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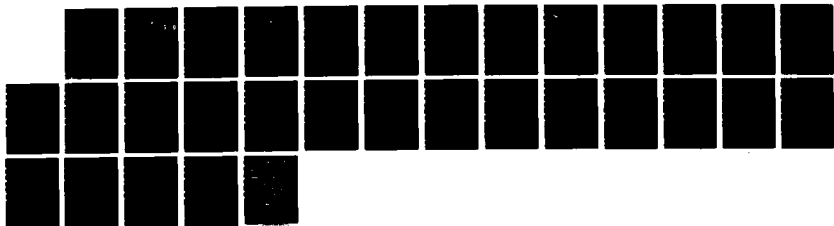
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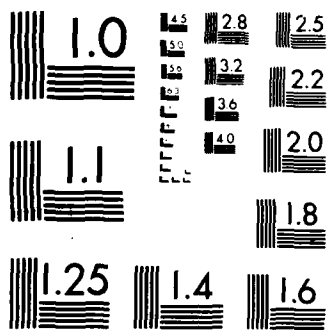
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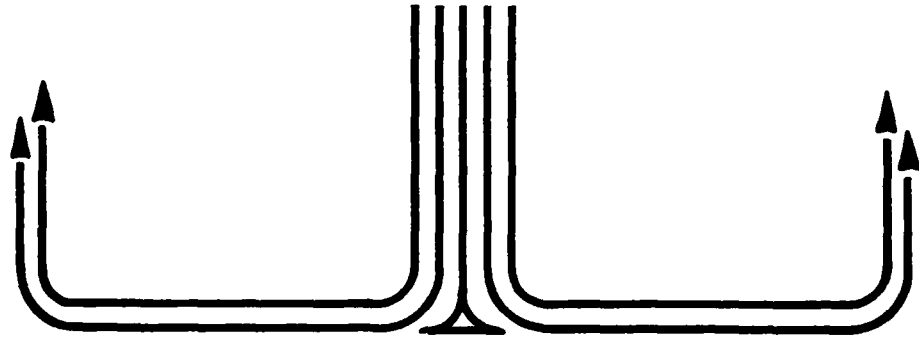
AIR COMMAND AND STAFF COLLEGE

STUDENT REPORT

TECHNOLOGY TRANSFER AND THE EARLY
DEVELOPMENT OF SOVIET COMPUTERS

MAJOR DANIEL L. BURGHART 88-0415

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AUTHOR(S) MAJOR DANIEL L. BURGHART, U.S. ARMY



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PREFACE

Technology transfer between the West and the East resembles the old saying about the weather; everyone talks about it these days, but there seems to be little anyone can do to stem the tide of such transfers. While debates rage in the West between governments, businesses, and just about everyone else involved, the Soviet Union and her allies seem more than willing to stand on the sidelines and encourage the chaos that surrounds the efforts to control the flow of technology. The benefits to be gained by exploiting Western technology are enormous, and the Soviets appear to be fully capable of taking advantage of what the West has to offer.

Or are they? For technology transfer to be of benefit, it must be effectively integrated into the receiving society. If not, the process can be likened to transplanting cuttings without sufficient water: the plants may survive for a short period of time; however, it is doubtful that they will ever bear fruit. Part of the problem for decision makers in the West is that they fail to truly understand all that is involved in the technology transfer process, and this failure greatly hinders any effort to regulate such transfers. *In order to deal effectively with a problem, one must first understand the nature of the problem and all that it entails.*

This paper represents one portion of an attempt to shed some light on the technology transfer process. Specifically, it is part of a PhD dissertation that will examine technology transfer as it relates to the area computers in the Soviet Union. By looking at computers as a "case study," it is hoped that the lessons learned can then be applied to a broader spectrum of areas where there is concern about Western technology being pirated and eventually being used against our better interests. In this way, it is hoped that a more complete understanding of the problem will lead to better ways of dealing with it.

While many people have contributed to this effort in terms of ideas, encouragement, and assistance, I would like to acknowledge especially the help given by members of the Air University Library Staff, my advisor Major Bruce Slawter, and last but far from least my wife, Susan, and our boys, Robert and William. Needless to say, the responsibility for any errors or inconsistencies that may have crept into the final text is purely my own.

—ABOUT THE AUTHOR—

Major Daniel L. Burghart is a U. S. Army Officer serving as a Soviet Specialist in the Army's Foreign Area Officer Program. He attended the University of Illinois on an ROTC Scholarship, received his BA in Political Science, and was commissioned in the Field Artillery in June of 1973. After serving his initial assignment with the 1st Infantry Division, he was sent to the University of Wisconsin on an Army Fellowship where he earned a Master's Degree in Political Science and a Graduate Certificate in Russian Area Studies in December of 1977. After a second tour as an Artillery Officer during which he served as a Battery Commander and Intelligence Officer in Germany, he returned to the United States in December of 1981 to begin his training as a Foreign Area Specialist. This training included attendance at the Army's Foreign Area Officer School, Ft. Bragg, NC, where he was the class Distinguished Graduate, a one-year intensive Russian course at the Defense Language Institute, Monterey, CA, and a two-year course at the Army's Russian Institute in Garmisch, FRG. After graduation, Major Burghart remained at the Russian Institute and served as the Director of Area Studies for two years before returning to the States to attend Air Command and Staff College. He is currently working on his PhD in the Soviet Studies field.

