}\frac{\omega_H}{\omega}\frac{\alpha_2}{\alpha_1}\right]^{1/2}; \bar{n}_b = \frac{c}{|N_m|}\int_{S_\perp} ds n_b(r) I_1(\mu_m r);$$

$$\alpha_1 = 1 - \beta_{ph}\beta_0 + \beta_{ph}\beta_0\Delta/k_m; \alpha_2 = 1 - \beta_{ph}\beta_0 + \Delta v_0/\omega;$$

$$\chi = \frac{\omega_{b\perp}}{v_0}\frac{k_m}{\mu_m}\alpha_2\left[\frac{\beta_0}{2}\frac{\omega}{\omega_H}I_1(\mu_m\bar{r})\right]^{1/2}; \omega_{b\perp}^2 = \frac{4\pi e^2\bar{n}_b}{m\gamma_0};$$

$$|N_m| = \frac{c}{4\pi}\frac{kk_m}{\mu_m^2}\int_{S_\perp} ds I_1^2(\mu_m r); \beta_{ph} = k/k_m;$$

From equations (10) the conservation law for the flow of wave energy and electrons kinetic energy takes the form:

$$\int_0^1 d\,\tau_0(1-\gamma/\gamma_0) = \frac{1}{2}\lambda\beta_{ph}\beta_0\left(|a_m|^2 - |a_m(0)|^2\right) \tag{11}$$

where $a_m(0) = a_m(z=0)$.

In general case a selfconsistent solution of the set (10) can be obtained only numerically. However, good estimates, describing initial stage of the instability and characteristics of the wave and the beam during saturation, can be obtained by analytical methods. So at initial stge from the equations (10b) and (10d) it follows, that wave amplitude grows accordingly to law:

$$a_m = a_m(0)\ \exp\ (\chi z) \tag{12}$$

with space amplification growth rate $\delta K_m = \chi$.

Since the change of the leading center of electron is neglected, acting force is independent of incoming phases, so we consider the solution of equations (10) in hydrodynamic approximation.

From these equations under satisfied condition (5) integrals of motion are obtained:

$$\mathrm{Im}\left(\rho_\perp^* a_m\right) + \alpha\rho_z^2 = 0 \tag{13a}$$

$$1 - \frac{\gamma}{\gamma_0} = \frac{\lambda}{2}\beta_{ph}\beta_0\left[a_m^2 - a_m^2(0)\right] \tag{13b}$$

$$\rho_z = -\frac{1}{2}\left[a_m^2 - a_m^2(0)\right] \tag{13c}$$

where $\alpha = \frac{k_m v_0}{2\omega}\frac{\gamma_0^2}{\gamma_{ph}^2}$; $\gamma_{ph} \equiv \left(1-\beta_{ph}^2\right)^{-1/2}$

It follows from (13a), (13c) that instability saturation takes place at $\Phi = -\pi/2$, where $\Phi = \arg a_m - \arg \rho_\perp$ is the spiral phase. Taking this into account, the expression for maximum wave amplitude and transverse momentum is obtained:

$$a_{max} = 2\left[\sqrt{1+\mu^2} - \mu\right]^{1/2} \Big/ \alpha \tag{14a}$$

$$|\rho_\perp| = \sqrt{2\,|\rho_z|\left[1 - \alpha\mu\,|\rho_z|\right]} \tag{14b}$$

$$\rho_z = -a_{max}^2/2 \tag{14c}$$

As a result of instability developemnt in the case of ADE at the initial stage the exponential growth of wave amplitude takes place. Beam electrons gain transverse momentum and retard in longitudinal direction. The instability saturation occurs as a result of a longitudinal velocity decrease and goint out of resonance Maximum values of wave amplitude and transverse momentum is determined by expression (14). Then the amplitude growth process changes taking away the field energy by the beam. Field amplitude and transverse momentum are decreasing while longitudinal velocity is increasing and approaching to the initial value. For more detailed investigation of the amplification process in the case of ADE the computer simulation is carried out.

3.4 SIMULATION OF AMPLIFICATION PROCESSES

As it was noted above, it is impossible to obtain the general analytical solution of nonlinear equations (10). The expressions (12) and (13) describe asymptotical behavior of wave amplitude and particle momentum in two limit cases: at initial stage for small wave amplitude, and at the saturation. To obtain precise quantitative output values of the amplifier we carried out the solution of the set of nonlinear selfconsistent equations (10). It was supposed that monoenergetic REB of uniform density is injected into the system at $z = 0$. Transversal velocity of beam electrons is absent. At the entrance ($z = 0$) the initial signal $a_m(0)$ ($a_m(0) << a_{max}$) is fed. The numerical solution of the set (10) has been conducted for 100 particles, uniformly distributed over initial phases from -1/2 to +1/2. The values of the dimensionless parameters are chosen as follows: $\lambda = 0.512$, $\lambda_\perp^2 = 1.366$, $\gamma_0 = 1.6$, $a_m(0) = 0.01$ beam energy is 300 keV and axial guide field is 500 G.

The results of numerical solution are represented in Fig. 2 - Fig. 3. In Fig. 2A the dependence of eave amplitude over longitudinal coordinate ξ in dimensionless variables is shown. It is seen that the initial stage of the amplification on a small distance ($\xi \leq 4$) the wave amplitude is growing exponentially. Obtained value of the spatial growth rate coincides with analytical one (12). For $\xi = 5$ the instability saturation occurs. At the saturaton the value fo the wave amplitude is equal $a_{max} = 0.4$ that is agree with analytical estimates (14a) . The length of waveguide, at which the amplitude reaches its maximum vlaue, is $\xi \equiv \xi_{sat} = 5$. At longer distance amplitude is decreasing to the value close of its initial one (at $\xi \geq \xi_{sat} \approx 5$) . Further (at $\xi \geq 10$) periodic growth and decreasing of the wave amplitude takes place.

In Figs. 2b and 2c we show the graph of the longitudinal (Fig. 2b) and transverse (Fig. 2c) momentum versus longitudinal coordinate (in the numerical simulation we consider the evolution of the momentum of the 10-th particle). In this figure we see that longitudinal momentum decreases monotonously and transverse momentum increases (in the region $0 \leq \xi \leq \xi_{sat}$), while the wave amplitude grows. In the region $\xi_{sat} \leq \xi \leq 10$, where amplitude of the field decreases, the momentum of the particles tends to the initial value.

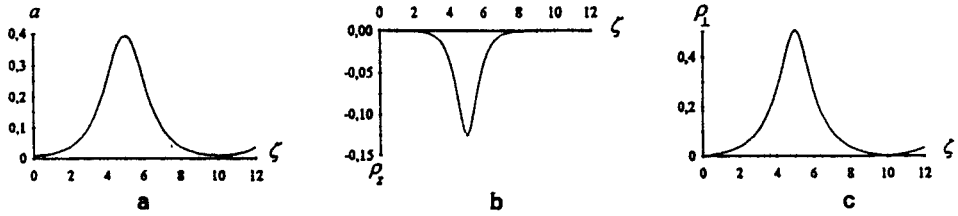


Figure 2. a) The dependence of wave amplitude a versus longitudinal coordinate ξ (in dimensionless variables). b) The dependence of longitudinal momentum p_z of 10-th particle versus ξ. c) The dependence of transverse momentum $\rho_\perp$ of 10-th particle versus ξ.

In Fig. 3 the phase plane of the beam is represented for the cases: $\xi = 0.5$, $\xi = 4$, $\xi = 5$ and $\xi = 6$. In Fig. 3A - the dependence of the longitudinal momentum ρ_z versus the phase τ, in Fig. 3B - the dependence of transversal momentum versus τ, in Fig. 3c - the depenccence of ρ_z versus spiral phase Φ are shown. In this figure it is seen that at the initial stage of the instability (at $\xi = 0.5$-4) the beam electron is decelerating in longitudinal direction and gains its transversal momentum. This process is independent of incoming phase τ of the particle. In Fig. 3C we can see, that the particles are bunching on spiral phase Φ. When coordinate ξ is increasing (up to $\xi = \xi_{sat}$) beam electrons decelerate, and its transversal velocities increase. At the saturation the vlaues of transversal and longitudinal momentum (see Fig. 3A, b; $\xi = 5$) are equal to the values: $\rho_z(\xi = \xi_{sat}) = \rho_{min} = -0.12$; $|\rho_\perp(\xi = \xi_{sat})| = 0.5$. These values coincide well enough with analytical ones, obtained from expressions (14b,c). The value of spiral phase, where electrons are being bunched, is equal to $\Phi = -\pi/2$ that exactly coincides with one obtained earlier as a solution of equations (1). For longer distance ($\xi > 6$) longitudinal momentum is increasing and approaching to its initial value (Fig. 3A, $\xi > 6$) while transverse momentum is decreasing to value $\rho_\perp$ ($\xi = 6$) = 0.25. Further periodic changing of longitudinal and transversal momenta completely repeat periodic changing of the wave amplitude.

As the beam density increases, the role of the term proportional h_2 in the equation (10d) increases too. This fact causes the decrease of the maximum wave amplitude at the saturation regime.

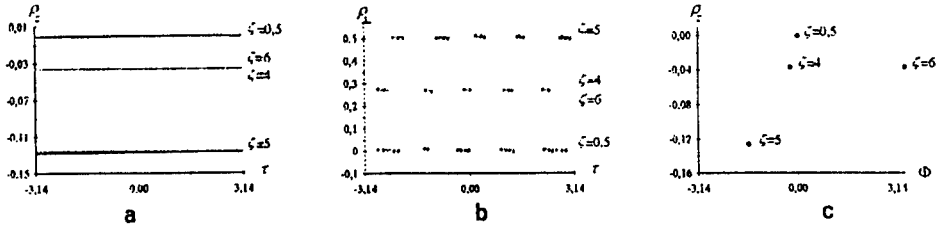


Figure 3. The phase plane of the beam for the longitudinal coordinate ξ as a parameter (ξ = 0.5, 4, 5, 6). a) The dependence of longitudinal momenta p_z of beam particles versus the phase τ. b) The dependence of transverse momenta $\rho_\perp$ of beam particles versus the phase τ. c) The dependence of longitudinal momenta p z of beam particles versus the spiral phase Φ.

