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Seventeenth Systems & Technology Symposium

October 25 through 27, 1994

San Fransisco, California

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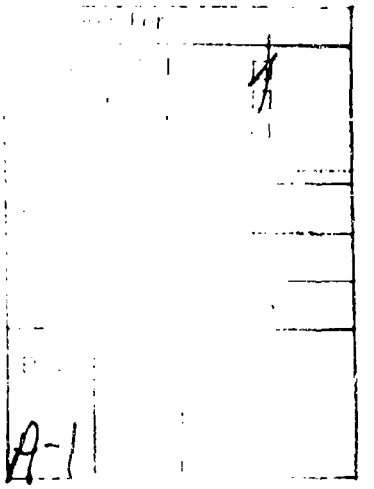
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Overview

The Seventeenth Advanced Research Projects Agency (ARPA) Systems and Technology Symposium was held October 25 through 27, 1994, at the Hilton and Towers Hotel, San Fransisco, California.

These proceedings include briefing material and corresponding text presented by Key Speakers, ARPA Technical Office Directors, and ARPA Program managers. Citations for the 1994 ARPA Director's Awards are also included.

Director's Awards



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IMMEDIATE RELEASE October 26,1994

ARPA RECOGNIZES EXCELLENCE IN PAST YEAR

Director of the Department of Defense's Advanced Research Projects Agency (ARPA) Gary Denman yesterday announced the winners of the 1994 ARPA Director's Awards. These awards, which have been presented since 1985, are designed to reward and encourage excellence among scientists and engineers working with and for ARPA.

Norman Ortwein, of the Research, Development, Test and Evaluation Division of the Naval Command Control and Ocean Surveillance Center, San Diego, Calif., received the Director's Award for Sustained Excellence by a Government Agent in recognition of his continuous performance well above standards. Ortwein's exceptional leadership and management skills, and his positive "can do" attitude effectively helped ARPA program managers to quickly begin and efficiently manage the Micro Global Positioning Satellite program, the High-Speed A/D Converter Program and the ULTRA Electronics Program. Denman noted, "Mr. Ortwein is an effective agent in discharging his responsibilities to the government and the U.S. taxpayer. His contracting experience enabled him to negotiate significant cost savings in contracts for these key ARPA efforts."

Denman recognized Dr. Barry Gilbert and the High-Speed Signal Processing Group of the Mayo Foundation, Rochester, Minn., with the Director's Award for Sustained Excellence by a Contractor. He noted that the team's sustained technical support of advanced technology development was above the high standards expected by ARPA, and resulted in key technical accomplishments. The performance of Dr. Gilbert and his team permitted rare successes in important microelectronics and electronics packaging programs at ARPA.

Three Director's Awards for Significant Technical Achievement were awarded

The first, to Professor Lambertus Hesselink of Stanford University's Center for Nonlinear Optical Materials, was given in recognition of his demonstration of the first fully automated digital holographic data storage system. Professor Hesselink managed to overcome the roadblocks that in the past have prevented previous researchers from making a working

Director's Awards

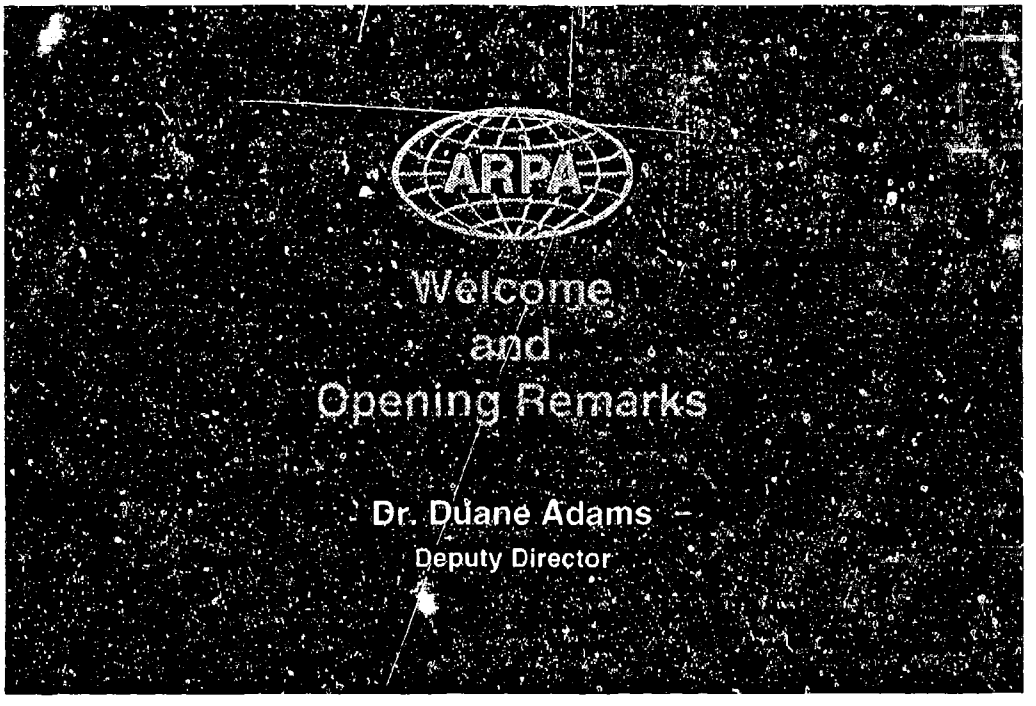
The Multimode Processing Array Project Team of Hughes Space and Communications Co., El Segundo, Calif., also received the Director's Award for Significant Technical Achievement, in recognition of their development of a 20 Gigahertz digital beamforming phased array antenna module that provides the basis for a lightweight downlink transmit antenna for Milstar-class satellites. The team's dedication, and the willingness of Hughes to cost-share the development of this important technology, was instrumental in the successful demonstration of the antenna module in June 1994. Their single module meets all the downlink requirements of the 13 antennas used on today's Milstar satellite, and will be able to reduce the size, weight and volume of future satellites.

Denman also awarded the X-31 Enhanced Maneuverability Team of Rockwell International and Deutsche Aerospace his Director's Award for Significant Technical Achievement in recognition of the team's many demonstrated achievements and aerospace "firsts." Denman mentioned John Perry of Rockwell and Peter Huber of Deutsche Aerospace as company program managers. The team demonstrated significant agility at extremely high angles of attack; agile and carefree handling within the full post-stall flight regime; the significant combat value of these advanced technologies during engagements with a modern front-line fighter aircraft; and, the effectiveness of thrust vectoring for stability and control at supersonic speed

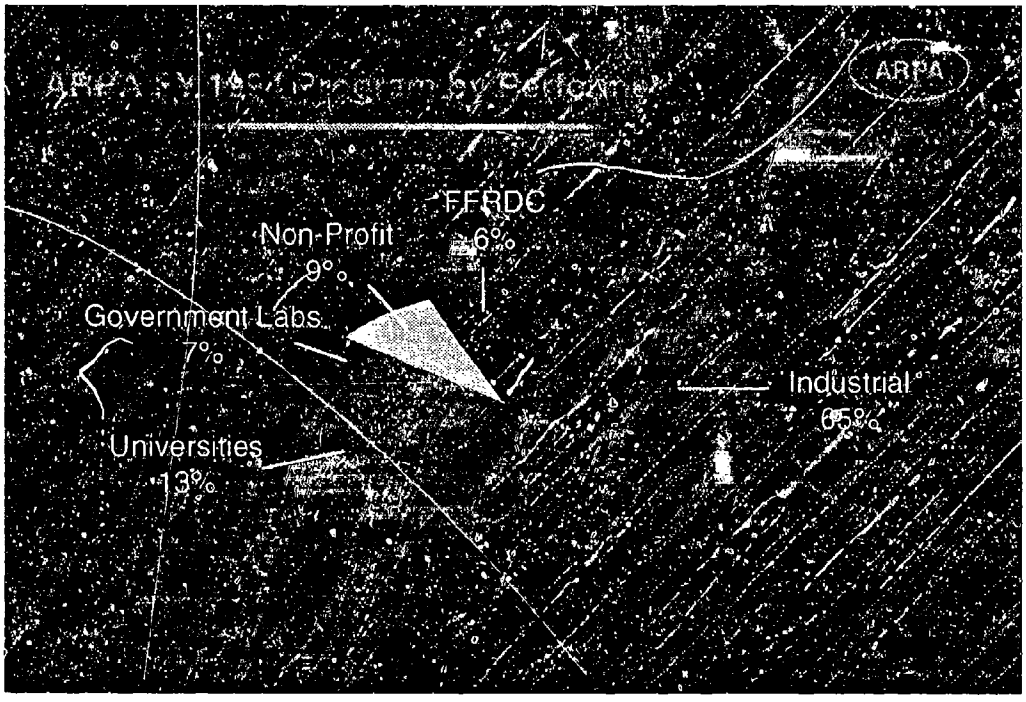
Denman also noted the achievements of two key ARPA program managers, presenting Colonel Robert Reddy, USA, and Kaigham J. Gabriel with Director's Awards for Special Achievement.

Reddy received the award for Outstanding Accomplishment in the Systems Arena in recognition of his management of the Advanced Distributed Simulation Program. This program is the largest and fastest growing simulation technology development effort Defense-wide. His unique ability to harness future technology to meet real-world Defense requirements has been key to the program's successes. Denman indicated, "Bob Reddy's efforts will reach fruition next month, with the Synthetic Theater of War-Europe, a key part of Exercise Atlantic Resolve 94. This will be the largest, single, distributed simulation exercise ever conducted. and will involve all three Services operating from 16 geographically distributed sites worldwide."

Gabriel's award was for Significant Technology Innovation (or Scientific Finding) in recognition of his efforts with the Microelectromechanical Systems (MEMS) program. Gabriel's exceptional management and technical knowledge moved the program from a modest start to a nearly $30-million, 30 project effort. Denman noted, "Ken Gabrial has taken ARPA's MEMS program from a laboratory technology to a core manufacturing capability for the next decade, and he did this in just two years. He has also served as an excellent spokesman for MEMS technology at workshops and conferences."