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MAJOR DANIEL L. BURGHART

TITLE

TECHNOLOGY TRANSFER AND THE EARLY DEVELOPMENT OF
SOVIET COMPUTERS

1. Purpose: To examine the evolution of Soviet computers (first through third generation) to determine the extent to which technology transfer played a part in their development.
2. Problem: Technology transfer is a topic that has received wide attention in the past several years, especially with regard to Soviet efforts to obtain technologies from the West that are considered to be sensitive in terms of Western security. The effects such transfers have, however, are not always those that would be expected, and in many cases have not resulted in the ends that the Soviets hoped to achieve. This paper is part of a larger study that seeks to examine the true nature and effect of technology transfer in the case of computer technology. Based on this case study, it is hoped that guidelines can be developed that will serve to aid decision makers in the future who seek to evaluate the effectiveness of such transfers in an effort to establish realistic measures for restricting the flow of technology.

CONTINUED

3. Data: The evolution of Soviet computers is not simply the history of Soviet efforts to buy, borrow, steal, and copy this technology from the West. Substantial evidence exists to show that the Soviets were well on their way to establishing their own independent computer industry with little reliance on Western inputs of technology. It appears to have been argued by several leaders in Soviet academic circles that any dependence on the West was dangerous and should be avoided at all costs. Others argued that Soviet efforts were falling behind those of the West, and therefore it was necessary to borrow from the West in order to catch up in this critical field. This debate resulted in a victory for the second group, as can be seen in Soviet efforts from the third generation on, to copy from the West at the expense of its own domestic efforts.

4. Conclusions: While it can be argued that by copying Western designs the Soviets have made progress in closing the gap between East and West in this critical field, there are other side effects from this reliance on Western technology that have not been as beneficial. By electing to copy the West, the Soviets seriously damaged their ability to make independent advances in the computer field. At the same time, Western efforts to control the transfer of such technologies, combined with the increasing difficulties involved with successfully taking advantage of Western technology and integrating it into their system, have left the Soviets in a dilemma. The net result may be that the Soviets have condemned themselves to a permanent position of inferiority to the West in the computer field, unable to obtain the latest in computer technology from the West and incapable of creating it on their own.

Technology Transfer and the Early Development of Soviet Computers

INTRODUCTION

The question of technology transfer between the East and the West has come to the forefront of debate in the last several years in government circles, the press, and the public. The fact that the Soviet Union and her allies rely upon and actively seek Western technology is generally accepted and is one of the reasons for the volume and intensity of calls for limiting the export of Western technology to the East. Less well defined and understood is the actual value of this technology, for the acquisition and successful integration of technology are two entirely different entities. Just as the value of sending steel plants to aid in the development of Australian Aborigines might be questioned, so too might the actual benefit that is derived from technologies so far advanced to those of the East that they appear as if from another planet.

Within the realm of the debates on technology transfer computers hold a special place, for there is perhaps no other technology that symbolizes the immense changes that have occurred in the world as we know it. Though a phenomenon of the last fifty years, there is not a part of life in an industrialized nation not affected by computerization. For any nation that wants to be competitive in the world arena, be it economically or militarily, computers are essential. This in turn explains the Soviet interest in Western computer technology, for if the Soviet Union is to compete with the West it must stay abreast in this vital area. That the Soviets have not, and the reasons why they have been unable to do so, are the underlying theses of this study.

The purpose of this paper is to examine the early development of the Soviet computers, specifically the period 1945-1975. The objectives are to trace their development during this period and assess to the part that Western technology played in this development. This task is complicated by the fact that the Soviet Union is less than forthcoming with information about its industrial developments, especially in areas it feels are related to

national defense. Still, by looking at the state of Western computer development and comparing this with what is known of corresponding Soviet work, it should be possible to make an evaluation of the influence of West upon East. This in turn should allow us to evaluate the importance that Western technology holds for Soviet computer development today, and may be expected to hold in the future.

BACKGROUND

The Nature of the Problem

Russian use of foreign technology to aid in economic development is hardly a new phenomenon. Beginning with Peter the Great and his attempts to modernize Russia, Western goods (and when possible Westerners themselves and the knowledge they possess) have been sought in an effort to transform "the sleeping giant" that Russia, or more specifically the Russian economy, has always represented. Far from changing this pattern, the revolution of 1917 and the rise of the Soviet state if anything accentuated this trend. The fledgling revolutionary government of Lenin actively sought aid and assistance from the West in rebuilding the shattered Russian economy. Foremost among these efforts were the establishment of joint ventures with Western firms on Soviet soil. These efforts were designed to trade Soviet resources, both raw materials and labor, for the know-how and finished manufacturing capability that the Soviet Union lacked. Such enterprises flourished until the rise of Stalin, when fear of contacts with the West, reflecting the general distrust by the dictator of things foreign, caused the country to turn inward and depend on internal capabilities and resources to spur growth and development.