The numerical simulations show that for the parameters of the electron beam and the electrodynamic structure of two-beam accelerator (I_b = 200 A, H_0 = 500 Oe, W_b = 300 keV, β_{ph} = 0.1) the longitudinal accelerating field about E_z = 60 kV/cm can be achieved.

3.5 WAVE GENERATION IN H-TYPE RESONATOR AT ANOMALOUS DOPPLER EFFECT (ADE)

In the previous Sections it was investigated the amplification regime, when the parameters of the beam and electromagnetic structure were such ones that the considerable amplification of initial signal takes place. For the description of excitation process in a high Q resonator we can consider the field structure as fixed (given) one.

Suppose, that the H-type resonator has length L. A REB injected has longitudinal momentum at the entrance of the resonator $z = 0$. In the resonator only one longitudinal mode is excited; its frequency and wave number are satisfied the ADE resonance.

To describe wave generation in H-resonator at ADE, we take the equations of electron motion in Lagrange variables (10a,b,c). The expression for space-temporal structure of excited field has the form (6). Characteristics time of wave amplitude changing considerably exceeds the flight time of electron through the resonator. To estimate the excitation efficiency of the resonator by electron beam at ADE, we introduce electron efficiency coefficient η as a ratio of the lost energy to the initial energy of the beam $\varepsilon = mc^2(\gamma_0 - 1)$:

$$\eta = \frac{\gamma_0}{\gamma_0 - 1} \int d\tau_0 \left(1 - \frac{\gamma(L, \tau_0)}{\gamma_0} \right) \qquad (15)$$

where $\eta\ (L, \tau_0)$ is the value of electron relativistic factor at the exit ($z = L$). Integration in (14) is carried out over initial phase of electrons injected into the resonator.

Under stationary regime of generation, the power carried in the resonator by the beam is compensated by the power lost in the resonator. The intensity of the field on the resonator axis can be calculated from the balance equation for these powers (see e.g., [26]):

$$I\frac{mc^2}{|e|}(\gamma_0 - 1)\eta = \frac{E_z^2(0)}{R_s}L \tag{16}$$

where I is the beam current, $E_z^2(0)$ is the squared of the z -component amplitude of the field on the axis,, R_s is the shunt impedance.

The left part of (16) represents the power lost by the beam in the resonator, the right part is equal to the loss in the resonator.

The value $\gamma(L, \tau_0)$ should be calculated from the equations (10a,b,c). In general case these calculations can be conducted numerically. However, such important characteristics of the generator as start current and efficiency can be obtained at the initial stage ($a_m << 1$) with analytical methods. Solving the equations (10a,b,c) for $a_m << 1$ and substituting obtained asymptotical values of beam output energy into equation (15), we obtained the following expression for electron efficiency:

$$\eta = \frac{1}{4}\left[\frac{eC_m I_1(\mu_m \bar{r})}{2mv_0\omega}\right]^2\left(\frac{\sin\psi}{\psi}\right)^2(1-\beta_{ph}\beta_0)\alpha_2\left(\frac{kl}{\gamma_0}\right)^2\left(\frac{k_m}{\mu_m}\right)^2\frac{\omega}{\omega_H} \tag{17}$$

where $\psi = \frac{L}{2}\left(k_m - \frac{\omega+\omega_H}{v_0}\right)$ - the flight angle of electrons through the resonator.

It is seen from (17) that at the initial stage of the excitation the efficiency η is proportional the squared ratio of the electron energy loss for one passage through the resonator to its initial energy. Electron efficiency is a nonmonotonical function of flight angle ψ. There are opotimal zones of the generation. Besides, for small phase velocities β_{ph} the efficiency proportional to phase velocity of the wave excited in the resonator at ADE.

Substituting the expression for electron efficiency (17) into (16), we find the value of start current:

$$I_{st} = 8\frac{I_a\beta_0\gamma_0}{R_s cL}\left[I_1(\mu_m\bar{r})\frac{\sin\psi}{\psi}\right]^{-2}\left(\frac{\mu_m}{k_m}\right)^2\frac{\omega_H}{\omega}\frac{1}{(1-\beta_{ph}\beta_0)\alpha_2} \tag{18}$$

Here $I_a = mc^3/|\varepsilon| = 17$ kA is Alfven current.

It is seen from expression (18) that start current is decreasing when resonator length and the Q-factor are growing. Besides, start current is minimum for optimal flight angle ψ, when the efficiency is maximum. For the experimental parameters (R_s = 30 Mohms/m, L = 160 cm and others mentioned above) the value of start current is of order of 10 A..

3.6. WAVE EXCITATION AT NORMAL DOPPLER EFFECT (NDE)

For our two-beam accelerator, in the second section, placed after the first one, can be realized the conditions for wave excitation by electron beam via the normal Doppler effect (NSDE). In this case beam electrons will be in synchronism with reflected wave:

$$\omega = -k_m v_0 - \omega_H^{(2)} \tag{19}$$

where $\omega_H^{(2)} = \frac{|e|H_2}{mc\,\gamma_0}$, and H_2 is the value of the axial magnetic field in the second section.

For the fixed frequency of the exited wave (ω) and absolute value of longitudinal wave number (k_m) values of magnetic fields in the first and second sections should be different. From the expressions (5) and (19) it follows, that relation between cyclotron frequencies in these sections have the form:

$$\omega_H^{(2)} = \omega_H + 2\omega \tag{20}$$

Suppose that the space structure of the fields in the second structure is the same as in the first one [1,2]. Selecting only the resonance interaction of beam electrons with the wave at NDE and assuming $\mu_m r_1^{(2)} = \mu_m v_\perp / \omega_H^{(2)} << 1$, the set of nonlinear equations for electron motion and wave amplitude can be obtained in the following form:

$$\frac{d\rho_z}{d\zeta} = \frac{\omega_H \mu_m}{ck_m^2 \alpha_1}\left(\frac{\mu_m c}{\omega_H^{(2)}} + \frac{k}{\mu_m}\right)\frac{\mathrm{Re}\left(\varepsilon_{(-)}\rho_2\right)}{1+\lambda\rho_z} \tag{21a}$$

$$\frac{d\rho_2}{d\zeta} + ig_2\rho_2 = -\frac{v_0}{\alpha_2 v_z}\left(1+\beta_z\frac{k}{k_m}\right)\varepsilon_{(-)}^* \tag{21b}$$

$$\frac{d\varepsilon_{(-)}}{d\zeta} - v\frac{d\varepsilon_{(-)}}{d\tau} = \frac{\omega_H \mu_m}{\alpha k_m \alpha_2}\int_0^1 d\tau_0 \frac{\rho_2^*}{1+\lambda\rho_z}\left(\frac{\mu_m v_z}{\omega_H^{(2)}} - \frac{k_m}{\mu_m}\right) \tag{21c}$$

where $\varepsilon_{(-)} = i\frac{C_{-m}}{2C_*}; C_* = \frac{mv_0^2\gamma_0^2\mu_m}{|e|I_1(\mu_m\bar{r})(\alpha_1\alpha_2)^{1/2}}\left(\frac{\chi}{k_m}\right)^{3/2}\left(\frac{\omega_H}{\omega}\right)^{1/2}$;

$$\rho_2 = \frac{p_+}{mc\,\lambda_\perp}e^{-i(\alpha x + k_m z + \varphi)}.$$

Evidently, that the equation for the field (21c) takes into account the specific of wave propogation in the second section. Namely, as the wave is propagating contrary to the beam motion direction, the growth dynamics of the wave should be investigated with consideration of its space and temporal evolution. This problem will be solved separately. In this section, we considered a principal possibility of the wave excitation at NDE by the beam leaving the first section after ADE interaction.

Since in the resonator a standing wave is excited, the generation of a contrary wave means the growth of the forward wave which should accelerate the ions.

At the exit of the first section E-beam has a perpendicular component of velocity due to the interaction with wave at ADE. Its magnetude can be easily calculated from equation (10). Taking into account this fact, we can obtain from general theory of wave excitation at NDE the following expression for temporal growth rate:

$$\delta = \frac{3^{1/2}}{2}\left[\frac{I}{I_a}\frac{\beta_{\perp 0}^2}{2\gamma_0\beta_{z0}^3}\frac{\lambda^2}{\pi SN}\frac{\beta_{ph}^2}{\gamma_{ph}^2}k_c^2\right]^{1/3} \tag{22}$$

where $\beta_{\perp 0} = v_{\perp 0}/c$, λ is the wave length. S is the waveguide cross-section, N is the wave norm, and k_c is the coefficient of beam - wave coupling. (A similar result was realized in Reference [27] for a gyrotron, in the case of fast transverse waves).

From this expression it is seen that intense beam with rather great perpendicular velocities of electrons can efficiently excite the oscillations at NDE. The answer on the whole problem about excited waves dynamics, saturation level and effiiciency can be obtained with selfconsistent solutions of the set of nonlinear equations (21) together with studying the beam dynamics in the first section. These investigations will consist the subject of further work on the development of the two-beam accelerator program based on ADE and NDE.

4. Summary

In this report presented are the results of the first stage of the project "Development of a two-beam high-current ion accelerator based on Doppler effect".