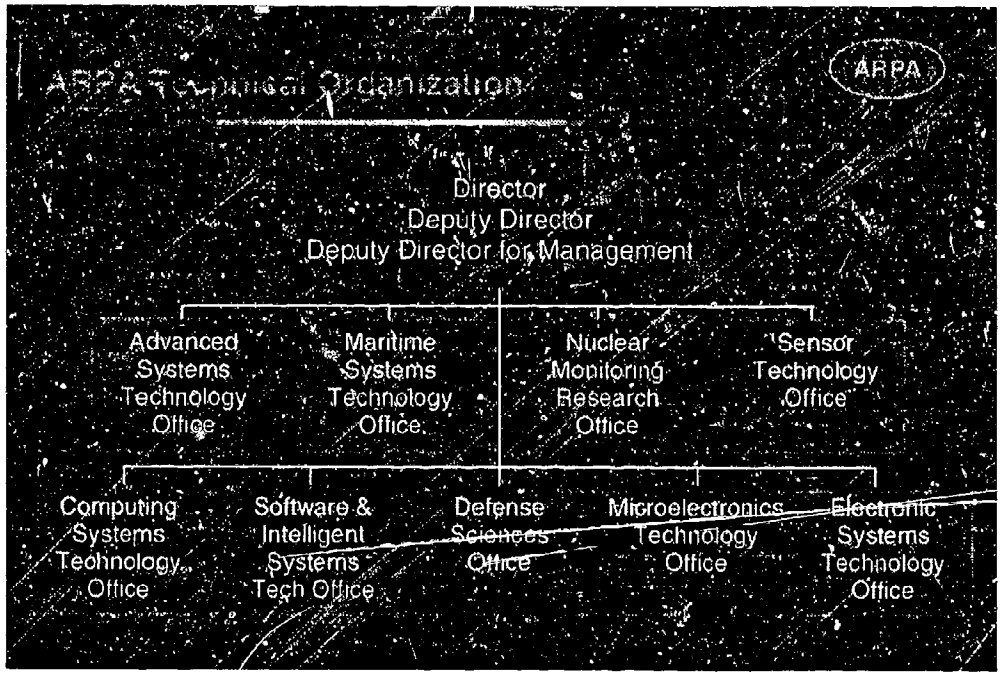


Good morning ladies and gentlemen, and welcome to the 17th ARPA Symposium. It's called the System and Technology Symposium today but it wasn't always called that. When the symposium was first started back in the early 1970's, it was called the Strategic Space Symposium and it was sponsored by the Strategic Technology office, and it was usually held in Monterey. Over the years, the symposium has evolved, we've got a name now that represents a broader set of topics across the entire agency. We have participation across the agency by all the offices and it has evolved from a classified symposium to, this year for the first time, an entirely unclassified symposium. This year the presentations are made by ARPA personnel only. In the past, they were made by a combination of ARPA personnel and contractors. But what has remained the same, is the purpose and that is to inform industry of what we are doing.



With the decreased defense budgets and increased pressure on the S&T programs, it's important that government and industry keep in step with each other - that we share with you what we're doing and that we try to mutually leverage off of each other's investments. So over the next three days, we're going to be sharing with you what our plans are and what some of our technology visions are and some of the trends that we see. I believe that you all know that ARPA has no laboratories, that all of the money that we spend is either spent in the private sector or with other Federal agencies or DOD labs. This past year, we managed a budget of $2.9 Billion. This chart shows where the money was spent and you can see the bulk of it went to industry -- 65%. And when you look at the non-profit line, it includes $90 Million of SEMETECH funds. A significant part of our money is spent with industry, but all of the participants you see on that chart are important to our program. The federally funded research and development centers, labeled FFRDC, include organizations like Lincoln Laboratory, the Mitre Corporation, the Software Engineering Institute and also the national labs such as Sandia National Lab. The Universities have always been an important part of our program, they've played an especially important role in much of the information technology. And the government labs, both the DOD labs, NIST, and the Department of Transportation.

Federal money only tells part of the story, there has been an increasing trend to fund consortia and partnerships and to do that jointly with industry. During this past year, Fiscal '94, we funded 210 consortia jointly with industry where the industry share was over $1 Billion. When you consider the money that was spent for IRAD, there is a significant amount of money that we leverage or that we would like to be able to work jointly with you on. In addition to the money that we directly spend, we have also changed some of our procurement practices to make it easier to work with industry. We now make extensive use of new funding agreements called "Agreements and Other Transactions." In fact, our own contract shop this past year put out about $850 Million and nearly $500 Million was in the form of grants or other transactions. Less than half was for traditional contracts. As we look toward '95, we have an appropriated budget of $2.8 Billion. In addition, there are many programs that we will be doing jointly that are not in our budget and these include such things as the ASTOVL Program, The Tier 2-plus and Tier 3-minus programs, some of the University Research initiatives and several others. It is very likely that we will manage over $3 Billion in fiscal '95.

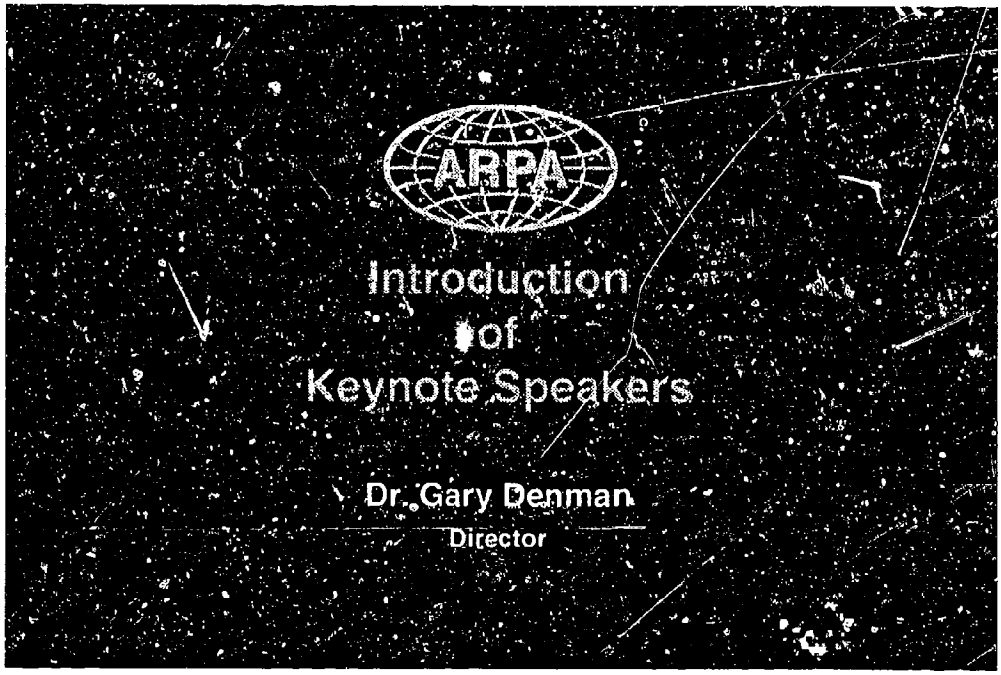


For this particular conference we've chosen to organize the agenda around four themes following the plenary session. The themes on Information Technology and Afford ability represent major investment areas that we're making at ARPA, and we want to share that with you . We have a number of programs which are reaching maturity, and they've done very well, there are also new opportunities that result from these mature efforts. And we have several new technology thrusts. So over these next three days, you're going to be hearing from program managers, office directors across the agency telling you what we're doing and where we're going.

In addition to the structure that we've organized for this symposium, we have the traditional organizational, or office, structure and that's the way manage our programs. The top 4 boxes on this organizational chart, in the blue color, we often think of as system offices focusing on systems and applications. The bottom 5 represent technology offices. This is the current way our technology program is organized and managed. We have recently announced the appointment of two office directors, and I'd like to share that with you this morning. Sonny Maynard with head the Microelectronics Technology Office, or MTO as it's often called, and Howard Frank will head the Computing Systems Technology Office, CSTO. These will be effective the first of November.

Before we go on with the rest of the program we have a few announcements. We've got a number of program managers, office directors and other personnel here this week. To identify us to you more easlily, most of us are wearing blue ribbons on our name tags that say : "ARPA."

There's a message board and if you need to have messages directed here they will be directed to the events office in the Lombard room. Also, messages that come in will be posted in the back of the room. You've all got badges, you need those badges to get in here and you should have gotten a little red card for the banquet tonight. And at the end of the session on Thursday, we will put out a questionnaire that we would like you to fill out. We're asking you to evaluate how we've done. We took your suggestions after the last symposium, we've tried to improve in a number of areas where you gave us specific feedback. We'd like to continue to do that. So when those come out, we'd really appreciate it if you would take the time to fill out those forms and give us your feedback. I'd like now to introduce Dr. Gary Denman, the Director of ARPA, and he will introduce the next two speakers.



My welcome, and good morning. Dr. Adams failed to mention that the last time the ARPA Symposium was held in this part of the country, it was, as many of you will remember, a rather significant event. Unfortunately, it coinsided with the tragic event of the earthquake here in San Francisco. What I wanted to announce this morning is that you may have noticed on our organization chart, that we have the Nuclear Monitoring Office which has primarily a seismic monitoring focus. Ralph Elwine, the director, decided to stay back in Washington at the seismic center. But he did promise us that we would be told 10 minutes afterwards if there's an earthquake here. So you can all feel comfortable that we're going to have good notice after the earthquake. It's my pleasure to introduce to you this morning our first keynote speaker, Paul Kaminski. Dr. Kaminski is the Undersecretary of Defense for Acquisition and Technology. Dr. Kaminski is certainly familiar to many of you here, he's familiar to all of us in the Technology business and he's been a strong friend of the technology business for a long time. Most recently he was Chief Executive Officer of Strategies and Alliances and he's also most recently been the Chairman of the Defense Science Board. Some of his distinguished career time as a career officer in the Air Force was in the early 80's when he was the Director of Low Observerables Technology Office and as you all know, he personally had a strong hand in the stealth technology that we see so effective today in our military forces. Dr. Kaminski is also a member of the National Academy of Engineering and it's my pleasure to introduce to you from the great State of Ohio, Dr. Paul Kaminski.

Dr. Paul Kaminski,
UnderSecretary of Defense for Acquisition and Technology

Thank you Gary, it's good to see so many friends, old and new in the audience today. To keynote the symposium is to try to give you some of the big picture for where we're headed having had the benefit of about 3 weeks in my new job. I find my new job very interesting in that I'm the first Defense Acquisition Executive who has two bosses who had previously held the position. Both Bill Perry and John Deutch held this job before I did. There's a good news piece of that in terms of their appreciation for the difficulties and the challenges of the job. There's a bad news piece as well, because each of them probably has some idea, not of the performance specification, but the detailed "how-to" specification in doing the job. So I need to work through some of those issues. I would say that my sort of overview assessment or appraisal for the environment that you're working in was very well summed up by Yogi Beara who said "the future sure isn't what it used to be", and it's not. We're in a period of very, very fundamental underlining change. The end of the cold war, as you all know, has fundamentally changed the way our whole national security needs are defined and pursued.