The ravages of the Second World War, the death of Stalin, and the birth of a new wave of industrialization in the postwar era all played a part in prodding the Soviet Union out of her self-imposed exile. The earliest example of transfers of technology in this period was the massive import of factories and manufacturing concerns taken from those areas occupied by the Soviet Union in order to rebuild her own shattered economy. At the same time skilled technicians and scientists, primarily German, were also brought to the East, where their efforts would be made manifest in the rise

of the Soviet space program (12:274). During the fifties and sixties, under the direction of Khrushchev and other reform-minded members of the Soviet leadership, Western technologies were imported in those areas where the Soviets felt themselves to be at a disadvantage. In this manner, the Soviet chemical industry was rapidly developed and became a showpiece which was made an example for other sectors of the Soviet economy (13:227-229). While impressive, these efforts also had their negative effects, the primary one being that it left the Soviet Union dependent upon the West as its source of development in these areas.

The question of foreign dependence is a key element in any discussion of technology transfer and the Soviet Union, and one whose origins extend beyond today's situation. Just as Peter the Great was the first Russian leader to actively seek Western technology, so it was during Peter's time that the first opposition to such imports arose. During the 19th century a group of the Russian intelligentsia known as the Slavophiles argued against Western influences, and made a strong case against Russia borrowing from the West. Their rationale mirrors statements made today concerning the need for importing and incorporating Western technology. By employing such measures, not only do the Soviets effectively admit their inferiority to the West in certain areas, but they find themselves in a position of dependency that must be galling for a country that prides itself on representing the wave of the future. In more practical terms, such imports are seen as an overall detriment to domestic development, in that by eliminating the need for an independent capability in an area, the infrastructure necessary to carry out research and development in that particular field is also eliminated.

All of these arguments, as shall be seen, apply to the case of Soviet computers. The fact that the Soviets rely heavily on Western inputs of technology for their development in this area is generally accepted in both the West and the East. The implications of this dependence, however, go far beyond the level of cultural pride or ideological dogma. In a world where national survival rests on sophisticated weaponry and the supporting measures needed to employ it effectively, computers play a dominant role. In a world where the products of technology can ensure a society's economic preeminence, and with it national survival in a world at peace, computers are no less important. To be dependent on foreign and potentially hostile

sources for technology in an area as critical as this is a state of affairs that must trouble the dreams of the Kremlin's leaders

Yet such is the state of affairs as it exists today. The obvious question is, if this dependence is so disadvantageous, why did the Soviets ever let such a situation arise in the first place? Surely a country with its resources in skilled personnel (over 1/4 of the world's engineers) and background in mathematics--key to the design and workings of all computers--should find itself in the lead in this field, especially given the strategic importance computers hold (15:6-7). The answer to this question is neither simple or straightforward. Instead, it combines many factors which, over time, interacted in such a way as to create the current situation. To begin to unravel the answer, it is necessary to examine the history of the development of the computer, both in the West and the East.

A Few Words On Computer Generations

At this point, it may be worth digressing for a moment to talk about some of the technologies involved in computers. Computer development is broken down loosely into "generations," based on the type of technology that is used. These generations, as commonly accepted, are:

First Generation--Computers having vacuum tubes as their basic components.

Second Generation--Computers using transistors in place of vacuum tubes.

Third Generation--Computers utilizing integrated circuits as their basic components, replacing transistors (4:14-15).

It should be noted that there are no hard and fast rules in these categories, and in fact some machines combine elements of more than one generation. More significant are the technologies themselves, for each represents a major advance in the development of the computer. These technologies, along with related developments in the areas of internal memory, input/output devices, and external storage, serve as a framework for tracing the evolution of computers and comparing the development process in the East and the West.

HISTORY

(Note-Technical data in this section, unless otherwise noted, comes from: Judy, Richard M. "The Case of Computer Technology." East-West Trade and the Technology Gap. London: Prager Publishers, 1978.)

The Early Years 1945-1950

The early origins of computers and computing are well documented and need only be touched on here. Mechanical calculators, developed for processing large amounts of numbers in scientific problems, first appeared in the 1930s. World War II and the need to do large numbers of calculations to produce firing tables led to the development of an electrical calculator, the ENIAC (Electronic Numerical Integrator and Computer), in 1945 (16:48-50). While a major accomplishment, the ENIAC did not have a memory that could store programs and thus was not a true computer in the sense that is recognized today. This honor goes to the EDSAC (Electronic Delay-Storage Automatic Computer) developed at Cambridge University in 1949 (9:44).

On the Soviet side, as is the case with most items that even remotely border on matters related to state security, the origins of Soviet computing are shrouded in secrecy. It is known that in 1941 the Soviets did have at least one of the early mechanical calculators (10:6). After the war, they showed interest in obtaining the documentation for the ENIAC, and even tried to buy the whole machine (6:541). Finally, in 1950, they built a punchcard calculator, the EV-80, that resembled the IBM 604. With this step, the Soviets entered the computer world.