The following results are obtained,

1. The Physical concept of the two-beam high-current ion accelerator based on Doppler effect is well grounded. This concept may provide the ground for creation of ion accelerators with 10 - 100 MeV energy, 1 - 10 A current, and 10 - 100 MeV/m rate of acceleration.

The following results are obtained:

1. The Physical concept of the two-beam high-current ion accelerator based on Doppler effect is well grounded. This concept m ay provide the ground for creation of ion accelerators with 10 - 100 MeV energy, 1 - 10 A current, and 10 - 100 MeV/m rate of acceleration.
2. The project of the EAS is developed. The EAS is intended to prove the workability of this type of ion accelerators and to optimize their parameters. The main EAS parameters are calculated to accelerate protons from 5 MeV initial energy to 8 MeV final energy. The accelerating section is designed on the basis of the H-type resonator with drift tubes on meeting suspenders. The operating linear proton accelerator will be used as an injector. At this stage of research the conditions are chosen when energy losses of the electron beam are small in order to simplify calculations and increase their reliability as well as to simplify experimental adjustment of the accelerator. This paper includes the design project of the EAS, the technical data on the EAS and H-type resonator, the description of the EAS and resonator detail design.
3. The set of nonlinear selfconsistent equations has been elaborated for wave excitation by an electron beam in case of anomalous and normal Doppler effects in a H-type accelerating structure both for amplification and generation regimes.
4. The theoretical investigation and computer simulation in the bounds of the obtained set of equations have been fulfilled. It has been shown that for the experimental setup the planned accelerating gradient of order of 60 kV/cm can be achieved. Initial efficiency of order of 1% will become higher with growing phasse velocity and keeping resonance by means of specially profiled magnetic field. (Part I discussesthe ways to enhance the efficiency considerably and they will be studied in later developments. In particular, it is suitable the method similar to one (10) which increase the FEL efficiency by tapering th ewiggler magnetic field).

   The main parameters of the EAS are confirmed by these theoretical investigations.
5. The investigations carried out show this acceleration method to advantage and lead to the expediency of the research and development continuation. At the present the EAS and H-type resonator are being manufactured at the KFTI.

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DOCTRINES OF NATIONAL SECURITY, AND PROBLEMS OF CONTROL OF ARMED FORCES EVOLUTION

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1. Introduction

The problems of analysis of national security and evolution of AF are extremely complex and many-sided. Being aware in full measure of the hopeless of their comprehensive study within the framework of one paper, the author nevertheless take the risk of proposing to the readers to consider simplest in some sense macromodels of military conflicts and formalized national security doctrines which make it possible nevertheless to take into account the main features of events being analyzed.

2. Macro-Models of the State of Armed Forces and Evolution

Only the case of a potential conflict between two parties will be considered below. First and foremost, despite somewhat conditional character of this operation, we will divide the armaments of the both parties into two main groups: offensive ad defensive weapons. The circumstance that some kinds of the weapons are of double purpose is not an obstacle for such subdivision since the objects which are set to AF of parties predetermine their assignment to one or other group.

We will characterize qualitative composition of offensive weapons of the parties by vectors X' and X" , respectively

$$X' = \| X'_i \| N''_{i=1}; \quad X'' = \| X''_k \| N''_{k=1}, \tag{1}$$

where X'_i and X''_k are the I-th and the k-th components of offensive weapons, respectively (generally $N' \neq N''$).

We will characterize total power of offensive weapons of the parties by vectors χ' and χ'' , respectively

$$\chi' = \| \chi'_i = q'_i \; X'_i \| N'_{i=1}; \quad \chi'' = \| \chi''_k \; = q''_k \, X''_k \| N''_{k=1}, \tag{2}$$

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where q'_1 , q''_k are, respectively, the number of the i-th and the k-th components of offensive weapon systems of the parties and, therefore, relation between vectors χ' and X' has the form

$$\chi' = Q'X', \ \chi'' = Q''X'' \text{, where } Q' = \text{diag } \{q_i\}N'_{i=1}, \quad Q'' = \text{diag } \{q_k\}^{N''}{}_{k=1}. \tag{3}$$

$$Y' = \| y'_1 \|^{M''}{}_{1=1}; \quad Y'' = \| y''_j \| \, | \, M''_{j=1}, \tag{4}$$

where y'_1 and y''_j are, respectively, the l-th and the j-th components of defensive weapons systems (generally $M' \neq M''$).

We will characterize reserves (quantity) of defensive weapons by vectors

$$\Im' = \| \Im'_1 = r'_1 y' \|^{M'}{}_{1=1}; \quad \Im'' = \| \Im''_k = r''_k y''_k \| \, | \, M''_{k=1}. \tag{5}$$

where r'_1 is a quantity of the l-th component of defensive weapon system of the first party, and r''_k is a quantity of the k-th component of defensive weapon system of the second party. Therefore, relation between vectors $\Im'$ and Y' and, respectively, between $\Im''$ and Y'' is of the form

$$\Im' = R'Y', \ \Im'' = R''Y'' \text{, where } R' = \text{diag } \{r_l\}M'_{l=1}; \quad R'' = \text{diag } \{r''_k\}^{M''}{}_{k=1}. \tag{6}$$

We will introduce also the third components of the military potential of each of the parties, which is very important and plays an increasingly important role (as demonstrated by the experience of the Gulf War), namely the information capacities of the parties which comprise all means of reconnaissance (electronic, satellite, airborne, etc.), communication, and control (staffs and command posts of all levels). We will characterize these components of the total military potential of the parties by the respective vectors

$$U' = \| u'_s \| G'_{s=1}; \quad U'' = \| u''_q \| \, | \, G''_{q=1} \tag{7}$$

where $u''_s \neq u''_q$ are, respectively, the s-th and q-th components of information systems of the parties (generally $G' \neq G''$) .

Then we will characterize the total military potential of each of the parties by the generalized vectors

$$(\exists')^T = [\, (\chi')^T, (\Im')^T, (U')^T]; \qquad (\exists'')^T = [\, (\chi'')^T, (\Im'')^T, (U'')^T]; \tag{8}$$

The state of each of the parties is characterized also by a definite level of industrial and economic potential π' and π''. Thus, the ultimate state of each of the parties will be characterized respectively by the generalized vectors of military and economic qualitative composition of defensive weapons of parties.

It is assumed that definite financial resources are allocated every year for maintenance and development of AF of the states (which correspond to the generally accepted practice of annual consideration and approval of military budget by parliaments of different countries). Then a further variation of military potential of the parties in time will be described by the system of difference equations which we will write below for brevity sake only for one party.

$$\chi'_{n+1} = F_1(\chi'_n, W'_n), \tag{9}$$

$$Y'_{n+1} = \Psi_1(Y'_n, V'_n), \tag{10}$$

$$U'_{n+1} = \phi_1(U'_n, H'_n), \tag{11}$$

Here $F_1(.)$, $\psi_1(.)$ and $\phi_1(.)$ are given generally nonlinear vector functions; W'_n, V'_n and H'_n are vectors of financial appropriations, for development (evolution) of respective kinds of weapons.

Since budget appropriations assigned for need of AF are always limited, restrictions are imposed on values of W'_n, V'_n and H'_n

$$\| W'_n \| + \| V'_n \| + \| H'_n \| \leq \sigma'_n, \tag{12}$$

where σ'_n is a number given for each n. Here $\| X \|$ is vector norm

$$\| X \| = \sum | x_i |,$$

where X_i is the i-th component of vector X, and m is its dimensionality.

The problem of determining budget funding level as well as that of its distribution between respective kinds of arms should be solved in accordance with the objectives which each of the parties poses for its AF. Thus, formalization is necessary of objectives which AF of the parties are facing. But this should be preceded by consideration of macromodels of potential military conflicts between parties and of the roles which should be played in them by each of components of generalized miliary potentials of each of the parties.

3. Macro-Models of Military Conflicts

First of all, to reduce fundamentally dimensions of macromodels agreed between superpowers and which allows us to consider instead of vectors X' and X'' and, respectively, vectors χ' and χ'', their equivalents (in total efficiency of action) which are defined as

$$X' = S^T_1 X', \quad X'' = S^T_2 X'', \tag{13}$$

where S_1 and S_2 are vectors of respective normalizing weighting coefficients. Then we obtain from (3) and (13)

$$\chi' = S^T_1 Q' X', \quad \chi'' = S^T_2 Q'' X'', \tag{14}$$

where χ' and χ' are, respectively, equivalent potentials of offensive weapons of the parties.

We will extend the general approach providing the basis of the JOSIM method also to defensive weapons and introduce in a similar way the defensive potentials (DP)

$$y' = C^T_1 Y', \qquad y'' = C^T_1 Y'', \tag{15}$$

$$\Im' = C^T_1 R' Y', \quad \Im'' = C^T_2 R'' Y'', \tag{16}$$

where C_1 and C_2 are vectors of normalizing weighing coefficients.

Similarly, we introduce scaler quantities u' and u'', characterizing aggregated information potentials (IP) of the parties

$$\upsilon' = E^T_1 U', \qquad \upsilon'' = E^T_1 U''. \tag{17}$$

where E_1 and E_2 are vectors of weighting coefficients.

We will assume further that on the basis of one or other grounds the offensive potential (OP) of the first party is divided into portions

$$\chi' = \chi'_u + \chi'_x + \chi'_\pi, \tag{18}$$

where χ'_u is the portion of the OP of the first party intended to strike the IP of the second party, χ'_x is the portion of OP of the first party intended to strike the OP of the second party, χ'_π is the portion of OP intended to strike economic potential (EP) of the second party. Division of the military potential of the second party is carried out in a similar way.

Now let us turn to consideration of macromodels of defense of division of OP and DP of the parties into their individual components introduced above remains invariable in the course of military conflict.