We had such a convenient algorithm in the cold war, it was almost executable in the F=MA sense. In terms of being able to see very early on the development of a threat system. The ability to infer when we might see it fielded against us. The ability to understand some of the technical characteristics that we would need to overcome. The ability to plan a program in response and execute it in a very understandable way. Well, unfortunately that paradigm is, to a large degree, behind us today. In a post cold war environment we're dealing with a combination of regional conflicts, dealing the potential for the spread of nuclear weapons and other weapons of mass destruction and we're also dealing with economic threats which can undermine our national security program if not appropriately addressed.

For the many of you in the audience who have a mathematical bent, the way I think about the environment today in contrast to the environment that we've left, is that the mean value of the threat that we're facing today is very much reduced. It's probably an order of magnitude lower. Ironically, the standard deviation of the threat, the situation we're trying to deal with, is probably up an order of magnitude. So it greatly complicates our planning and our need for flexibility in dealing with the future environment. Now as I said, we're in a period of very many changes. We've seen significant reduction in our defense budget overall, but especially in the investment component of the defense budget that affects many of you. We are seeing significant changes in our defense industry and I would alert you that are more ahead. We have a great turn out today as I look at this audience, an indication to me of the proactive attitude that's present with your being willing to be agents of the change ahead.

To provide some perspective, let me share with you a story about a person operating during similar turbulent times who was so frustrated that he turned to God for help. He said "Please God, you've got to help me, please let me win this lottery," and there was no response. The next day was no better. Again he prayed, "please God, you've got to do something. The only way I'll get back on my feet is if I win the lottery. Please make me win." This went on for several days. The man thought that God wasn't hearing him at all and after a while he was beyond desperation. With the last breath of hope in his body, he turned to God and said, "I beg of you dear God, all I need is to win the lottery." Well, there was a long period of silence and this deep voice came back to him saying, "Give me a break, at least buy a ticket." Well, all of you here today bought a ticket. I hope I can encourage and involve you today in a strategy for change and I think it's

particularly important because, as you'll see as I describe this strategy for my perspective a large component of this audience will find it's self on the cutting edge that will be acting as a principle agent for the change that we see ahead.

Now, as I describe this strategy for dealing with change, I need to point out that there's one thing that will not be changing, the underpinning of technological superiority, the foundation for technological strength in the defense systems that we develop and deploy is not changing at all. The new administration and this team have that as a paramount objective and in the talk that follows. You'll be exposed to a very logical, thoughtful and well describe S & T strategy that Anita Jones has developed and is in the process of implementing. I highly recommend that to you and I won't discuss that further in my remarks.

What I want to do now is to move to some of the industrial base issues that will be confronting all of us. If we look at the industrial base today, what we find is that our procurement appropriations are down to about 1/3 of what they were at their peak in 1987. That is a transient phenomenon. I don't believe that the size of our current procurement budget can be carried out in steady state and preserve the modern equipment needed to support the bottom up review force. If you look historically at budget adjustments, you will always find that the procurement budget is the major effective element in a period of change.

I look back at our budgets over a period of about 50 years and if you wanted to find the beta analog in the stock market, the beta of the procurement is a little over two. What I mean my that is when the top line defense budget changes by X percent, you will find typically that the procurement budget changes by 2X percent. That has to do with the fact that, for example, once we've settled on a force size and we've equipped that force, let's say just for simple illustration that we postulated the need for a force that has a thousand tanks and that we had 750 modern tanks in the force and 250 older ones that we had a development and procurement program to replace. If our requirement for the force was reduced to 500, not only do we need to not build those new tanks but we sort of have 250 in the bank and so for some period of time we needn't produce any. On the other hand, the responsibility falls to a person like myself to think long term about the industrial base.

What plans do we need to put in place to, at some time in the future, be able to produce tanks? Should we be producing at an inefficient rate for some period of time to keep a base alive? Should we let the base go down to zero and try to rebuild it later or should we adapt some strategy that looks at critical components looking at a commercial industrial base to support the rest? The problem is that this isn't a simple question to answer and it isn't the same for tanks, as it is for submarines; as it is for fighter aircraft. The department is in the process of looking at this more carefully.

I would also say that in this period of transient development, one of the things that we are doing is that we have the freedom in the short term to allow for our procurement account to be a bill payer until we make more fundamental adjustments in the underlying infrastructure in the Department of Defense. The adjustment in the size of our forces will not be temporary but will be a permanent adjustment in the size of our base, our real property structure and some of the underlying support elements. We have a major "Rack 95" process underway right now which will take the next step in that activity.

Dr. Paul Kaminski,
UnderSecretary of Defense for Acquisition and Technology

I indicated in this process that one of the alternatives to be thought about in the defense industrial base is to rely more heavily on a commercial industrial base. There are several reasons to think about this and this movement from a defense unique industrial base to an integrated national industrial base is one of the fundamental elements of change that I wanted to talk to you about. This, in my opinion, is a permanent change. It's a change in how we'll be looking to manage our overall industrial resources for the defense department and for the country.

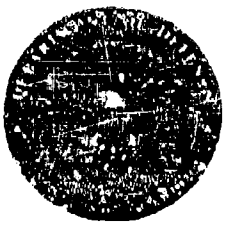
Going back to my tank story, in this environment, if we could have found for example, a tank engine that was very close to an engine being produced, say, for a large truck and could find a means to make application specific changes off that production line, we would be in a much better posture than thinking about a unique line that supported defense only need. That's the sort of direction we're going to be looking at as we look at our industrial base in general. Certainly there are going to be areas in our industrial base where there is going to be no commercial equivalent where the DOD will have to look fundamentally after it's own base. A key example would be stealth technology. I don't imagine that we're going to see any large commercial use for that technology or the underlying base. That is something that the DOD will be forced to continue to develop and support in and of itself.

In other areas, we will be looking much more broadly to obtain economies of scale by leveraging our commercial industrial base and applying it to defense needs. We will be looking to do the same thing in our technology base activities to look to pool into defense application that which is being developed at the leading edge of commercial technology. To be able to put in some hooks, perhaps, to influence a development in a particular direction that's more advantageous to us. I would use as an example that which we have done in the Department of Defense with the conversion of commercial aircraft for our transportation needs through a program called CRAF. We spent money to strengthen floors of commercial aircraft and paid for an insurance policy to have the aircraft available for our use. This greatly leveraged our base rather than buying aircraft to serve that need.

To implement this kind of a strategy of greater exploitation and reliance on our commercial industrial base, one of our major impediments are the barriers to buying commercial equipment or using commercial processes in our current DOD acquisition system. There are several reasons for wanting to undertake a major program of acquisition reform, but one of the major motivations from my perspective is ability to allow access to this commercial base; to, in fact, move in the direction that I was describing to a base which is truly national in nature.

If we think about the characteristics of a national industrial base, there are at least two things that this base needs to provide for us. One, is to give us the ability to insert the very best, leading edge commercial technologies into defense systems wherever possible. Here's a situation in which in the past DoD was driving very much of the technology base that it's needed. In many areas, in particular, I would highlight the areas of information technology, the development of advanced electronics processing systems and some sensors, it's the commercial base that's leading. And the issue is providing access for DoD to this base. I would also project that as time goes on and this commercial base ends up being the key driver in these several areas this commercial base will be available to adversaries as well as to us and the premium will go to the country who is most adept in being able to identify what's available, being to draw it to it's need, being able to provide some application specific tailoring and doing this all with the shortest possible cycle time.

Dr. Paul Kaminski,
UnderSecretary of Defense for Acquisition and Technology



Another one of our challenges will be to get our cycle time down for obtaining access to and fielding commercial technology. There's another aspect that I think is equally important, and it's sometime forgotten. Simply developing and fielding equipment is not adequate unless we have addressed how best to employ that equipment. To develop the employment doctrine, to develop the tactics for application and to integrate it into our forces. One of the major thrusts that we are undertaking in the department to do a better job of doing that, impedance matching, so to speak, to get our best equipment in the hands of people who can really use it effectively is through our program of Advance Concept Technology Demonstrations (ACTD). It's a program I will be strongly supporting and it's a program in which what we are really doing is making our users a smarter customer, better able to exploit that which is being developed in commercial industry for our defense applications.

An example of this kind of activity is the use of commercial integrated circuits in a program like our modular avionics radar. Leveraging off a warm commercial production line to produce what we need at lower cost at a sustainable volume. Another characteristic that our national industrial base must possess and support is the ability to integrate defense technology into commercial production. This dual produce concepts must be pursued in two ways. First, the commercialization of defense sponsored technology and products and secondly the development and deployment of new manufacturing technologies. An example of this case is the commercialization of monolithic microwave integrated circuit (MIMIC) technology. This is taking a defense technology, applying it for a commercial use, developing a scale again of production. The benefit now coming back to the Department of Defense [in having deployed that production base] is to have access to it where we may be a minority purchaser [in terms of what's being produced for a commercial base]. To have access again to a line which has the latest technology implemented for our use, and which in a declining environment might be too expensive for us to support alone.

If we think about this kind of an environment where we're relying upon and exploiting heavly a commercial base, there is another premium to be placed on the development of skills in system engineering and system integration. To be able to take commercial components and subsystems to realize the enabling base and to successfully integrate them into applications that support our DOD needs.

Let me talk now just a little but about acquisition reform which I think you can see is a key enabler in this kind of an environment. The issues again in my mind are the ability to have access to commercial products where the encumbrance of dealing with the DoD has been a deterrent to those suppliers working with the department and secondly, the ability to reduce cycle times so that we can get equipment that's at the cutting edge integrated into our systems and deployed in the field by users who can use it in the minimum time. Acquisition reform is not a new subject. Many of my predecessors have struggled with it with mixed success. The road to acquisition reform is not going to be an easy one. Don't underestimate at all the challenge that's ahead in implementing the program to improve our access and our cycle times.

For the past decade or so, many preeminent leaders and groups have studied the problems, have made recommendations. Notable commissions, such as the Grace Commission, the Packard Commission, the Writenhouse Study; I've been involved in several of those personally as a supporting staff member or though Defense Science Board activities. This is an area which many people talk a good game but it is very difficult to actually get things implemented where the rubber meets the ramp. Now, I think of this program to be undertaken in three phases. The first phase

Dr. Paul Kaminski,
UnderSecretary of Defense for Acquisition and Technology

was the development of fundamental enabling legislation. That phase is now behind us with the President's signing, last week, of the Federal Acquisition Streamlining Act of 1994.