What is interesting to note here are the imperatives that drove these early computer developments. In the West, a core of engineers and scientists carried out this early research and brought the importance of computers, in terms of their capabilities, to light. In the East, no such block or lobby existed, or if it did, its actions were severely curtailed. During the last years of his life, Stalin railed against the study of cybernetics, one of the elements essential to computer development (5:38). In a dictatorship not known for tolerating dissenting views, this in itself was a hindrance to early research efforts. The other major group that could

have spurred Soviet computer development consisted of the German scientists who had been captured and taken back to the Soviet Union at the end of the war. While extremely gifted, their experience did not provide them any background in this area, for the emphasis in Germany during the War had been on rocketry and atomic physics, and not on "computing." One Western expert has even gone so far as to suggest that this lack of background among the Germans acted to curb early Soviet efforts (12:325). In either case, there appears to be no Soviet counterpart to the group in the West that recognized the potential value computers held, and pushed for their development.

First Generation 1950-1957

The first generation computers that were produced in the early fifties appear today as the Wright brothers' first plane must appear in light of modern flight and space travel. Still, their significance was in their very being, for they represented a capability that man had never had before. Further, developmental work with these early models set the stage for what was to follow.

In the West, UNIVAC I (Universal Automatic Computer-1951) became the first computer commercially available on a large scale. It was followed in the next seven years by over 300 other systems, all available to the general public. Internal memory, aided by the introduction of magnetic core memory devices (1952), increased the ability of machines to store information and the instructions needed to process this information into useful data. Input/output devices, primarily paper tape and punched cards, were slow at first, but improvements in reading devices, plus the development of buffering techniques that allowed computers to engage in more than one operation at the same time, helped to increase their speeds. External memory was initially stored on large magnetic drums, though IBM did produce a commercially available magnetic disc storage device in 1956.

The first Soviet computer of this era was the MESM (Small Electronic Calculating Machine), designed by A. Lebedev of the Ukrainian Academy of Sciences and acknowledged by one Western expert as "an important achievement close to the technical state of the art" (6:541). This was followed by the BESM-1 (Large Electronic Calculating Machine), a medium

sized computer, the Strela (arrow), and a small computer, the Ural-1. Internal memory was accomplished primarily by magnetic drum; magnetic core was not yet available. Input/output devices were the same as the West, though the quality of Soviet paper products often led to problems with tape and punch card readers (9:54). Magnetic disc storage devices were unknown. Total output for the period was extremely limited. "Between 1950 and 1959, the USSR is estimated to have produced fewer than 400 computers, most of which were the small Ural-1" (9:53).

Comparisons between East and West during this period reveal the two sides coming to grips with the new technology in their own way. While the Soviets were not, as far as can be determined, in the forefront of computer technology, neither were they very far behind. (In just one example, the BESM-1 "was, in some ways comparable to the first American 'supercomputer,' the NORC") (6:542). As with any new field, there were false leads. One of particular importance was the early choice by the Soviets to emphasize analog over digital computers. The latter were more capable and eventually became the world standard; the former, however, were easier to build and for a period received official favor in the Soviet hierarchy (6:542). The only other major difference between the two sides is one of scale. Whereas in the West hundreds of systems were produced with some of these systems having extended production runs, the total Soviet production of computers was less than 500. This disparity in numbers was to play a significant part in future Soviet development.

Second Generation 1957-1965

Second generation computers, as noted earlier, are distinguished by the replacement of vacuum tubes with transistors, themselves a new technology at the time. Two characteristics of computer design and performance affected by the introduction of solid state electronics were size and speed. Decreased size meant that computers of greater capacity could now be built and installed in smaller areas, making them both more functional and more available to a larger segment of their potential users. Speeds increased as a result of the decrease in size and improvements in design and manufacturing techniques. Along with these two factors, solid state design increased reliability, something that moved computers from the realm of a scientific curiosity to an item of interest for fields ranging from engineering to business.

In the West, second generation computers became available in the late 1950s and were dominant until the mid-1960s. Improvements in core manufacture brought significant increases in internal memory capability and access time. Input/output rates for punch cards also increased, while devices such as cathode ray display and non-impact printers became more readily available. The capabilities of external storage devices also showed great increases due to the expanded use of disc storage. In terms of usage and acceptance of these new machines by the consuming public, one need only look to the example of the IBM 1400 series, where "IBM sold an estimated 15,000 of the extremely successful [series] . . ." (9:51).

Second generation Soviet computers started from the same general position as their Western counterparts, but progress was slower and uneven in terms of mutually supporting developments. Magnetic cores for internal storage, used on many first generation Western machines, were not seen on Soviet computers until 1958. Further, "no particularly significant technological advances were apparent in Soviet central processors and internal storage before 1965" (9:54). As a result, while the IBM 7030 had up to 256K of internal storage in 1961, the Ural 14 could boast only a 64K storage five years later. Input/output devices caused problems either because they were not available or they were slow and unreliable. External storage continued to depend on magnetic tape or drum, for Soviet manufacturers "had great difficulty in trying to produce magnetic storage devices" (9:57).