Macromodel of IP Protection. In accordance with designation introduced above, we will consider component χ' as a part of OP intended for striking IP of the opposite party, and we will denote by χ'_u the portion of this OP which overcomes defensive line of IP. In the general case of relation between these components takes the form

$$\chi'_u = f''_u (\chi'_u, U'', \Im_u, L''_u), \tag{19}$$

where $f''_u(\cdot)$ is a function given accurate to parameter vector L''_u, such that $\chi'_u \leq \chi'_u$. In this case

$$L''_u \varepsilon \zeta''_u, \tag{20}$$

where ζ''_u is a given convex set.

We will point out here that the availability of only estimate (20) is of fundamental importance since it reflects the presence of uncertainty in description of military conflict whose final results do not lend themselves to a comprehensive determinate description. In our opinion, the model of uncertainty accepted here is more adequate to the essence of the phenomenon being considered here than introduction of some kind of probability characteristics.

Macromodel of OP Defense

$$\chi''_x = f'_x (U'; \chi''_x; L'_x), \text{ where } L'_x \varepsilon \zeta''_u, \tag{21}$$

Macromodel of EP Defense

$$\chi''\pi = f'\pi (U'; \chi''\pi; L'\pi), \text{ where } L'\pi \varepsilon \zeta''\pi, \tag{22}$$

Macromodel of Striking IP

$$\mathbf{U}' = \psi'_u (U''; \chi''_u; R'_u), \text{ where } R'_u \varepsilon \Re''_u, \tag{23}$$

Macromodel of Striking OP

$$\chi' = \psi'_x (\chi'; \chi''_x; R'_x), \ \Gamma\, \Pi\theta \quad R'_x \varepsilon \Re''_x, \tag{24}$$

Macromodel of Striking EP

$$\Pi' = \psi'_\pi (\Pi'; \chi'_\pi; R'_\pi), \ \Gamma\, \Pi\theta \quad R'_\pi \varepsilon \Re''_\pi. \tag{25}$$

4. Formal Models of Military Doctrines

The availability of models of potential military conflicts of two opposing parties allows us to evaluate the accessibility of objectives which are formulated as military doctrines. In particular, general schemes of optimizing problems solution are considered in [1], [2], to which the problems are reduced formulated in the context of such well-known military doctrines as: a) the doctrine of delivering a preventive disarming blow; b) the doctrine (strategy) of guaranteed retaliation (equilibrium of fear); c) the doctrine of defensive sufficiency, etc. In this case a natural assumption is introduced that each of the parties striving to achieve its objectives acts within its restriction in an optimal way. For example, for the doctrine of delivering a preventive blow the objective of the first party is a solution of the problem

$$\max \{\chi'' = \psi''_x [\chi''; f'_x(U'_x ; \chi'_x ; L'_x); R'_x]\} , \quad x' \varepsilon \chi'. \tag{26}$$

The circumstance that each of the parties instead of possessing true values of military potentials of the opposing party, and parameters characterizing the efficiency of defense of military and economic potentials, as well as parameters characterizing the efficiency of defeating respective targets, has available only some their estimates, results in the fact that respective optimizing problems are ill-defined and therefore must be defined additionally in some way. Under these circumstances the urge to use the approach resulting ultimately in the necessity to consider and to solve minimax problems seems to be quite natural. In this case instead of problem (26) it is necessary to solve the problem

$$\min \max \{\chi'' = \psi''_x [.]\} , \chi''_x \varepsilon \chi' \, R''_x \varepsilon \Re''_x , L''_x \varepsilon \zeta'' x. . \tag{27}$$

If inequality $\chi'' \leq \chi''$ is satisfied for solution of this problem, where χ'' is a number given by the first party, then the objective sought by the problem is accomplished.

U.S. SMALL BUSINESS IN INTERNATIONAL COOPERATION FOR DEFENSE CONVERSION

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1. Background

There are two approaches to defense conversion. One focuses on redirection of existing knowledge or production capability in the military sector to civilian application, usually requiring little new investment. The second is to reinvest in the existing defense infrastructure to convert it to commercial production of new products. While the second way demands significant investments, long term strategic planning, and government involvement, small companies engaged in international business can contribute to the defense conversion process if they focus on the first approach.

2. Conversion Activities in Kiser Research, Inc.

This presentation concentrates on defense conversion activities of Kiser Research, Inc., a Washington, DC - based company which, for the last fourteen years, has served as a successful matchmaker for Eastern and Western partners in various science, technology and engineering programs. Today, dozens of US firms broker FSU technology [1], but KRI was a pioneer in this business.

Mr. John Kiser,the founder and President of KRI, started the company in the early 1980s and made a contribution in international cooperation for defense conversion. He has worked out customer driven mechanisms and strategies for this business [2, 3]. Under his leadership, KRI concluded over 75 commercial and technical agreements, primarily in the defense conversion area. Tables 1 and 2 demonstrates examples of KRI's accomplishments for the last three years. A majority of projects utilize defense-based technology or equipment developed in Russia and the Former Soviet Union, and are transferred to U.S. Customer for evaluation of civilian applications.

KRI is constantly engaged in identifying world class technologies, developed in Eastern Europe, which represent opportunities for acquiring new products and process optimization technology and for Western industry and new investment opportunities for venture capital. Examples from KRI's venture portfolio include:

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Electric Propulsion System for Space Vehicle (Plasma Thrusters) - KRI helped to establish the first commercial space joint venture utilizing advanced Russian plasma thrusters between Space Systems/Loral Inc. And Fakel Enterprise. The thrusters are used for satellite orbit transfer and station maintenance control and are the only flight tested hardware of their kind in the world. The thrusters are smaller and more efficient than chemical fuel tanks now used in the West.

SHS Technology (Self-Propagating High Temperature Synthesis) - In 1990, KRI representing both Russian and U.S. Interests, helped to establish SHS Spain, a joint venture between United Technologies Corp., the INI Group, and the Institute of Structural Macrokinetics (Russia). The technology, based on controlled explosion processes, is a revolutionary method to synthesize hundreds of types of ceramic, composite and intermetallic materials using only head energy from the combustion process. According to Dr. Hernan, Managing Director of UTRC Spain, "SHS is in a position to place high-purity ceramic powders on the market at a price as low as $35 a kilogram, compared with prices that currently range from $100 to $500 a kilogram, depending on the purity of powder" [4]. SHS plans this year to switch production from its experimental factory in Madrid to Granada former arms factory.

TABLE 1. Contracts 1993/1994

TECHNOLOGY	MARKET	BUYER	TYPE OF AGREEMENT	STATUS
RSD Semiconductor Pulsers	Stack gas cleaning desulfurization	Scientific Utilization Inc.	Exclusive Option	Negotiations being concluded March 1994
Oxygen Separator	Medical, Industrial	Air Products and Chemicals Inc.	Testing	1St prototype tested
Multi-beam Klystrons	Compact power Sources for radars	EEV/Marconi	Testing and Option	2Nd device to be tested March 1994
High-Frequency Pulsers	Communications	Los Alamos National Lab	Device Purchase	Testing; more offers possible
Silicon Carbide Transistor & Wafers	High Temperature Electronics	Wright Patterson AFB, US Army, EPSD	Sample Purchase	Devices to be tested
Plasma Thruster	MISTI Program	Edwards AFB	Device Acquisition	Testing at Edwards AFB
Nanosecond Pulse Generator	Surveillance Disabling Device	Phillips Laboratories	Device Acquisition	Evaluation Period

TABLE 2. Contract 1992

TECHNOLOGY	MARKET	BUYER	TYPE OF AGREEMENT	STATUS
Plasma Membrane Processing	Gas Separations	Air Products	Option Agreement	Contract R&D
SHS	Refractory Materials	United Technologies	Joint Venture	First Stage
Microwave Generator		Phillips Laboratories	Equipment Purchase	R&D/ Experimenting
Plasma Thruster	Civil Satellite Orbit Maintenance	Edwards AFB	Equipment Purchase	Active

KRI supports the proposed mechanism for defense conversion and participates in the programs where national lab and industry are grouping to identify, verify and commercialize world class R&D advances in the /FSU with significant competitive implications for the U.. And the FSU. Such a mechanism benefits the FSU by defining their higher value technical scientific assets, validating the results and linking them to the eastern marketplace. U.S. National laboratories and industry gain access to new research and technology and create strategic relationships with FSU institutions which can enhance overall competitiveness of the U.S. Organizations involved. The United States industry Coalition Program funded by U.S. Department of Energy is a good example of implementing this mechanism. KRI has assisted Sandia National Laboratories to identify projects in Urals and Ukraine related to material and process engineering. Sandia technical team took a trip in July 1994 and selected technologies for projects which have the most promise for direct US private sector investment. Projects last approximately one year, their results should enable investors to make a decision about the value of the technologies. The reports of this projects (deliverables) have been published and are accessible for industries [5].

3. Role of Small Company in Defense Conversion

Benefits of using an experienced intermediary for international cooperation in defense conversion are as follows:

3.1 CREDIBILITY WITH RUSSIAN

KRI is known in a number of government and industry circles in Russia as credible and an early performer in the field of science and technology (S&T) transfer. KRI's frequent

visits to technology sources in Russia (with U.S. Industry and government clients) have a high success rate -- measured in agreements struck and creating cash flow to Russian technology owners. KRI's success in getting SDIO "launched" into a Soviet program five years ago occurred because of its credibility with Russians as an industry oriented technology transfer company. SDIO's first Russian technology transfer agreement was done through KRI in 1989 to acquire access to the Kurchatov institute's power conditioning (tacitron) experience for use in TOPAS.

KRI's successes are tied to its "demand driven" approach of working with industrial firms who have retained KRI to find technologies, make introductions, and manage the interactions with their Russian partners.