The Act doesn't include everything that I would like to have seen it include, but it includes a great deal. Now the second phase of the program can begin and that is one of implementing the reforms that we now have freedom to implement. The Act gave us a great deal of freedom, but I would also say that there were a number of institutional barriers in the department which need to be overcome. We are now at work doing that. I'm sure that most of you say the announcement made by Secretary Bill Perry, putting what I would describe as the shoe on the other foot with respect to military and commercial specifications. But, it is, rather than having the onus on the program manager of justifying a commercial specification, the onus is just the otherwise. Where there is a commercial specification available that will work, we'll use.

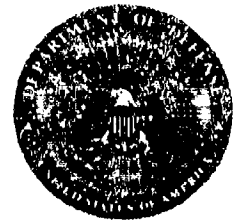
We're also in the mode of using performance specifications rather than how to when they're necessary. The justification in this case is required to use a military specification. Now there are cases where we're going to have to use military specifications where there is no equivalent or where it's the right thing to do, so the policy has to be applied with reason. I think now the risk and the arrangements, the ones, is back in the right position. Along with this program of specification changes, there are a number of process action teams in place to facilitate development of electronic commerce with the Department of Defense to simplify small purchases; to develop innovative contract management approaches; to reduce the excessive tierings in the use of specification and standards and just to remove the whole family and fabric of underlying obstacles.

I think the system we are dealing with today was very well characterized in a little anecdote by Mark Twaine who describe a cat that sat on a hot stove and his remark that that cat will not sit on a hot stove again. The problem is the cat will not sit on a cold stove either. That's the problem we're dealing with all the institution apparatus that has been set up, each to solve some particular problem that developed in the past, not well recognizing the opportunity costs that go with it in terms of limiting our flexibility, our access and our cycle time in the future.

Now, I said earlier that I wouldn't minimize the difficulty and obstacles ahead. So what's different this time in the attack to undertake acquisition reform? I would say that there are three things that are fundamentally different today. One is the underlying need with the resources available, something has to be done to be more efficient in that which we do and the need is well recognized and well shared. The second thing is the commitment of the Administration and the leadership in the Pentagon. This is absolutely number one priority for Bill Perry, it's number one priority for John Deutch, it's number one priority for me and there's a team of service acquisition executives who are in harness and it's their number one priority.

I would say, if every anything is going to happen, this is the time for it to happen. There's wide-spread Congressional support, so we are serious about implementing this kind of a program to give us access to a national industrial base in the form I described. I would just close with one more remark in acquisition reform. The metric, from my perspective, is not policy announcements made in Washington or even legislation that's signed, the metric is what's actually happening in the field in our implementation. That's the feedback loop that has to be monitored and closed. That's where I intend to put my attention. To see really what's happening between the program manager and the contract officer and the industry in terms of what's really being implemented.

As an indication of that, one of the policy arrangements that I've put into place is to stop this business "we're going to fix our implementation on every single new contract that we sign, never mind all the old ones we have in place". My view is that the place to start is with the contract that



are in place today to begin to get things to happen in the field. Let me talk a little bit about the role of ARPA in this environment. ARPA has had a legacy in history that demonstrates an ability to support this very dual use concept that I've described. This really is not a new strategy or approach for ARPA, this has been undertaking in their leading technology program now for some period of time. In fact, it plays to the strengths of the organization.

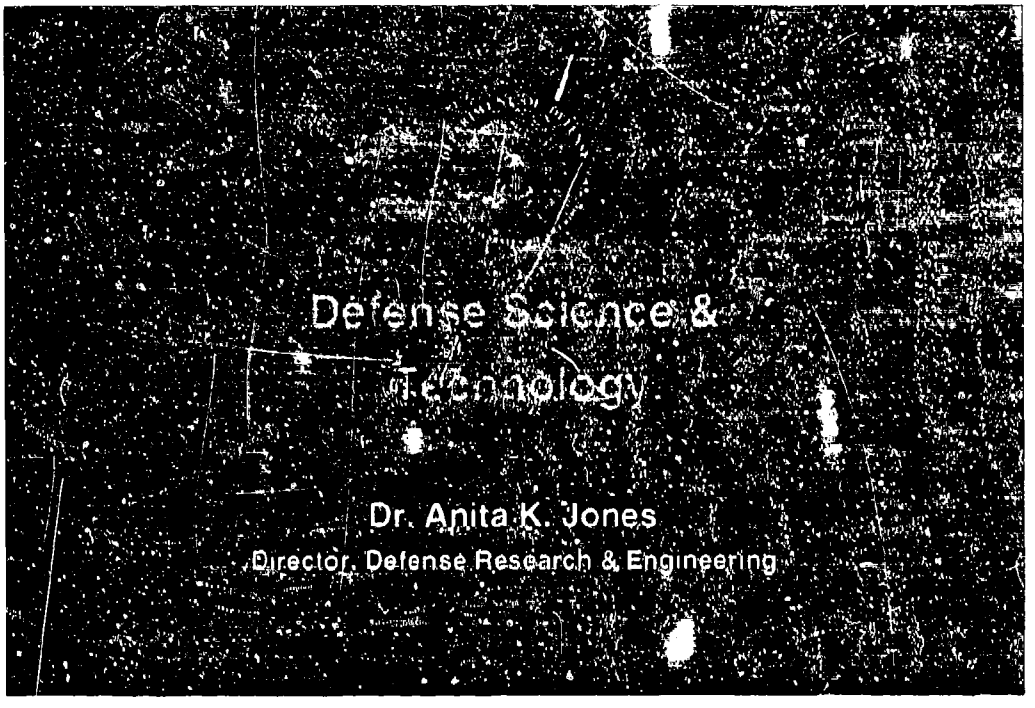
Historically, ARPA has supported technology areas of enormous importance to the commercial as well as to the defense industrial base. Examples such as computer technology, networking, advanced materials, electronics, communications technology are a number of the rich areas in which this has occurred. ARPA is extremely well positioned to continue to invest in the creation and utilization of dual use technology. Many of the new business strategies have been demonstrated by ARPA in the implementation of the technology re-investment project and in other program areas.

This new way of conducting business is marked by, first, collaboration with industry and a formation of partnerships to foster that collaboration. This model is an important tool which we are using to move from the transaction based model of the past to relationship based models in place throughout the rest of the world. Second is cost sharing. The policy of cost sharing, in my opinion, is crucial not so much as it doubles our investment but because of the incentives that it provides and the guarantees of a continued commitment with each participant when commercial opportunities exist by allowing for sharing both the risk as well as the rewards of the activity.

Lastly, the other agreements authority that Duane mentioned earlier in his remarks providing for the creation and use of new legal authorities and instruments; another very important tool. For example, the TRP is making extensive use of this other agreements authority provided to it by the Congress several years ago. This combination allows entry into cooperative agreements outside the confines of our traditional government contract approach to foster cooperation and collaboration and improve both the access and the cycle times that I discussed earlier. As I said in my introduction, we're in a period of dramatic change. We can see ways to improve our current system, ways, in fact to do more with less resources and yet accomplish the mission. Some look at the constraints that we're operating under in the current system stand back and they ask why? I encourage and charge all of you to join with me, take a step back and envision what is possible with this dual use approach and ask instead, why not? Thank you.

Dr. Gary Denman, Director:

Thank you very much Dr. Kaminski, we sincerely appreciate you taking the time from your busy schedule and we sincerely appreciate you coming all the way out here to talk to us.



Dr. Gary Denman, Director:

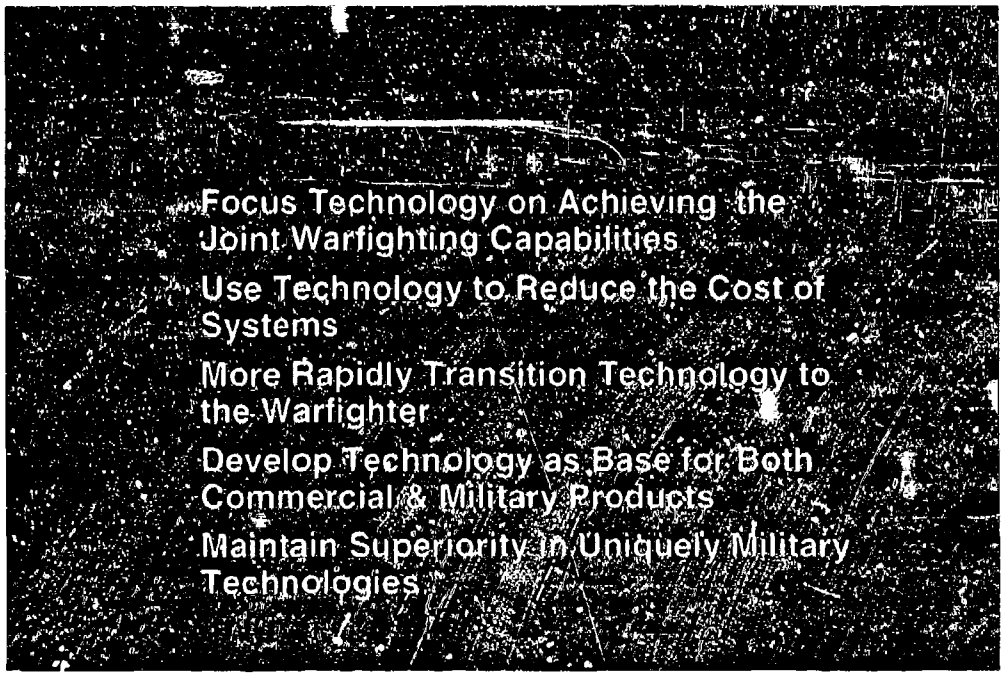
Our second keynote speaker is my boss, Dr. Anti Jones. She is the Director of Defense Research and Engineering and as such, she is responsible for all of the defense science and technology program for the full department including the services as well as ARPA and other agencies. Dr. Jones has served in many advisory capacities to the department over the years ranging from serving on the Defense Science Board, the Air Force Scientific Advisory Board and also she was just recently inducted into the National Academy of Engineering. Dr. Jones has an interesting academic background. She comes to the department from the University of Virginia where she was chair of the Computer Science Department and her formal academic training was in mathematics at Rice University followed by a Master's of Arts in Literature at University of Texas at Austin, and finally a PhD. in Computer Science from Carnegie Mellon so she has quite an interesting background there. So, it's my pleasure to introduce to you Dr. Anita Jones from the great State of Texas.