Problems of the type mentioned above were not unique to computers, but rather tended to mirror the problems encountered throughout Soviet industry. In an economy driven by command directives from above, rather than responding to market demands from below, there is little incentive for technical advancements and improvements. Development requires the allocation of resources, money, skilled people, and equipment. In the Soviet Union all of these tend to be in short supply, and as has been noted, there was no strong sponsor to provide these resources. The most likely candidate for supplying this support, the military, did not yet appreciate the full significance of computers. "Although the military had the capability to insist on the massive commitment of resources that would have been

necessary to close the 'computing gap' with the West, that task was clearly not on the top of its list of priorities" (8:545). The absence of a market system also caused problems with the quality and suitability of those items that were produced, for there was no incentive to make computers that actually met the needs of the user. Finally, there was the question of scale and exposure. Production itself was a problem, as Soviet industry had difficulties mass-producing the complex technologies involved. As seen in the example of the IBM 1400, computers in the West were, if not common, then at least no longer unique; the more they were used, the more people were exposed to them and the faster the innovation cycle was regarding changes in their design and use. Such was not the case in the Soviet Union. While work on developments continued, these efforts were normally isolated and thus not mutually supportive. Moreover, the "computer culture" that was developing in the West failed to materialize in the East. All these problems were characteristic of the Soviet system as a whole, and as a result the system itself can be blamed as much as any other factor for the failure of Soviet computers to keep pace with their Western counterparts.

Third Generation 1965-1975

The third generation of computers brought with it the technology that, more than any other, has come to represent the computer in the eyes of most people--the integrated circuit or microchip. Microchips carried out the functions previously performed by transistors in the second generation; one early processing chip, the Intel 4004, replaced over 2000 transistors while taking up a fraction of the space (4:153). This decrease in size, as with the transition from tubes to transistors, meant not only faster processing times, but because more chips could be packed into a computer, greater power and storage capability. Computers could be manufactured that were small enough to be used in areas where their size had previously been restrictive, and were becoming cheap enough that they were no longer the domain of the government and major industries. Thus, the advent of the microchip, possibly more than any other technology, signaled the arrival of computers as we know them today.

In the West, third generation computers were also "marked by greater modularity of design" (9:51); that is, they could be broken down and configured to meet the needs of individual users while still maintaining

compatibility. Perhaps the most famous of these computers and one of the most popular, with over 35,000 units produced by 1970, was the IBM 360 (4:198). Its processor and internal storage, benefitting from integrated circuitry, recorded impressive improvements in operational times. Its performance was further aided by the general use of magnetic disks for external storage. Another factor in the success of this system was the large number of Input/Output devices and peripherals developed to support the line. The overall capabilities of this and other machines of the third generation, combined with the ability to adapt to the needs of the user, played a large role in expanding the use of computers beyond the traditional areas of science and technology and into the texture of society as a whole.

At the time that the West was producing its third generation computers, the Soviets were at least a generation behind. Their largest computer of the period, the BESM-6 (of which 150 were produced during a twelve year period), was much less powerful than its Western counterparts. Its performance, in the words of one expert, "was severely degraded by a slow and inadequate core memory and by a lack of suitable and reliable peripherals (magnetic secondary storage and input/output devices)" (6:549-550). The first significant Soviet third generation computers to appear in the mid-seventies were models of the Unified System series of computers, commonly referred to as the Ryad (the Russian word for series or line). These computers were noteworthy in a number of respects. Their performance, while not up to Western levels and marred by technical flaws, was nonetheless impressive and represented a major leap in Soviet capability. Like Western third generation computers, Ryad was a modular series designed to provide compatibility throughout a number of layers of users. It represented a joint effort on the part of the Soviet Bloc as a whole, with the countries of Eastern Europe sharing development and manufacturing responsibilities. Most important, however, these computers relied on third generation technology that had come from the West rather than from domestic efforts. "The entire project [had] been based on a massive transfer of Western technology" (6:554).

Soviet third generation computers mark a watershed of sorts for a number of reasons. While their first and second generation predecessors had appeared within a year or two of comparable machines in the West, the Soviet third generation was a full ten years behind the Western lead.

Indeed, while the West had been operating at the third generation level for several years, the Soviets were still developing and introducing new second generation machines. This phenomenon did not go unnoticed in either the West or the East. In the former, writings began to emphasize the "gap" in the capabilities between the two Blocs in the computer field; in the East, though obviously not publicized, it appears that the gap was strongly debated at the highest levels of the party and the government (6:547). The results of these debates are evidenced in the nature of the third generation that eventually appeared, for the Ryad series was designed to take advantage of and emulate Western developments of the day. Soviet first and second generation computers, while sometimes borrowing from the West in terms of basic knowledge and technologies, were still independent efforts that reflected their own designs and innovation. In sharp contrast, this was the first time that the Soviets had consciously sought to obtain and duplicate Western efforts rather than rely on their own developments and initiative. The reasons behind this decision will be examined shortly. For now, it is sufficient to note that as of the third generation of Soviet computers there has been a conscious and continuous effort on the part of the Soviets to use technology transferred from the West to aid in the development of Eastern Bloc computers.