In turn, its successes representing Russian S&T owners in finding commercial partners is a result of KRI's willingness to tale risks up front by investing time and money in marketing for its Russian partners.

3.2 LONG EXPERIENCE AND KNOWLEDGE IN-COUNTRY

KRI understands many of the fine points of making things work to reach agreements and keeping things on line.

3.3 ON-GROUND OPERATIONAL CAPABILITY

Working through proven reliable Russian partners in Moscow, St.-Peterśburg, Ekaterinburg, Tomsk, and broad networks. KRI has the ability to instantly implement a wide range of tasks.

3.4 SPECIALIZATION IN TECHNOLOGY AND FSU

KRI has developed as a small business by specializing the niche market of finding and converting value in the Eastern bloc countries.

3.5 STRONG TIES TO INDUSTRY

By building most of its business on demand side, and being an early missionary in creating demand within U.S. Industry, KRI has knowledge of U.S. Industrial approaches, practices and concerns in this arena. KRI track record can make industry feel more comfortable that it ha an experienced and proven U.S. Guide in entering uncertain troubled markets.

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AN EXAMINATION OF THE UK'S MILITARY AIRCRAFT INDUSTRY'S RESPONSE TO THE POST COLD WAR

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1. Introduction

This paper examines the response that companies in the UK's military aircraft industry have adopted to the declining levels of defense spending experienced since 1989 and will investigate the reasons for the lack of organic diversification[1] attempted. For analytical purposes the market will be divided into a pyramidal hierarchy of companies, structured largely around the requirements of designing and building modern weapons platforms which has three separate and distinct tiers. Prime contractors represent the apex and small component suppliers the base, with avionics companies occupying the intermediate middle tier. Companies from all three tiers were examined with evidence being based on interviews with a range of management personnel.

Two particular issues were examined in relation to each company. The first concerns the extent to which the peculiarities of the defense procurement environment have shaped or constrained the resources and capabilities of companies. The second examines the factors which have influenced their behavior and strategic response following the end of the cold war. It is often argued that military markets have particular requirements which have profound effects on company organization and capabilities, limiting their general relevance, and thus making diversification a difficult and unlikely process. For example, it is argued that these companies possess relatively little in the way of 'commercial' marketing skills since they are unnecessary or that the products and technical capabilities of the companies aren't suited to other environments since equipment is designed for unique requirements and where the design efforts are biassed toward issues of technical performances. The paper will therefore examine the relevance of these assumptions about the unique nature of the military market environment for each of the three ties under consideration. It is assumed that the behavior of all companies (not simply those which operate in military markets) is partially, but significantly, influenced by the requirements of their operating environment, thus making their technical skills, behavior and organizational capabilities rather narrow and specific. These ideas are developed from evolutionary economics and theories on the specificity of company knowledge.

[1]Organic diversification refers to what is often called conversion, where resources previously dedicated to military work are adapted to other non-military applications.

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It will be seen that particular aspects of defense markets have shaped the capabilities and behavior of these companies thus making them unsuited to a wide range of non defense environments. However, this will be seen as inadequate on its own as an explanation for the response of the companies. Their behavior can be better understood by also looking at other factors which influence their strategy, the most important of which include the narrow economic motivation of the company's behavior, the effect of corporate centres on divisional behavior and the ubiquitous influences of government.

2. Company Capabilities

2.1 ORGANIZATIONAL CAPABILITIES

The organizational structures and capabilities of the first and second tier companies were found to be very similar and were influenced by both the particularities of defense markets and to the requirements of conducting long term, large scale development projects. The requirements of undertaking such development work places a number of organizational demands on these companies: large design and development functions are required, which results in high proportions of professional staff development staff: extensive facilities for the design, manufacture and environmental testing of design prototypes: large administration, quality and contract departments to monitor both the development of design progress and control the large amount of sub-contract work that is required. These constraints are more related to the general requirements of undertaking this type of work than to any particular aspects of military markets [2].

However, there were also unique aspects to the operation of military markets which have influenced the organizational structures and behavior of these companies. In military markets, at the first and second tier level, company efforts tends to be focused on complying with the technical requirements of specifications. This emphasis results in organizational efforts being devoted more to improving the technical capabilities of products during the development process and less to other issues, for example reducing manufacturing costs. Therefore the idea that military companies are more concerned with product than process innovation was found to be true. Due to the extended period of time that these companies have operated under these constraints there has been an under-development of effective systems for monitoring and complying with such requirements as cost efficient manufacturing. Competition in environments with a greater emphasis on manufacturing cost or efficient delivery is therefore likely to be difficult.

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[2]There are a large number of non-military markets in which similar requirements are demanded and such organizational structures exit, the most obvious and closely related example being in civil aerospace development.

Another aspect of defense markets, at the first and second tier level, is in the nature and operation of customer relations, which are very distinct with the customer (government) having substantial control and power in terms of contract relations, which is due to the fact that they fund R&D, control the procurement environment and are also the ultimate customer of equipment. In this environment company performance, and competition for contracts, is measured against compliance with technical specifications. This results in marketing processes being done in very different ways from many non-military markets[3]. It can therefore be concluded that the requirements of military markets do have a discernible influence on the operation and structure of the companies, the result of which is to partially constrain the relevance of their capabilities to markets which operate in the same way.

For the third tier companies considered organizational structures and behavior was found to be shaped more by the requirements of aerospace markets than any particular requirements of military markets. At this level, for sub-contract manufacturing, the requirements of military and civil aerospace work are almost identical, that is, the batch manufacture of low volume, high quality components. The organizational requirements this places on the companies is to operate extensive and thorough quality systems for all work, demanding substantial administrative procedures, and an additional overhead cost burden to that required in most market environments. This effectively prevents them from competing in higher volume, lower quality markets due to the overhead cost penalty. Where military market requirements did impinge on the organization of these companies was the general under-development of pro-active sales and marketing functions. Due to the sheltered nature of defense markets until approximately the mid 1980's this type of company could operate on repeat business from a small, but remarkably constant group of customers. Their business had traditionally depended more on establishing a reputation as an effective supplier depending on informal contacts and automatic follow on contracts, more than on active sales and marketing, thus such functions were never required..

2.2 TECHNOLOGICAL CAPABILITIES

Technological capabilities, in relation to organizations, refer not only to the physical artifacts produced, but also to the collective skills and knowledge of the workforce. Both these aspects are examined for the companies, however, the third tier companies were purely manufacturing entitles, therefore their capabilities will be discussed in terms of the skills and knowledge of their personnel alone.

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[3]There are a number of non-military markets which operate in a similar way, for example air traffic control product specified and bought by the CAA. But in civil aerospace markets R&D must be funded by the company and not the customer, without the benefit of a precisely defined specification to define the customers needs. In all the first and second tier companies which had civil and military aerospace work this was done in separate divisions due to these very different customer relation dynamics.

For both the primes and the second tier companies military products weren't suitable for use in other, non-military environments, even after substantial modification. For example, this was found to be the case for both radar and display systems, where differences in the functional capabilities of civil and military systems were such that the military systems simply weren't adaptable. This can be attributed to the unique functional requirements of military systems[4], which have to be incorporated at the design stage, the result of which is to make the equipment very specific and non generic in nature.

With the general technological capabilities and skill of the first and second tier companies, a significant difference was noticeable, with the capabilities and skills of the second tier companies being less specific and more generic than those of the prime contractors. Prime contracting on military aircraft means the skills and capabilities of a company are focused around the design and assembly of large, complex mechanical structures and their integration with sophisticated electronics systems, which has limited generalizibility to other applications for example civil aerospace or prime contracting in the shipbuilding sector. The capabilities of the second tier avionics companies, on the other hand, are focused around designing complex electronics systems. While this also requires system management and integration skill, the capabilities of being an electronics system designer are more generic, with a wider range of applications than for simply military equipment. An example of a market which requires similar technological capabilities could be the extensive civil communications market which has been expanding massively over the last decade. This supports the assumption that the lower the position of a company within the product hierarchy, the more general its skills and capabilities are likely to be.

The technological capabilities of the third tier companies, like their organizational capabilities, were less specifically constrained by the requirements of defense markets than by the requirements of being precision, high quality manufacturers. The level of precision and accuracy which needs to be built into components in this environment is much higher than in many other environments. For example, when one of the companies attempted to diversify into the manufacture of agricultural products, the machine operators found adjusting to environments of lower tolerances and specifications difficult. The result was that they tended to take longer than was required and make components of a greater accuracy than was necessary, thus pushing up their cost. This, however, was not felt to be an insurmountable problem and that after a period of transition the workers could adapt to the manufacturing for lower accuracy environments.

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[4]Designing equipment for limited space environments, low weight requirements, unique power or cooling requirements are examples of typical functional requirements military equipment is designed for.

3. Company Strategies

It was shown that both the organizational technological capabilities of the companies examined were, to varying degrees, influenced by the particular requirements of defense markets and the nature of the tasks undertaken, thus limiting their relevance to other markets of product. However, these factors are not adequate on their own for explaining the strategies adopted by the companies. The market environment does not totally constrain and define the behavior of companies, as companies respond in different ways to the same factors, and interpret these external factors differently. Also, particularly in relation to the largest companies, it is important to remember that their relationship with the market is not uni-directional, and that these companies have the ability to shape the market as well as being constrained by it. These other influences on their strategic behavior therefore need to be considered.

Aggressive cutbacks in employment, internal restructuring and an almost complete lack of interest in organic diversification are the most common strategy policies pursued by companies at all three levels of the product hierarchy. While the 'downsizing' has been primarily initiated in response to declining defense orders, the companies have used it as an opportunity to implement substantial rationalization and efficiency measures, which in many cases far exceed the decline in business they have experienced. The result of this is that while absolute turnover levels have decreased, employment has reduced even more substantially, while simultaneously profitability and other financial ratios have tended to increase or at least remain constant.