Dr. Anita Jones:

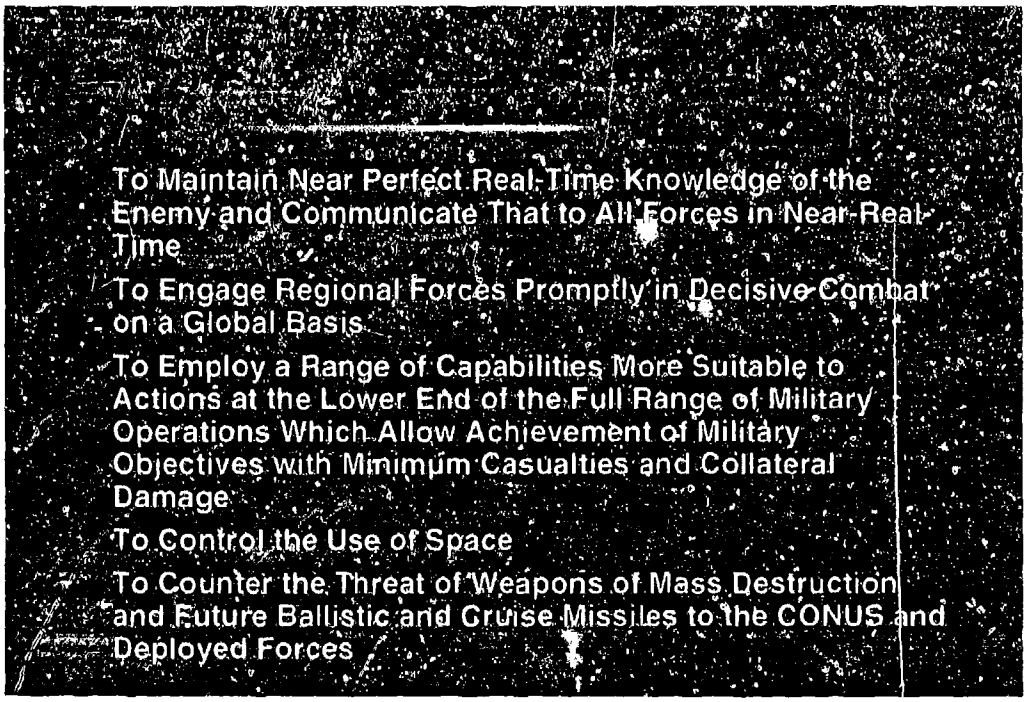
Good morning, it's a pleasure to be here at the ARPA Symposium. I'd like to talk to you about the science and technology program in the Department of Defense and I want to talk to you about change. In this post cold era, as many pundits, many newspaper articles have told you, there are real changes. From my point of view, although lots of people talk about the competition, the military competition scaling down in the technology arena the competition just got hotter. Instead of competiting with a, to some degree, a predictable Soviet Union, we now meet, or prespectively meeting on the battlefield of technology that comes out of the total global arms market. And that means our technology has to continue to be better against a stiffer competition. So for our program, the demands got higher, not lower.

The objective of the Science and Technology program is to offer technology options to the war fighters. To develop technology that can be imbodied in a military capability to proffer it to the arms services so that they can choose the system that they want to build and field in the future. And those systems must continue to imbody technological superiority. As been alluded to earlier in Dr. Kaminski's remark about standard deviation, there's now what really a broader mission. There's more emphasis on peace keeping, there is a more challenging counter proliferation mission and we have some daunting challenges when we send just small numbers of troops into an urban area to execute a mission; technology needs to protect them. At the same time, of course, the budget is down and the challenge to the U.S. economy, I think one can argue, is up. I want to talk to you today about our strategy for dealing with this.

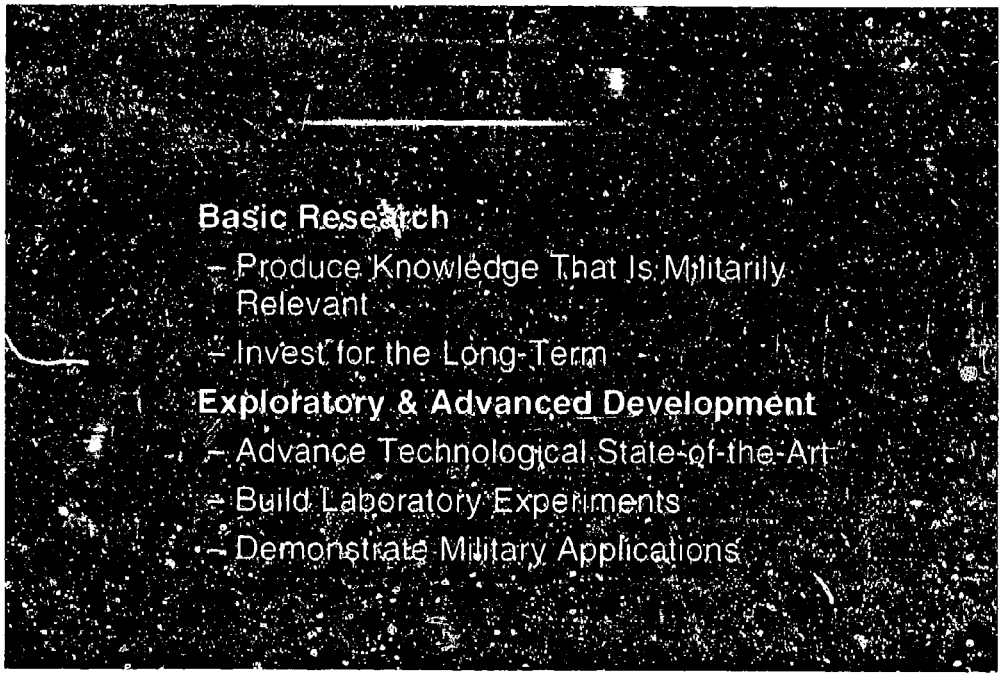


One of the marvelous things about the Department of Defense is it still has a mission and that mission is very clear. For the science and technology, that mission is what guides the investment from research tthrough late technology demonstration. The armed services have rethought, in fact, have reset some of the objectives and we look particularly to the Joint Staff to lay out what the objectives for the future are and I'll show you that on a succeeding slide. Before I do this, I want to make a couple of other points about a strategy for responding to this new era. Rethink your objectives is the first point. Second point is, with the budget down, we need focus not just on performance as we have in the past but we need tturn technology to the objective tof building more affordable systems and that's a real challenge. That's something that hasn't had stem to stern attention and therefore there's some real benefits, I believe, to be reaped in both the near term and the far term.

As Paul Kaminsky alluded to, partly because of this new technology competition, partly because we could meet many different adversaries in regional conflicts, we need to more rapidly transition technology to the armed forces. We need to rely, to a great extent driven by budget, on a combined military commercial base for the products that the armed services need. Again, the bottom line is we need to maintain our superiority. Including, with those technologies that are uniquely military, which means that in the science and technology budget we must ascribe a proper priority to those that protects that investment.

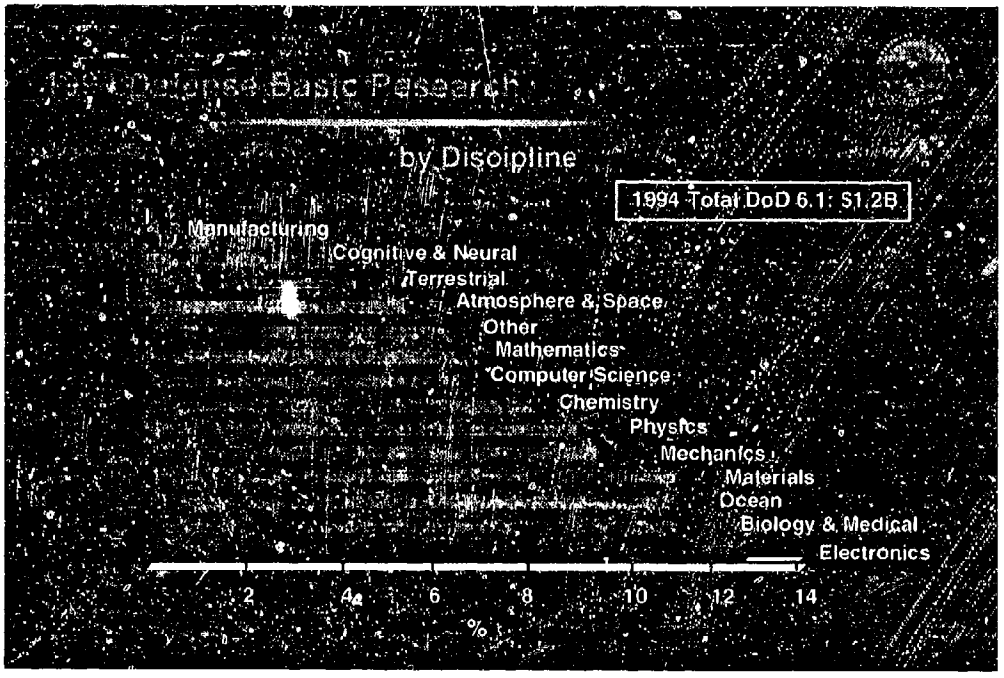


To elaborate on an earlier point, this is a description of the Joint Staff's statement of the future joint war fighting capabilities and I think it shows you that order of magnatitude standard of deviation. Much more stress on the individual, protecting the individual in urban warfare, in urban police actions, in peace keeping, more emphasis on counter proliferation. Now I've just been focusing on changes, I do want to tell you that some things really are the same.



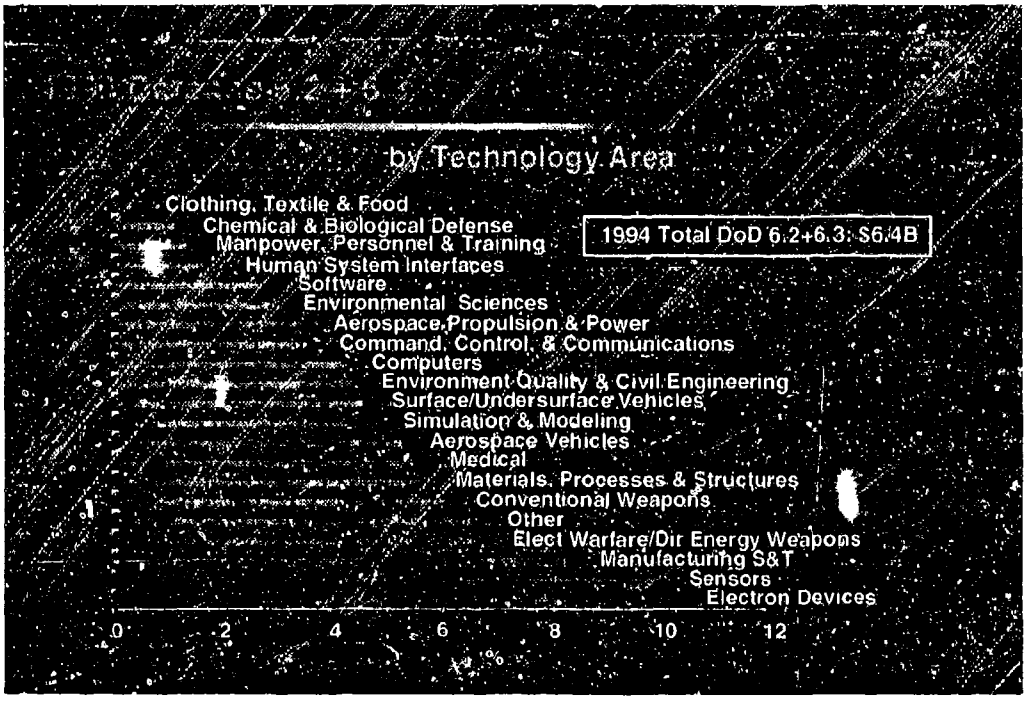
The science and technology program has continued it's form, if you will -- and I want to take a couple of slides to illustrate that.