ANALYSIS

The Extent of the Western Influence on Soviet Computers

Having looked at the development of first, second, and third generation computers in both the West and the East, it is possible to evaluate the extent that the former has affected the latter. As noted earlier, this is far from an easy task for a number of reasons, among them being the lack of information available from the Soviets and their general unwillingness to admit, much less discuss, their efforts to obtain Western technology. Still, based on what has been established, it is possible to draw some conclusions as to the extent Western technology has been used to assist Soviet developments, the effect these inputs have had on the overall development of Soviet computer capabilities, and finally, what implications this may have for Western decision makers who must deal with questions concerning the transfer of technology to the East.

The first years of Soviet computing seem to owe little to Western efforts or inputs.

By world standards, the Soviet computer industry got off to a good start in the early 1950s. Accomplishments included one of the first electronic digital computers with internal program storage, a large scale scientific computer, and the serial production of a small general purpose machine. By 1953, the year that Stalin died, the Soviets were a respectable third, after the US and UK, on the world computing scene (7:41).

As has been noted, early development efforts were somewhat hampered by lack of a strong sponsor or supporting group within the Soviet bureaucracy. However, those efforts that did take place were basically sound and produced creditable results. Early developments may have paralleled the West in some respects, but this is to be expected with emerging technologies where the development of similar ideas may occur in several places at the same time. Further, in those cases where the concepts involved had their origins in the West, the machines that resulted were still distinctly Soviet in conception and design. Even if the Soviets were behind the West in some areas, the evidence suggests they were still progressing fairly well with their domestic efforts.

The gap between Western and Eastern capabilities began to grow with the second generation of computers. While it has been suggested by some that the Soviets were already committed to copying the West, this does not appear to be the case. "Soviet progress was not insignificant: a number of new models (not terribly innovative but not close, compatible copies of Western machines) appeared during this period, and there was something of a 'love affair' with cybernetics" (7:41). The major problem for the Soviets was not one of theory but manufacture, due in large part to problems endemic to Soviet industry as a whole. As the Soviets began to fall behind in the implementation of computer technologies, a debate arose within Soviet computer circles. "The Slavophiles, followers of the academician Sergei A. Lebedev, argued that regardless of what was happening in the West, the Soviet Union must continue developing its own line of computers. The Westernizers, worried by the accelerated computer production in the United

States, Europe, and Japan, lobbied for copying Western designs--and the Westernizers prevailed" (2:29). Thus began the wholesale copying of Western computer designs evidenced in the third generation of Soviet computers.

This decision to try to stay abreast with the West by co-opting Western technology had several impacts on the Soviet computer industry. In effect, it "passed a no confidence vote on the emerging Soviet electronics and computer industry because it failed to come up with the supporting computer systems to match the USA. . . [with the result that]. . . Domestic projects were scrapped" (11:866). As a result of this decision, imports of Western related computer technology rose sharply, from \$5,000 in 1965 to over \$1 million in 1967 (12:321). Beginning with the third generation, almost every major Soviet system has been based on Western designs; in some instances the copies were so close to the originals that they even included Western part numbers (14:143). Thus, because of a conscious decision on the part of the Soviet leadership in the 1960s to rely on imported technology to make up for the shortcomings in their own industrial production, Western technology has become the leading influence on the development of Soviet computers. As one commentator notes, "The bureaucratic party attitude became 'West is best; East is least'" (14:138).

The Effect of Technology Transfer on Soviet Computer Development

The key element to be determined in the issue of technology transfer as it relates to Soviet computers is the effect that such transfers have had on the overall course of Soviet development in this area. As has been shown, the Soviets began with an independent capability in early computers that, while lagging behind the leaders in the West, nonetheless showed promise and seemed to fulfill the needs of the country at that time. The realization of the importance of computers, however, combined with the inability of Soviet efforts to keep abreast with Western developments, led to the decision to actively seek Western technology in order to bridge the gap that was developing between East and West. The rationale for this decision was fairly obvious. Not only would the Soviets be able to keep within striking distance of the leading Western technologies by copying Western developments, but they would save millions and possibly billions of dollars

in research and development costs. In an environment where resources are limited at best, this had to be an attractive incentive. (As just one case in point, the Ryad system of computers was designed to be IBM compatible in order to take advantage of the large amount of software that was available) (6:553,555). The question is were they successful, and if so, what have been the consequences for Soviet computer development?