The lack of interest in organic diversification is related to this since the companies appear confident that current levels of military work are adequate to ensure their survival, while the rationalization measures implemented have ensured their economic viability. The short term financial motivation of companies provides an effective barrier to organic diversification. Maintaining employment levels or re-using facilities is seen as a social, rather than economic goal, likely to require long term investment, careful planning and significant adaptation. Therefore it is unlikely to be in the narrow economic interests of the companies to pursue this strategy.

An increase emphasis on exports of military equipment has been a strategy pursued most aggressively by the industry prime contractor, with the second tier companies putting less emphasis on changing the geographic distribution of their sales and the third tier companies not pursuing this strategy at all. Similarly, in terms of international mergers and joint ventures it is the prime contractor who has been most active in developing such links.

Government policy over the last 10 years has been significant components; not to intervene in any industrial restructuring; not to fund any diversification; supporting and encouraging the export efforts of the defense industry. These policies have therefore reinforced the strategies of rationalization and non-diversification which the companies have pursued. The dominant corporate groups in the military aircraft industry have also adopted strategies which have influenced their defense companies strategy as they have been more concerned with diversification at the corporate level than with encouraging

their defense companies to organically diversify[5]. At the same time, corporate demands for strict financial performance targets have encouraged the defense companies to purse nothing more risky or adventurous than economic rationalization strategies.

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[5]Corporate diversification refers to the dilution of a corporations level of military business which is likely to occur through the acquisition of non-military interests, and which therefore has little effect on their autonomous defense divisions.

USE OF ELECTRON ACCELERATORS TO DEACTIVATE POISONOUS WAR SUBSTANCES

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Abstract. *A new method for solving the problem of poisonous war substances (PWS) destruction is proposed. Using a mobile industrial electron accelerator it is possible to considerably reduce the toxicity of PWS directly on their storage location. After the radiolysis the modified PW can with much less risk be stored and transported to a place where they can be completely salvaged. The estimates show that the output of the modern industrial electron accelerator for deactivating of PWSs of about 100 tonnes/year can be achieved.*

1. Introduction

The destruction of poisonous war substances (PWSs) is one of the most urgent problems for the world community. One of the chief factors in this problem is that of solving the question of the safe transportation of PWSs to specialized factories in order to salvage them completely. A new method for solving this problem is now proposed. It is to considerably reduce the toxicity of the PWSs directly at their storage locations, using a mobile apparatus, after which the modified PWSs can with much less risk be stored and transported in stages to a place where they can be completely salvaged.

It is well known that the toxicity of PWSs is determined by the special characteristics of the chemical structure of the compounds on which they are based. One might expect that a change in this structure would have a very strong influence on the intensity of their action on biological objects (their toxicity).

The well-known highly toxic substance dioxin can serve as an illustration for this proposal. Its toxicity is extremely high, its maximum permissible concentration (MPC) being $1 : 10^{12}$ (State All-Union Standards 121005 and 121007). Meanwhile, replacing one atom of chlorine in the dioxin molecule with a hydroxyl group results in a sharp reduction in the toxicity of this compound (an MPC of $1 : 10^6$). A further reduction in the number of chlorine atoms in the structural formula of this compound leads to a still greater lowering of the toxicity. Bearing in mind that the poisoning action of the majority of PWSs on biological objects is of a catalytic nature one would expect, by

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analogy with dioxin, that a modification of the structure of PWSs could also lead to an abrupt change in their toxicity. The obvious and simplest method of modifying the structure of a molecule is to destroy it. This can be achieved for the majority of organic compounds by heating them to their characteristic dissociation temperature. Despite its simplicity this method for deactivating PWSs in sealed containers is little used, for quite a number of reasons.

The present authors consider the most promising method to be the radiolysis of PWSs using electron beam sources of hard gamma or electron radiation [1]. The considerable successes achieved in developing of high-power industrial electron accelerators possessing a long operating life, a high efficiency, safety and simplicity in operation [2] make them the most realistic candidates for use in the radiolysis of PWSs.

Moreover, the use of isotope devices utilizing Co^{60} and Cs^{137} is not promising from our point of view on account of the risk of strong radioactive contamination of the environment.

2. Engineering and Physical Aspects of PWS Radiolysis

The main information on the physical processes occurring under the action of ionizing radiations is given in [3]. The action of the radiation leads to the formation of intermediate products; electrons, ions, free radicals, atoms, excited particles etc. Under normal conditions these products are highly reactive and actively interact with matter to form a large number of final radiolysis products.

The dependence of the penetration depth (the depth at which the absorbed dose is comparable with the dose on the irradiated surface) on the electron energy, in the range $E = 0.5 - 4.0 MeV$, is given by the expression:

$$l = 3.6 \cdot E[MeV] - 0.2, \tag{1}$$

where $l\ [mm]$ is the effective penetration depth for a medium density lg / cm^3.

It can be seen that effective penetration depth in aluminum for electrons with energies of the order of $4MeV$ is less the $5mm$.

When the wall thickness of the sealed container (missile) in the which the PWS is stored exceed the electron penetration depth it is inefficient to employ a beam directly. One must then use bremsstrahlung gamma radiation which can be obtained by utilizing a special target, onto which the electron beam is directed. The conversion efficiency from the electron beam to the flux of bremsstralung is then quit high, and the technology of the process is well developed. The expression $P_\gamma = 3.0 \cdot 10^{-4} ZI_e E^{1.9}$ is given in [4] for the conversion of electron beam power into bremsstralung gamma radiation. Using a $D = 2.27\ g / cm^2$ thick foil of tantalum, $Z = 73$, with 3 MeV electrons a conversion coefficient of the order 3 - 5% can be obtained. Since the average energy of the bremsstralung gamma photons is $0.2E$, we obtain a penetration depth of the order of 12 cm.

3. Summary Information on Radiolysis of Organic Substances

An extensive amount of experimental data on the radiolysis of organic substances has so far been accumulated which is rather fully presented in the monograph [2]. These data can be briefly summarized as follows:

- The absorbed dose (the absorbed radiation energy per unit mass of the substance) is a weak function of the elemental composition of the materials.
- The radiation-chemical conversion rate for organic compounds increases on going on from solid to the liquid state.
- If one knows the chemical composition of the organic molecules one can predict their radiation stability (the dissociation threshold).
- As a rule, substances which are more thermally stable have a lower radiation stability.
- In addition to the radiolysis processes (dissociation) of organic substances, one also observed their polymerization (a transition from the liquid to the solid state).
- The radiation stability of organic materials is strongly depended on additive used as oxidants.
- As a rule, radiolysis is intensified when the temperature is raised. This effect is especially marked on passing through the melting point.

4. Estimate of Energy Required for Deactivating PWSs

Since we do not know of data on deactivation of PWSs using an electron beam, preliminary experiments were performed to get the estimate required for changing, the toxicity of powdered and liquid organic compounds (pesticides) which formulas are similar to PWS.

From these experiments [5] we have got that the average energy is on the order 10 *eV / molecule* for which the significant changing of toxicity were observed.

Let us take three chlorbrommethane (CCl_3Br) as another independent estimate of the specific energy required for the radiolysis. The energy necessary for the radiolysis of this substance is well known to be 20 *eV / molecule* [6]. We consider this to be an analogue of the lacrimatory asphxiation types of poisonous substance three chlornitromethan (CCl_3NO_2) and three bromnitromethan (CBr_3NO_2) [7].

It can be seen that these two estimates (10 *eV* [5] and 20 *eV* [6]) are in satisfactory agreement with each other.

5. Estimate of the Output of an Apparatus for Deactivating PWSs Using an Industrial Electron Accelerator

One can estimate the output achieved when deactivating PWSs by means of an Θ JIB-type industrial electron accelerator developed in the Budker's Institute of Nuclear Physics [1]. The output can be estimated from the following formula:

$$M\ [tonnes\ /\ year] = 3 \cdot 10^{-3} \cdot \eta \cdot P \cdot \frac{\mu}{\epsilon} \qquad (2)$$

where P is the accelerator power [kW], η is the industrial efficiency of the accelerator [%], ϵ , is the specific energy required for the radiolysis of one molecule [*eV /molecule*], μ is the molar mass of the substance.

Using the technical characteristics of the Θ JIB-6 industrial accelerator: electron energy 1.5 *MeV*, average beam power 90 *kW* , we estimate $M \approx 200$ *tonnes / year* (for $\epsilon = 20$ *e / molecule* and $\mu = 200$).

Operating the Θ JIB in the bremsstrahlung gamma radiation regime, the output of the apparatus is given by the expression:

$$M_\gamma = k \cdot M\ , \qquad (3)$$

where k is the power conversion coefficient for the generation of bremstrahlung gamma radiation from the electron beam.

Taking into account the fact that an accelerator having a power of ≈ 0.5 *MW* has already been developed in a conversion regime with $k \approx 1\%$, we estimate the output of the apparatus to be ≈ 15 *tonnes / year.*

It may be expected that the data obtained with real PWSs will not differ greatly from the above estimate since the spread of the data is not great.

6. Conclusion

A method has been proposed here for deactivating poisonous war substances using a mobile radiation apparatus on the base of industrial electron accelerator such as developed in Budker's Institute of Nuclear Physics at Novosibirsk.

This method makes it possible to lower the toxicity of PWSs by directly irradiating the containers (missile) at their storage location.

The preliminary estimates show that the expenditures of energy, finance and materials for the deactivation process are entirely acceptable as regards putting this method into practice.