It still has a basic research component in which we want to develop fundamentally new ideas that might have applications to making quantum jumps in military capability. We have invested in the long term, we will continue to invest in the long term. The bulk of the investment, however, is in exploratory technology and in advanced development where we're drawing technology out of scientific ideas, trying to capture sometimes slippery ideas in the laboratory and finally fielding demonstrations in quasi realistic senerios to try to demonstrate with, as high a fidelity as we can, their military application.



To show you this graphically, this is a depection of the defense research budget. It's basically 20% of the roughly 8 billion dollars annual science and technology budget -- 20%. Most of that, by the way ,is not in ARPA. Just a few percent of ARPA's budget is actually in the so called 6-1 or basic research account. Point being made here is that the budget is broadly spread. That's necessary to prevent technology surprise.

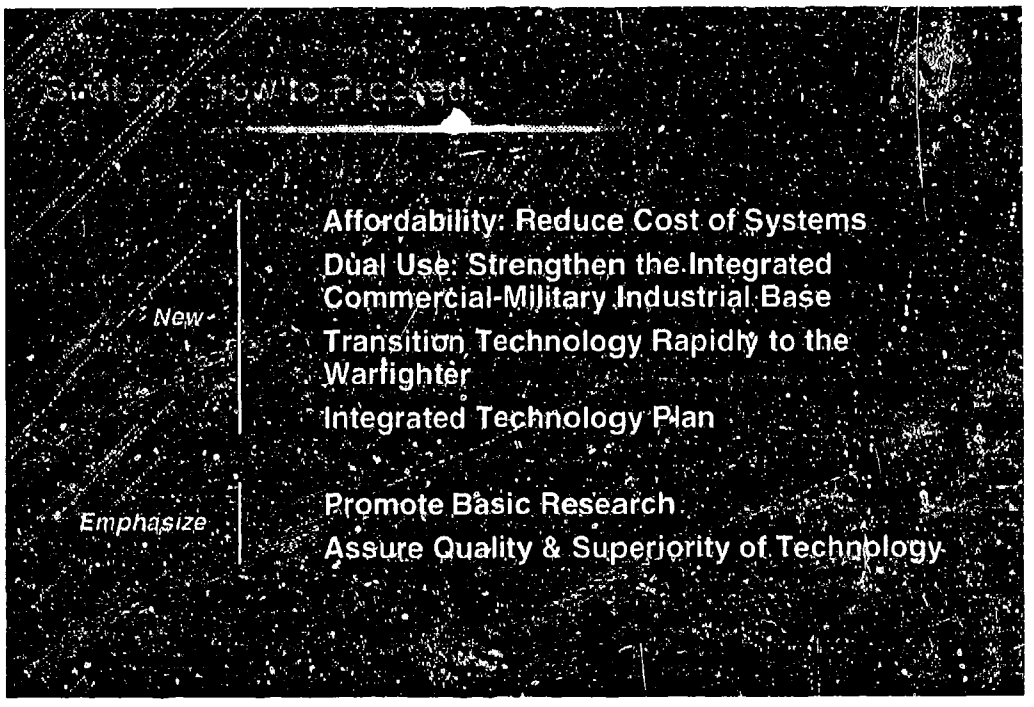
It is mandatory to be able, either in a university or an industry, to replicate experiments when one hears about them, to have a standing infrastructure that really does understand the leading ideas in a particular area. So you'll see the fundamental sciences listed here and of course, you see sciences tightly corralated with each of the services, terresterial, air and ocean. You'll see a heavy emphasis on electronics and particularly in this area ARPA is a player.



There was an earlier question about university funding. University performers are important contributors, important performers in the science and technology program and we continue to look to them. I think universities have a challenge and one way they are rising to that challenge is over, say, the last decade, universities have formed more than a thousand university industry. Whether there's government, state or federal participation or not but industry, university consortium and partenerships. Another way universities have risen to what the challenges of today are is both in principle investigater programs and also in these kinds of consortia, you see alot of multidiciplinary work where I think a lot of the gold today is to be mined. Our universities are organized by department and we have come to realized -- we, you see it's a throwback to university life.

Universities have come to realize that in the research area, as well as in the education areas, that there is much benefit to be had by coupling diciplines, spanning department and consortia are one way to do that. Roughly, 80% of the science and technology program is in the technology investment accounts 6263 -- if you speak that language. This percentage-wise along the horizontal access is where that investment is being made. So to first approximation, you've got 5% in a wide variety of diverse technologies.

The Department of Defense will continue its investment in a diverse set of technologies. Partly because we seek technological superiority in all kinds of ways from the food that we feed troops in the field to our ability to manage logistics and maintenance to the more usual examples of weapons and sensors. I might point out again, the ARPA investment is primarily in the technology end and so roughly 98% of their budget is in the 6263 arena.



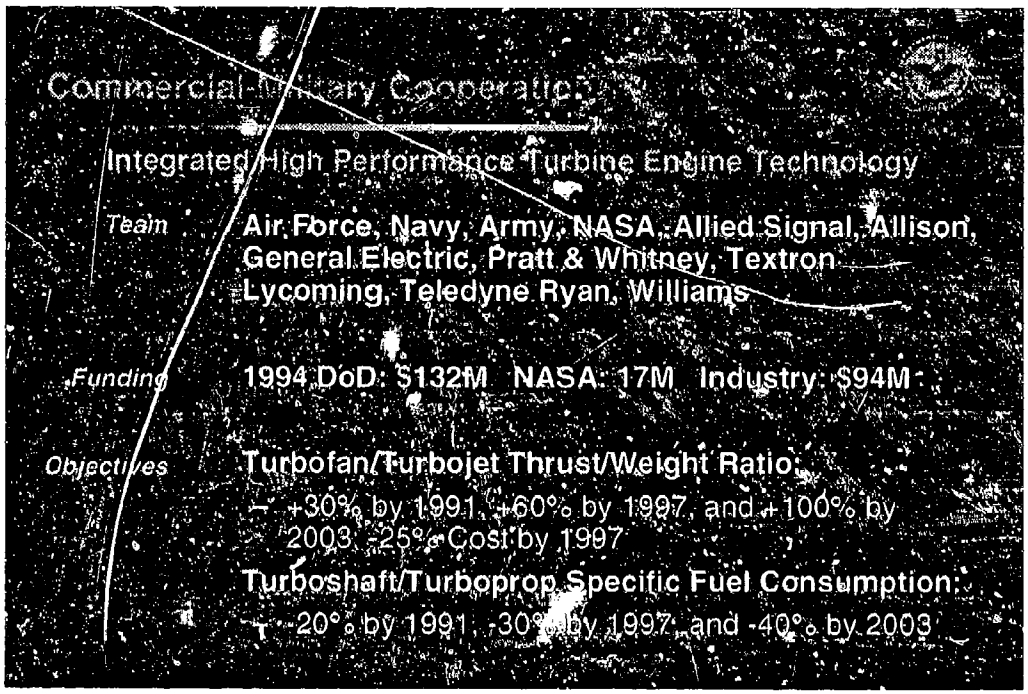
So how are we proceeding? You have a document that's called the "Science and Technology Strategy" in your package of conference materials. Working together with the services and with the agencies, this is the strategy we've hammered for moving forward. I want to highlight some of the elements of it in the remainder of my talk. We wanted to write it down, partly because we need to communicate it to you, particularly to you. Partly because it represents a real culture change within the Department of Defense. It marks a change in the way we're doing business. That change is in progress, it started a while ago, it's far from complete.



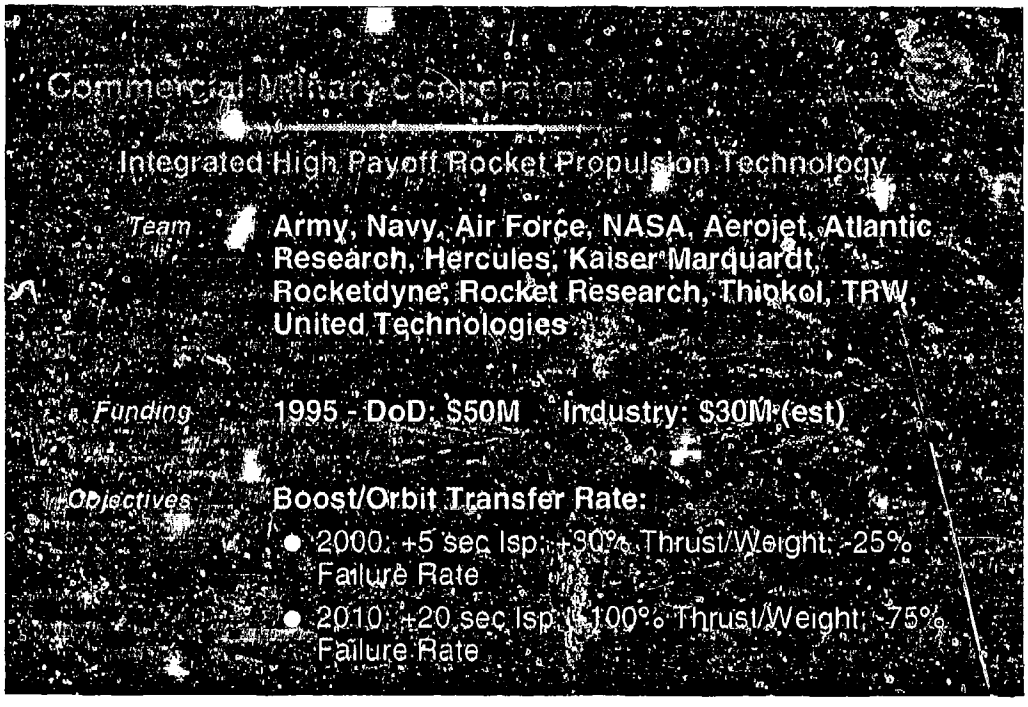
We need to see change in the services and the agencies particularly in the laboratories. So what are the main new elements? The first one is to harness technology to reduce the cost of systems; to use best commercial products, practices, and capabilities. Dr. Kaminski highlighted a number of aspects of this. We're investing roughly a billion a year just in the science and technology program. nevermind what's out in the procurement or modernization accounts, to improve manufacturing processes. We're particularly agressive about exploiting simulation, we use it already heavily in training, but it needs to be harnessed in the area of manufacturing. We need to use it in our requirement setting.