Initially, it would seem that the Soviets did achieve at least part of their objective. While evaluations of Soviet capabilities in the late 1960s placed the Soviets ten to fifteen years behind the West, by the mid-1970s this estimate had been cut to four to six years by at least one Western observer (14:138). The introduction of the Ryad, after some initial technical problems, was heralded as a great advance in Eastern Bloc capabilities, and did in fact allow for the exploitation of a large amount of Western assets built around the IBM 360 series. Other Soviet computer systems were developed that closely paralleled Western computers, often being built around established Western processor chips. All these facts led one commentator to state that, "The Soviets have progressed well beyond what existed around 1970, and their earlier history is such that it is unlikely that they would have come as far since then without the intensive pursuit of technology transfer" (7:51).

There exists, however, an equally convincing body of evidence that the import of Western technology has not been the panacea that people in both the West and the East might have thought. In the first place, Western embargoes on leading technologies, especially in areas such as computers, keep much of what the Soviets truly want and need from being delivered to them in a timely manner, if at all. Second, in those cases where Western computers and computer technology have been imported, there have often been problems with its incorporation and effective use. Stories where Western computers were imported, only to stand idle because they could not be successfully integrated, often appeared in the press of the 1960s and 1970s. More recently, the growing complexity of the technologies involved has made their absorption even more difficult. Underlying these problems are the same difficulties that led to the original decision to import Western technology, the inability of Soviet industry to produce the computers necessary to meet the country's needs. In the words of one leading Soviet

computer official, "We have no industrial base to make the necessary computers" (2:24).

What we are left with is a paradox, in that while the Soviets sought to close the computer gap between East and West by importing Western technology, they may in fact have reinforced the problems that led to that gap in the first place. When they turned to the West, the Soviets shelved their own domestic efforts--efforts that while lagging behind those of the West nevertheless gave them an independent capability in an area of critical importance. By relying on the acquisition of Western technology, they have condemned themselves to a perpetual second place in computer development. While it may have been hoped that Western technology would allow the Soviet Union to catch up and overtake the West, this has not been the case. In shifting resources away from their domestic efforts to copying those of the West, the Soviets sacrificed the infrastructure their industry needed to be an innovative force of its own. In short, by relying on the West, "The Soviet Union has failed to develop an indigenous computer and electronics industry which can produce volume, or surpass Western technical excellence" (11:886). Thus, what may have been a short-term gain for the Soviets from the infusion of Western technology may result in a long term loss because of the failure to develop their own capabilities in this area.

Lessons For the West

Over the past fifteen years the alarm has been sounded many times that the West is sealing its own fate by allowing the Soviet Union and her allies access to our technology. As former Commerce Secretary Lawrence Brady stated, reiterating the words of Lenin, "We may be selling [the Russians] the rope with which we may eventually be hung" (1:34). In the case of computers, this equates to allowing the Soviets to overcome their deficiencies in this area by obtaining, legally or by other means, Western computer technology. That the Soviets hoped to do this seems obvious from what has been outlined above. What is more, the pattern remains in effect to the present day.

Since the early 1970s, there has been a drastic change in the character of Soviet hardware. Before then there had been Western influence in the designs of Soviet computer equipment, but not

much close functional duplication, that is, the use of the same architecture, instruction sets, and data interfaces. In the last 12-15 years, functional duplication of well established US systems has become the rule (7:42).

By copying from the West, have the Soviets attained the goals they set out to achieve? Though constrained by a lack of information, the answer appears to be that they have not, or that their success has been limited at best. Even in those instances where they have succeeded in obtaining advanced technologies, they have had problems in exploiting these technologies, and thus in taking full advantage of the information gained. One Western expert categorizes these problems into three basic failures with regard to computers: the failure to be able to mass produce the copied technology, the failure to be able to ensure reliability and quality control, and the failure to generate independent domestic efforts using imported technology (8:64). While the reasons for these difficulties go beyond the scope of this paper, the same difficulties can be seen in other areas of their economy as well. In the words of one Soviet official, "We don't lag behind the U.S. in basic research. . . . But when it comes to adapting scientific discoveries to industry, we have a problem" (3:98).

What significance does this hold for the West, and specifically for those whose responsibility it is to determine policy in the area of technology transfer? Technology can be transferred in a number of ways: in ideas, in products, and in the capability to turn ideas into products (4:23). The main weakness of the Soviets with regard to computers has been in the third of these areas. Further, by shelving their own domestic efforts in order to pursue the West they have reinforced this weakness, for as long as they continue to copy Western technology they will never be able to forge ahead with technologies of their own. Thus from a Western perspective, technology transfer may not be entirely bad, for it has contributed to the limiting of Soviet capabilities in the computer field. This does not mean that efforts at controlling the flow of technology should be relaxed. Rather, it suggests that such efforts should be structured in such a way as to foster a continuation of Soviet dependency on the West, thus maintaining the Western lead in computing technology.

SUMMARY AND CONCLUSIONS

In summary, what we have seen is the evolution of a sector of the Soviet economy that is of great importance to their survival and economic well-being. Paradoxically, it is an area in which they are reliant upon the West, their ideological enemy, for technology and industrial know-how. What is even more intriguing is that the current state of affairs is a result of a conscious decision by high-ranking levels of the party and state. While this decision was intended to allow the Soviet Union to catch up to the West, the result has been to limit research and development efforts--efforts that might eventually provide the Soviet Union with an independent capability in the field of computers. That the Soviets possessed the beginnings of such a capability is reflected in their work through the second generation of their computers. That this capability has either been sacrificed entirely, or at least severely curtailed, is witnessed by the fact that all major Soviet computers since then have been based on Western designs already in existence.