Recently we have known that the similar investigations and experiments for electron beam destruction of chemical warfare (CW) are performing in USA [8]. We would be very interesting in a cooperative research effort with our American colleagues.

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HIGH-VOLTAGE STRING SATELLITE SYSTEM FOR ACTIVE EXPERIMENTS IN THE EARTH MAGNETOSPHERE

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Abstract. *A new method [1] for man-made control on the high energetic charged particles of radiation belts of the Earth are discussed. The use of the long conductive string with high potential relative the space provide the possibilities for a series of active experiments in the magnetosphere of the Earth. This space system can be used as a tool for studying the processes in natural radiation belts of the Earth. At the same time the series ecological problems of the space environment can be solved: precipitation of charged particles from the man-made radiation belts, ozone layer depletion problem etc.*

1. Introduction

Near the Earth there exist the regions with trapped high energy particles, the so called radiation belts of the Earth (RBE). This high-energy particles (electrons and protons) are formed due to the cosmic neutrons decay and accelerating processes in the space fields. The magnetic field of the Earth is the magnetic trap for charged particles. This follows from the orbital angular momentum and energy conservation law:

$$p^2_{\perp \min} + p^2_{\parallel \min} = p^2_{\perp \max} + 0 \tag{1}$$

$$\frac{p^2_{\perp \min}}{H_{\min}} = \frac{p^2_{\perp \max}}{H_{\max}} \tag{2}$$

where $P_{\perp}$ and $P_{\parallel}$ are the components of particle momentum along and perpendicular to magnetic field, respectively, indices *max* and *min* correspond to maximum and minimum magnetic field regions. Solving this equation we obtain condition for particle confinement: $(p_{\parallel \min} / p_{\perp \min})^2 = \mathrm{ctg}^2\,\Theta_{cr} = k\text{-}1$, where k is mirror ratio H_{max} / H_{min} and Θ_{cr} is a critical pitch angle. The particle is trapped and oscillates between the mirror points if their pitch angle $\Theta \geq \Theta_{cr}$. This is valid when the particle Larmor radius is smaller relative to the scale of the magnetic field inhomogeneity.

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The particle life-times inside the RBE are fairly long: 10^8 s for electrons and 10^9 - 10^{10} s for protons. If in one way or another one provides the intense angular scattering of particles their life-time will not exceed the value $t_{e,p} \cong L_H / \nu_{e,p}$.

So if we provide the sufficient angular scattering of the particles we have to observe the rapid decrease of the density of the high energy particles inside RBE and increase of the flux of charged high-energetic particles into the ionosphere.

Below the long high-voltage string as a scattering center for RBE particles is discussed [1].

2. Technical Parameters of High-Voltage String Space System

The simplest version of the project under study is a system consisting of the main satellite (with energy supply and high-voltage generators) tethered to two sub-satellites with long (10-20 km) strings. This is quite similar to TSS-1 project.

When the potential of conductive string is of the order of the energy of charged particles ($\approx$ 1 MeV) the scattering cross-section ($S \approx 2L_sR_c$) will be achieved. L_s is the length of the string, R_c is the radius of region where electric filed near the string exist. According to electrostatic Langmuir probe theory we have estimation for R_c:

$$R_c = \left(\frac{\phi_0}{4\pi ne}\right)^{1/2} \tag{3}$$

where ϕ_0 is potential of the string relative to the space, n is the cold plasma density, and e is the electron charge. For $\phi_0 \approx 1$ MV and $n \approx 100$ cm^{-3} we have estimate for $R_e \approx$ 1 km.

The electric current collected by the string under the negative potential from the cold plasma environment is estimated as follows:

$$J_s \approx en\pi r_s L_s \upsilon_{Ti} (e\,\phi_0 / T_i)^{1/2} \tag{4}$$

where r_s is the string radius. For r_s =1 mm, n = 100 cm^{-3}, ϕ_0 = 1 MV, T_i = 100 eV, L_s = 10 km we have $J_s \approx 5 \cdot 10^{-3}$ A.

The high-voltage generator must have power $P = J_s \cdot \phi_0 = 5$ kW. The second string which is under the positive potential will collect electrons and the corresponding current equals to J_s.

The total current which must be provided by high-voltage generator envolves the photo-emission and field-emission (autoemission) currents. The photo-emission current density due to solar UV radiation is of the order of 10^{-9} A, which is smaller than the collecting ion current density $J_s / 2\pi r_s L_s \approx 5 \cdot 10^{-9}$ A/cm^{-2}. Because the electric field strength on the surface of the string is:

$$E \sim \frac{\phi_0}{r_s \ln \frac{R_c}{r_s}} \tag{5}$$

i.e. $\approx 10^6$ V/cm the field-emission current is negligible.

The energy transport to surface of the string due to the collecting particles which lead to additional heating is $J_s \phi_0 \approx 0.005$ W/cm^2 .

The total mass of the construction is estimated as 2 tons.

3. Conclusion

Taking into account the previous facts, the principal possibility of the project is not doubtful.

For realization of the project it is necessary to consider additionally the questions of high-voltage discharge prevention.

A special attention should be made to the problem of interaction of space system elements and ambient plasma including the satellite charging.

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CONVERSION ACTIVITIES OF SCIENTIFIC AND PRODUCTION CENTER "SOLITON-NTT"

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1. General Information

The company is founded in 1990 by the Military Academy after Dzerzhinskii and by the Aero-Cosmic Agency "Souz".

Presently SOLITON funds scientific and technological programs and organization of production high-technological products based in Russian state enterprises. Among them are: Institute of Chemical Reagents, GIRIKOND, Istok, VNIOFI, Karpov Institute, Kurchatov Institute, Lebedev Institute, Institute of General Physics, VNIIFTRI, Institute of microelectronics that in the past implemented orders of the military-industrial complex of the USSR.

SOLITON actively participates in the privatization of state enterprises as directly as through founded Investment Foundation "Invest - Center". SOLITON is a big shareholder of the stocks of a number of Russian enterprises such as:

- NIPIM with electrochemical and mechanical factories. Activities are in the development and production of high purity alkoxydes and oxides and also medicines and vitamins with a new electrochemical technology, development and production of differents monomers, paint and acids for industry.
- "Phonon" - Activities are in the field of electronics.
- "Signa"; "DTD", "BIFO" with activities in the field of medical equipment and instrument.
- Yuganskneftegaz and others.

SOLITON has agreements and cooperates on development and production of new technologies, devices and materials with a number of foreign partners, such as:

- Lawrence Livermore National Laboratory, Lawrence Berkeley Laboratory, General Atomics, Symetrix Int., Advance Technology Materials, (USA).
- Ecole Polytechnique, Comissariat a L'Energie Atomique, Universite de Limoges (France)
- Queens University of Ontario (Canada)

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- Philips Research Laboratories, Holec Zero-Flux, FOM (The Netherlands).
- Advanced Institute of Science and Technology (Korea).

SOLITON participates in a number of grant schemes: DOE and USIC (USA), CNRS (France), Russian Foundation for Basic Research, Russian Foundation for Technological Development, Foundation for Support of Scientific and Technological Business.

2. The Main Directions of SOLITON Activity

- Optronics including streak and frame cameras, gating image intensifiers, image converters and other accompanying equipment
- Ultra high purity alkoxides and alkoxy-derived oxides for electronic industry
- Chemical industry
- Capacitors including ones with a high dielectric permittivity and low losses
- Medicines: ß-carotene and novokain
- Medical instruments: X-ray apparatus, high speed dental drills, diamond dental tools
- Utilization of the chemical weapons, ecology
- Oxide and rare-earth elements cathodes
- Free-electron masers and backward wave oscillators
- Powerful and tunable Cherenkov generators with a broad bandwidth
- Multilayer mirrors and curved crystals for X-ray optics.

3. Brief Summaries of the Activities

3.1 OPTRONICS

The different kinds of streak and frame cameras constitutes the main achievements of SOLITON in the field of optronics. The camera K-001 working in the visible and near infrared ranges has the world highest rate of registration - 2 x 10^9 frames per second. The camera is equipped with two different sweep units providing both the streak and the frame regimes. The universal camera K-005 covering the visible range has the time resolution in the streak regime of 300 femtoseconds. The X-ray streak and frame camera with sensitivity in the range of 10 - 10^6 eV that is now under development will break the picosecond resolution. Apart of the cameras all kinds of accompanying equipments is developed and produced such as gating image intensifiers for the pulse photometry with the high sensitivity and the capability to obtain short (below 1 ns) image frames; pulse image converter tubes; single frame image converter cameras, image intensifiers. The cameras already installed at Ecole Polytechnique and Lawrence Berkeley Laboratory

enabling to obtain unique physical results. The company EATA is an official dealer of thee products on the European market.

3.2 ELECTROCHEMISTRY AND CHEMISTRY

The synthesis of transition metal alkoxides and alkoxy-derived metal oxides is based on a unique electrochemical technology operating with large currents. As a result high purity (up to 99.999%) solutions and powders can be produced. The main feature of the technology except the high purity are: high efficiency (the process is continuous with the only reaction stage); ecological cleannes (the only side product is hydrogen); versatility (derivatives of the most transition metals can be produced with the same technology), low crystallization temperature (lower than 100C), low sintering temperature of micronsize powders. The field of application of those new materials is extremely broad: It covers compact capacitors, high quality resonators, nonlinear dielectrics, picroelements, memory devices, energy converting devices, superconductors, etc.

It is planned to use the alkoxyde solutions for the further development of the planarization technology for microelectronics. This work will be done in cooperation with Moscow Institute of electronics and automatization.

The alkoxydes and oxydes are consumed by Advanced Technology Materials and Symetrix (USA), Philips Laboratories (The Netherlands and Germany), Ecole Polytechnique (France), Korean Institute of Advanced Materials, Universities in France, Canada, Spain and others.