ARPA is a leader in exploring new opportunities to apply simulation distributed down to a single workstation. There're mirad opportunities to get tighter control of processes whether they're requirements, manufacturing, product improvement and evolution and maintenance. We need creative ways to insert technology into long life systems.

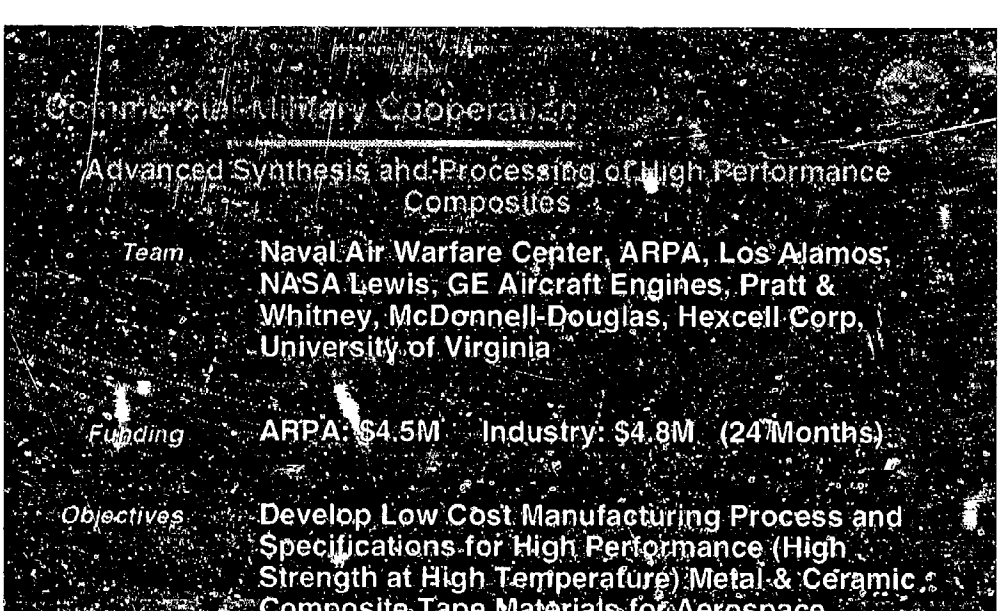
The second point on the "How Do We Proceed" slide is "Dual Use". Again, Dr. Kaminski talked about this at some length and so I won't dwell on this. Except I'd like to give you some examples, some concrete examples, of doing business in a different way.



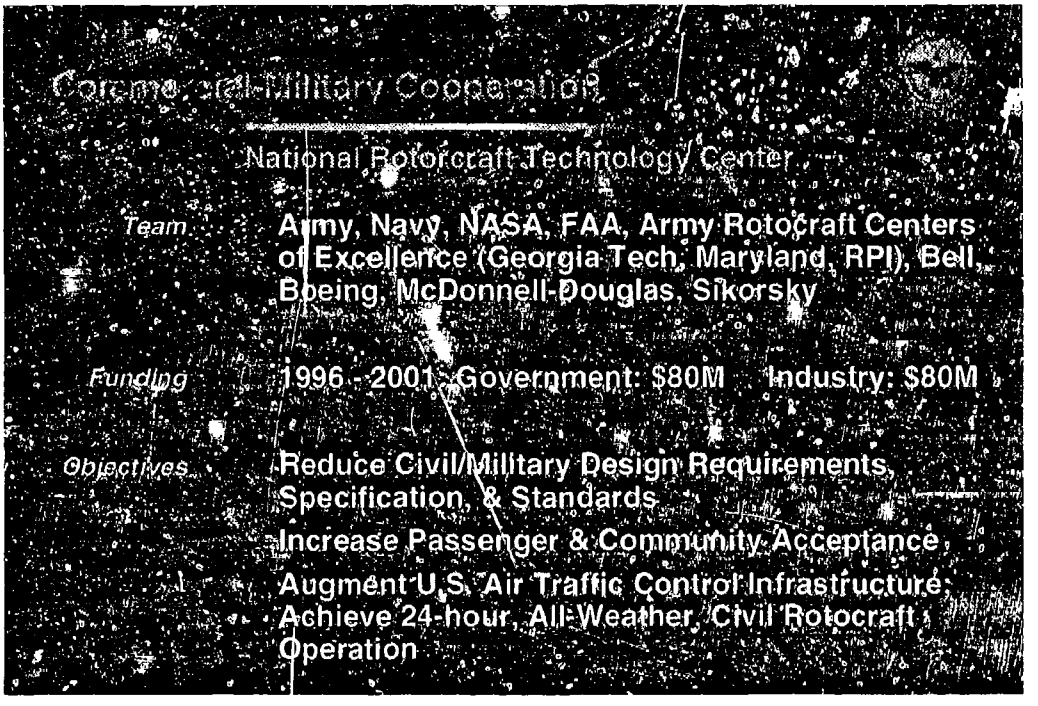
The first one of those is a consortia, in fact there are going to be four examples of consortia. This is a several year old program that I think is an excellent example. The integrated high performance turbine engine program which is lead by the Air Force involves all the services and NASA, and the leading corporations in high performance turbine aircraft engines. There is cost sharing, industry share is substantial. The objectives are well thought out and clear. They have to do with performance, they're usually described as performance, for example, increasing thrust to weight ratio. We have objectives that are quantified and associated with a date. This program is roughly on track for it's '94-'95 objectives, maybe a slightly bit late; but in fact they are meeting their objectives. I would point out that these are not just performance objectives. If you improve thrust to weight then in fact you have to pay the less logistics cost for getting fuel to the aircraft, both the cost of the fuel and the cost of the logistics, the lift to get it there. So these are not just performance objectives, these are affordability objectives.



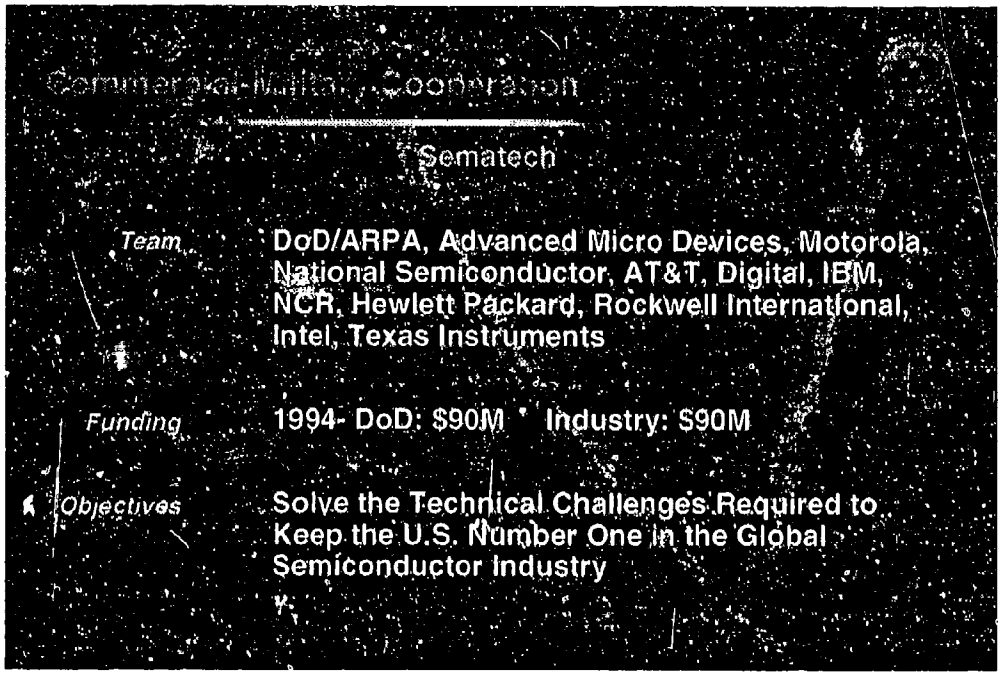
Second example, here's a "Me Too" program. This was fashioned after the high performace turbine program, it's in rocket propulsion. It's Army, Navy, Air Force and NASA, it involves leading corporations in this area. It again has matching to that industry is making it's own decision about whether it wants to buy into these objectives. The objectives are quantified; associated with dates. They are things like improving specific impulse power. That's a measure of effiency and if you can increase it by 5 seconds, that's the unit of measure for an Atlas rocket for example, you can increase the payload by a thousand pounds. The failure rate is failure of stages, today that 4 in a thousand. 25% increase would mean we would have 3 stage failures out of a thousand firings. So again we have quantified, time stamped objectives.



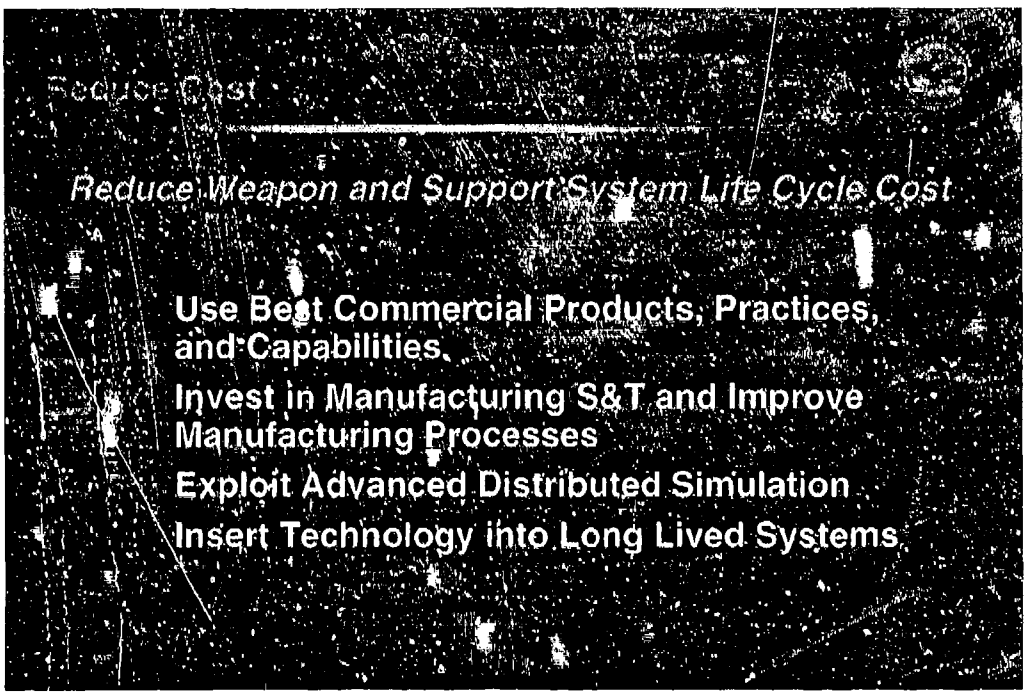
Next program is an ARPA l d program in high performance composites; this is relatively new, it is cost shared. The objective is to improve the manufacturing process in high strength, high temperature materials -- particular focus on areospace structures.