This does not necessarily mean that the USSR is a "computer cripple." "Although the majority of the Soviet computers are based on technology that is ten to fifteen years old in the West, many experts point out that the technology of the 1970s is nothing to ridicule. Among other things, that generation of hardware sent spaceships to the moon" (2:29). Still, by copying from the West, the Soviet Union has doomed itself to second place in the race to develop computers with greater capabilities because it sacrificed its own domestic research assets in the process. Thus, as computer technologies become more sophisticated and complex, the Soviet Union lacks the very basis that it must have to effectively exploit these developments. In the words of one writer, "The Soviets will always be fighting from a position of weakness, given their previous history, unless . . . [they can] . . . develop an electronics and computer industry along Western lines" (11:867).

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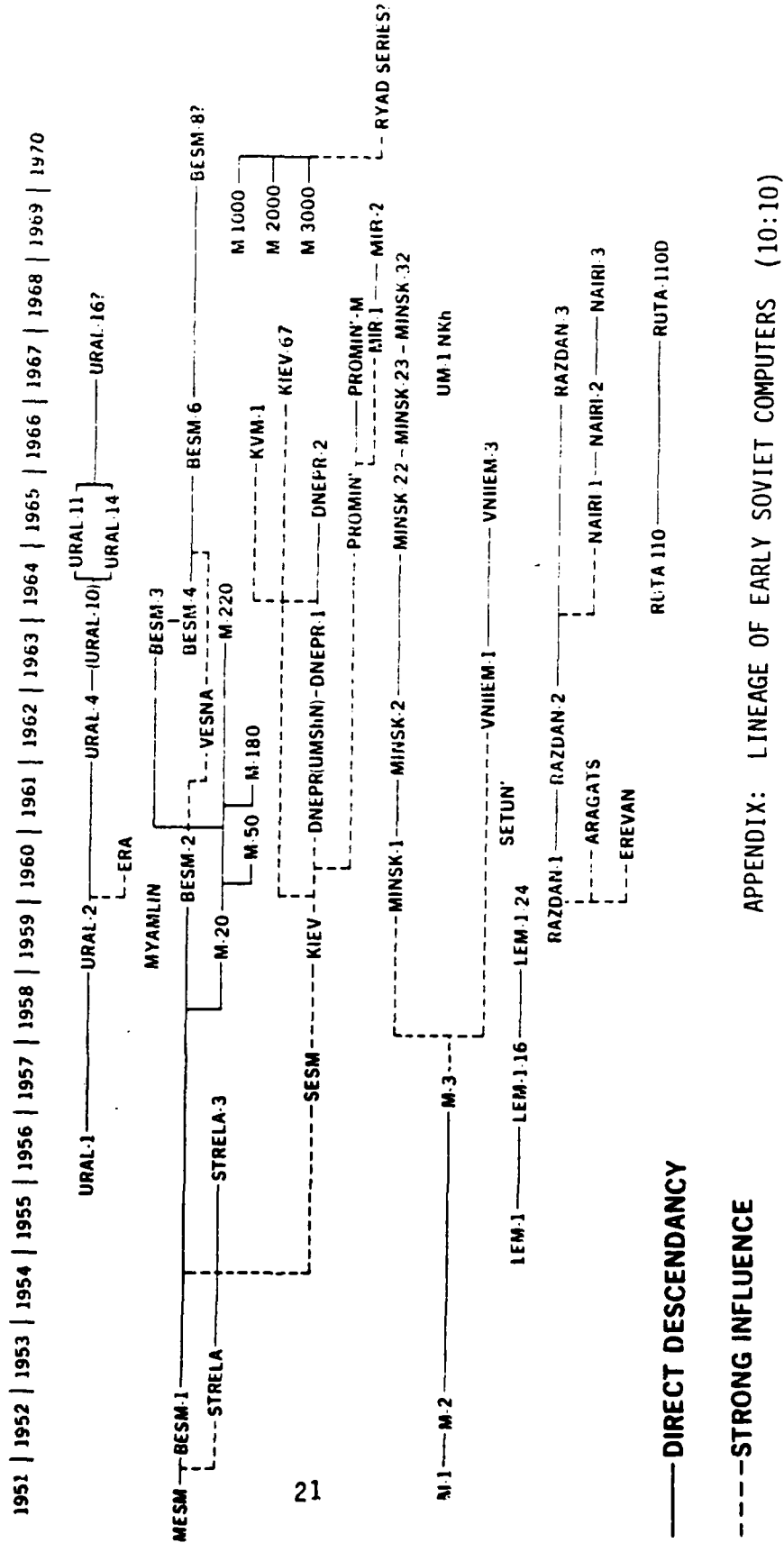
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APPENDIX



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