The other important application of the ultra pure oxyde powders of strontium titanate and titanate dioxyde is the production of the optical crystals. This direction is under promotion in cooperation with Moscow Institute of energetics.

The chemical production includes different acids, monomers, polymers and others, as strategic significance as for the polymer chemistry, kxylens, katalisators etc.

3.3 CAPACITORS

Well developed technology ceramic sintering allows to produce capacitors with the unique properties. The used material is BaTi powder of extra high purity. The capacitors unify high dielectric permittivity of 3000-4000 and very low loss tangent of 0.0015-0.006. These parameters are obtained when BaTi includes strontium as an impurity. The other impurities can produce substantially different properties. The technology of addition of Zr into BaTi has shown that the final product has as large dielectric permittivity of 40000. Therefore, the further development of technologies Zr, Pb and other elements is planned.

3.4 ß-CAROTENE

The main disadvantage of the present world wide technology of the production of ß-carotene is the toxibility. SOLITON has developed a new technology enabling to

exclude the toxic 3-phenilphosphine. The process is based on the dimerization of retinal under the action of 0 and 2 valence titanium. The main know-how is the electrochemical process of the generation of the low valence titanium. The process is effective in output and completely ecologically clean.

3.5 DIGITAL SCANNING PULSED MULTIFRAME X-RAY APPARATUS

The apparatus consists of a small-size X-ray tube, electron-optical image converter with a microchannel plate, readout CCD-camera, electro-mechanical scanning system and a personal computer. The whole image of the size 210 x 210 mm^2 is composed from 49 frames (7 x 7). The total scanning time is about 25s. The image can be displayed either altogether or separately. The apparatus is superior in a number of parameters: extremely low radiation dose (50 times lower than in the existing models), by 5 times exceeds the best analogs in the resolution (20 lp/mm), the small size and the low weight, absence of the limitations on the size of examined area. The fragments of the image of an area of a human body are stored in PC and can be displayed either altogether or separately ("zoom" of the doctor's interest).

3.6 HIGH-SPEED COMPACT DENTIST'S DRILL

High-speed compact dentist's drills. The Soliton activity is in marketing and expanding of the production capabilities. The main know-how is a technology of noncontact (without brash collector) micromotor developed at SPA "Astrofizika". The speed of rotation can be smoothly varied from 5000 cpm to 70000 cpm at the power consumption of 110W. The size of micromotor is 20 mm x 115 mm, the weight is 70 g, the power supply size is 220 x 210 x 55 mm^3. The power supply contains 12 V battery.

3.7 DENTAL TOOLS

All kinds of dental bors and disks are produced at DTD by developed coating technology. The superhard kinds of diamond and enhanced concentration of the diamond grains on the surface results in the extra wear-resistance. The efficiency of the technology leads to very low production costs. The tools have been tested in USA and Europe. Now the tools are sold at the Russian market. Simultaneously Soliton enters USA, France, Holland and Indian market with this production.

3.8 CATHODES

On the base of technologics elaborated with a long time experience oxide, platinumbarium, irridium-tanthanum, irridium-cezium scandate and osmium cathodes are manufactured. The cathodes are applicable to the microwave industry, (communication systems and radar), accelerators (high energy physical, cancer therapy) and cathode ray tubes (television, displays). Developed cathodes have much longer lifetime and higher

emission densities than produced elsewhere. The joint project with Istok, Varian and Lawrence Livermore National Laboratory on the cathodes has been started recently.

3.9 UTILIZATION OF THE CHEMICAL WEAPONS

Highly effective methods of the distruction of the chemical weapon (lewisite) have been developed. As a result high purity arsenic is obtained from lewisite. It has been shown that lewisite is a real source of high purity arsenic and its derivatives (gallium and indium arsenides etc.). The solar sells is the most perspective market for high purity arsenic. Medicine is the other field of application of arsenic compounds that can be produced from lewisite.

The other direction is theoretical and experimental investigation of low temperature pirolisys of phosphor contained chemical weapons. The reaction at the temperature of 800^0 C and the successful process of the purification of the gas provide the degree of destruction of initial chemical weapon up to 99.99999% without any toxic waste. Cooperation with Massachusetts Institute of Technology is being established on this subject.

3.10 GENERATORS

In free-electron maser projects for fusion applications such important components as undulators and microwave systems are developed by SOLITON. These FEMs cover the spectral range of 200-250 GHz and the power range of 1-4 MW in long-pulse of 100 ms. The developed plasma-filled Cherenkov generators are broad-band powerful (50-100 MW) oscillators. The mean frequency is tunable in the X-band. Different kinds of BWO's with the long lifetime operating in the frequency range from 35 up to 1100 GHz are produced. The different generators are jointly developed with Ecole Polytechnique and Lawrence Livermore National Laboratory, Institute of general physics and Istok.

4.0 SUMMARY

The above listed activities of Soliton are on the different stages. Some of them are on the stage of scientific and technological development. A number of pilot industrial projects are under implementation. There are already a number of products with a real industrial output. The strategy of Soliton is to develop high technological projects in cooperation with foreign partners. Many fruitful connections are already established. However Soliton has permanent interest in widening of cooperation. The main aim is to develop jointly advanced technologies, to create reliable and promising ways of investments flow, to promote the projects with mutual interests of partners.

DEFENSE CONVERSION AND THE PROBLEM OF NUCLEAR NONPROLIFERATION AND OTHER HAZARD MATERIALS

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The end of Cold War and the termination of military opposition of the two super powers have brought about situation when even the conservatively minded strata of society have come to understand that there is no necessity for the heaps of nuclear and usual weapons accumulated during the Cold War years. A problem arose concerning sharp reduction of weapons, determination of their quantity acceptable for security, utilization of the destruction weapons, conversion of defense industry, and social security of the serving soldiers which retire in consequence of the armed forces reduction.

All these problems exert great influence in the political and economic situation of the states drawing into the disarmament and conversion process. That is why I'd like to discuss first of all the difficulties and even dangers which are accompanying this process. Let us consider the situation with nuclear disarmament which essentially gets complicated by the disintegration of the USSR and formation of the new independent states. As a result Republic Belarus possess now only one properly guarding frontier Belarus-Poland. The others frontier parts (Belarus-Russia, Ukraine, Lithuania, Latvia) are transparent. The situation creates the chance for the smuggling of hazard materials included the nuclear weapon components. For example, there were several cases of arrests of the uranium merchants at the Belarus-Poland frontier in 1993-94 years.

The situation on the whole is complicated by the economic crisis of the new independent states, availability of the huge weapon storehouses and raw material for production of nuclear weapon storehouses, and raw material for production of nuclear weapon at the regions where the armed conflicts are possible. All this is complicated by the actual transparency of the Russian south frontier.

The possibility of the illegal transport of nuclear weapon and other hazard materials across the Belarus frontier represents the great threat not only for Belarus but also for other countries in consequence of the terrorist action threat growth which can use the nuclear materials (nuclear weapon) and the other hazard materials. The political and economic instability influences and on the psychological climate. This has lead to change for the worse of the inspection to check quality of the weapon storehouses guarding, which arises because of disarmament.

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Obviously, the control problem is different for the nuclear states and for the nonnuclear states. Moreover, on the face of it the control problem does not exist for the nonnuclear states.

However, the excessively high pay for the possible nuclear terror forces all states (and Belarus too) to improve the control for the possible smuggling of nuclear and other hazard materials.

Unfortunately, this task is very expensive and one state can not solve it completely. For example, according to analysis which have been done by the Nuclear Problems Institute (Minsk) the cost of the control systems for Poland-Belarus and Belarus-Baltic states frontier is more than 50 millions dollars.

Very serious problems for Belarus is the problem of the usual weapon destruction in accordance with the disarmament treaty and the problem of the artillery projectiles destruction. This situation is due to the geostrategic situation of Belarus. As result the Belarus territory was the most militaristic part of Europe.

There are 10 arsenal at the different regions of Belarus now. They occupy the considerable part of the agricultural areas. A great many of them are not good for keeping as the technical fit time is up. The keeping of ammunitions is very expensive. One form of the possible variants of the decision of this problem is the utilization. The American company "Alliant Techsystems Inc." and the English company "Rapierbase Ltd." has been attracted for the utilization by our government.

These companies use the newest technology of extracting explosive from projectiles by the water jet. This makes sure of the safety of work and permits the use the projectile materials for industry. At the present time the American-English-Belarus stock company "Belconvers" carry out all works at the Belarus territory. The destruction of the military equipment created the very difficult economic situation for Belarus. The Belarus government was forced to declare that though Belarus won't refuse to fulfill the international agreements it must stop the distruction of the military equipment. According to our opinion the help of the west countries is required in this question.

It is known that the reduction of armaments and, as a result, the conversion of war industry leads to the necessity of the consumer goods production arrange. It leads to the necessity of the training to the new professions of the serving soldiers who leaves the military professions. Of course, we must create new worker' places for these serving soldiers. Decision of this problem is very important both for our country and the west countries because in this case we are discussing the fate of the very experienced serving soldiers. Their knowledge must not be used in the regions where there is or may be armed conflicts.

There are the very serious ecological problems also. The strategic disarmament treaty obliges Belarus to destroy 81 rocket platforms. The US gave 6 millions dollars to Belarus for this aim. However, the method of destruction by the explosion is absolutely unfit. Several month ago there were blown up the two rocket platforms. Experience has shown that as a result after explosion there appears a concrete pile, which creates a very difficult ecological situation. Thus, the disarmament and conversion are very difficult economic, psychological, and ecological problems. We think that only the united efforts

of a great many countries can ensure decision of this very completed problem with the minimal risk of the appearance of new serious conflicts.

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