Next to last example, this is a Rotocraft Center, this is Army lead. The Army realizes that it cannot maintain, on it's own, a defense Rotocraft industry. It's paying substantial attention of how to work with commercial industry. For example, when we built and qualified the T800 engine this last year, FAA certification and Army certification, against different standards, was achieved at essentially the same time so that the engine went to market available for both applications. Again, there's industry matching funds because the objectives serve commercial product development as well as military product development. We want to simplify and bring closer together the requirements and standards, the specifications. We want to achieve 24 all weather civilian Rotocraft operation and many of the issues are the same. Many of the failure issues are the same for both civil and commercial helio operations.



Here's my last example. The familiar SEMETEC, this is an ARPA lead consortia. Industry really sets the objectives and certainly industry sets the implementation program. It is cost shared. The objective is to maintain our leadership in the semiconductor competitive market place; strong focus on manufacturing and the supporting tooling. That's been a very successful partenership. Back to the center slide, I want to talk about transition of technology, insertion of technology. We do have a new program that Paul alluded to. That's the Advance Concept Technology demonstrations where we, in fact, involve the operators substantially in defining a technology demonstration with operator participation in that demonstration and with some residual capability left with the operator to explore tactics and doctrine. It's not enough to field a technology, to show that a system will work. It only works if it works in the context of the tactics and doctrine that the leadership pursue when they imploy that system. Companion the technology transition is insertion and maintaining inhouse expertise, particularly the challenge today is in house expertise that understands what's happening, what's about to happen out in industry because industry makes a larger investment in R & D than the U.S. Government.



Back to the center slide, as I said, there are some aspects of the program that remain the same. We continue to invest and promote basic research because our edge often comes from surprising quarters. Scientists looking to solve one problem, hatching a wholly new solution to maybe even a different problem. It remains an objective of the DOD science and technology program to assure and improve it's quality. So in conclusion, the DOD sceince and technology program is changing not in form but in accepting both a broader set of challenges that it must meet.

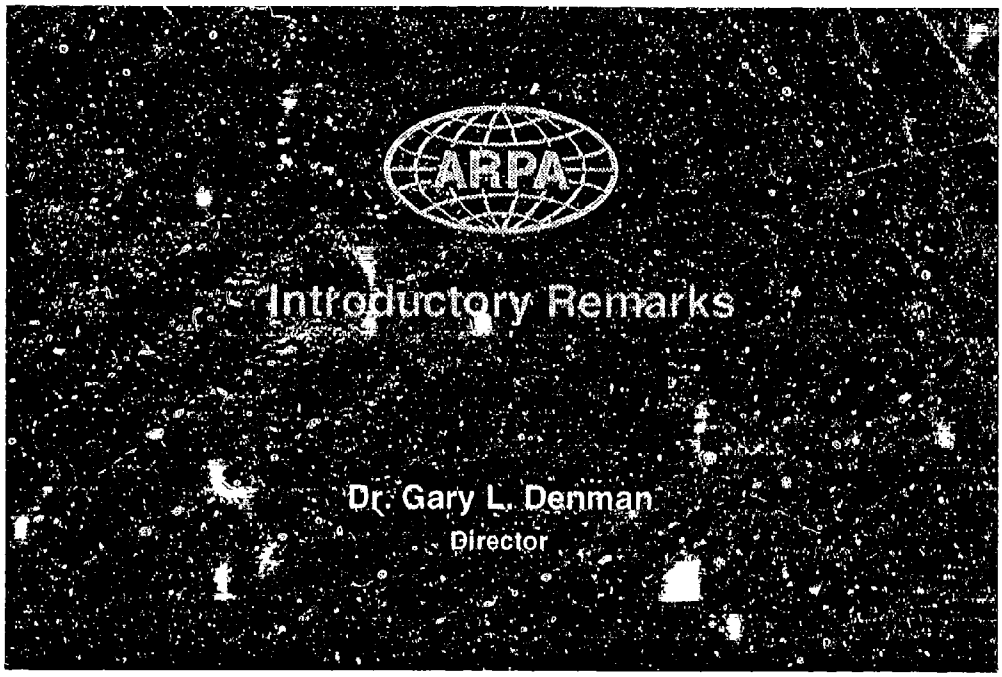
A rapid technology competition cycle in which it must be successful and a real change in the way we do business. For us it' a culture change, we particularly look to industry to propose new solutions that, in fact, honor our new affordablity objectives and sit well with the objective of having an integrated commercial and military industry; buying military products off an industrial line. Long reach and technology breakthroughs have long been ARPA's objective and ARPA's strong suite. I believe you can achieve that same quality of result when you take on the affordability and dual use challenges as well. So this is not just a challenge for our laboratories, it's a challenge for ARPA and I look forward to their contribution to this. One of the marvelous things and I said before, is that the DOD has a clear mission.

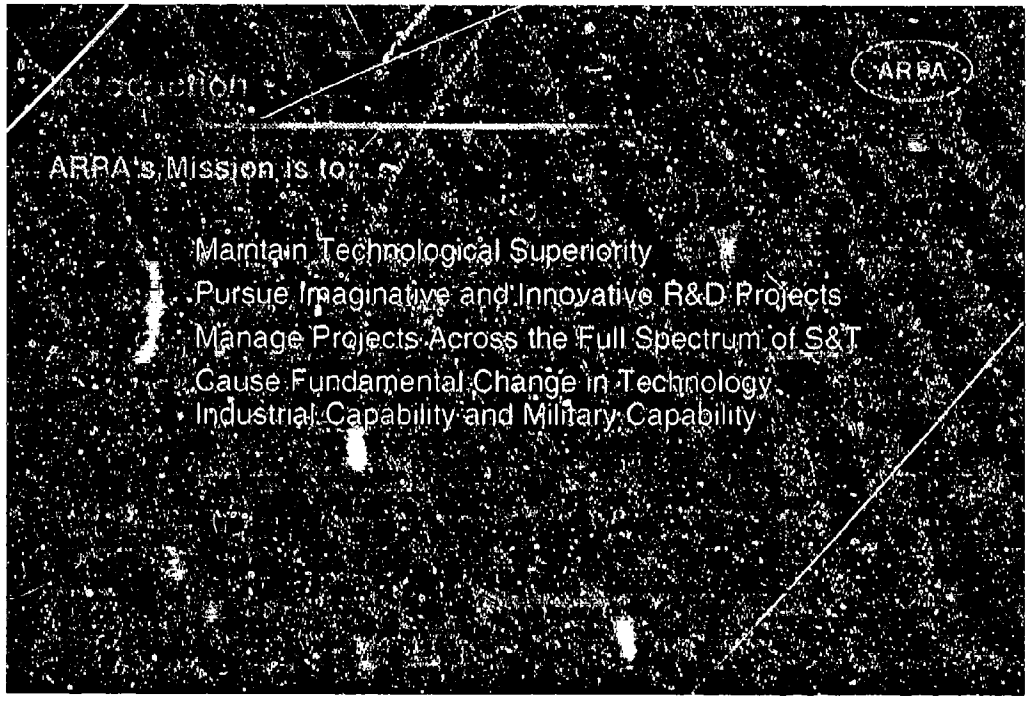


One thing that translates into for the science and technology program, is that focus on harnessing technology to deliver a capability and that means that we focus on not just developing the technology, but focusing on all the elements that are required to deliver that capability and today to deliver it affordablly to the war fighter. ARPA has been the major player in investing in manufacturing. Ialluded to that earlier. This end-to-end view that having to actually deliver a capability for somebody to use is a wonderfully focusing impetus and it leads you to ask the right kinds of questions of how do I actually get from here to there. Not just ask the question of what's the latest whiz-bang technology that might do something.

Let me close by thanking ARPA for inviting me to be able to talk to you. I'd welcome your comments on the science and technology strategy, I particularly welcome your help in acheiving the goals that we've set out there. Does it make a difference? Well, it makes a difference, not just to the DOD and I thought there was one aspect of this conference that I would call out to you, just in case you missed. ARPA is very good at arranging symposia, but I want to point out to you they have really gone a step beyond today. If you noticed in today's morning edition of the San Francisco Cronicle, on the front page, the banner headline says "Watch the news on your PC at Work" . One of the derivatives of an early ARPA investment in what came to be known as the ARPANET, which this year is 20 years beyond the time the first elements of it were put in place, here's CNN and Intel deliverying CNN to the PC in your work place. We at DOD are probably a prime, prime candidate for buying that. And that would not be there except for some early ARPA investment, that would certainly not be there today. Just in case you missed that and went straight to the business page, the banner headline on the business page is "Internet Advertising May Not Pay". It's a very interesting article, I commend it to you, again, we'll credit ARPA with the INTERNET existing as it does today and for them making the founding moves. The INTERNET server 20-30 million users. I read with surprise that it's 86% male, I don't understand that. I'm certainly an avid user.

The thing that is quite surprising, though the average age is 30.7 years, most of those people are student, faculty, and staff in the univeristy and if you're in the advertising business, that's not a good market. But it really gets worse, I really did find this an interesting article, but it really gets worse because they thought the WorldWide Web probably catalized by Mosaic was going to be the easiest place to spread the advertisting. That covers 56% of the users, I read with real trepidation th re's 94% male. Some one did a survey, this is not my number, I report what the Chronicle ays, but for the advertisers it really gets worse, they're in the 21-30 year old range and they REALLY d 't have any money to buy anything. So ARPA get it mostly right, but it's a long way to commerce because you've got to get the greyer portion of our economy on the Internet, but I think we'll get there. Thank you very much.

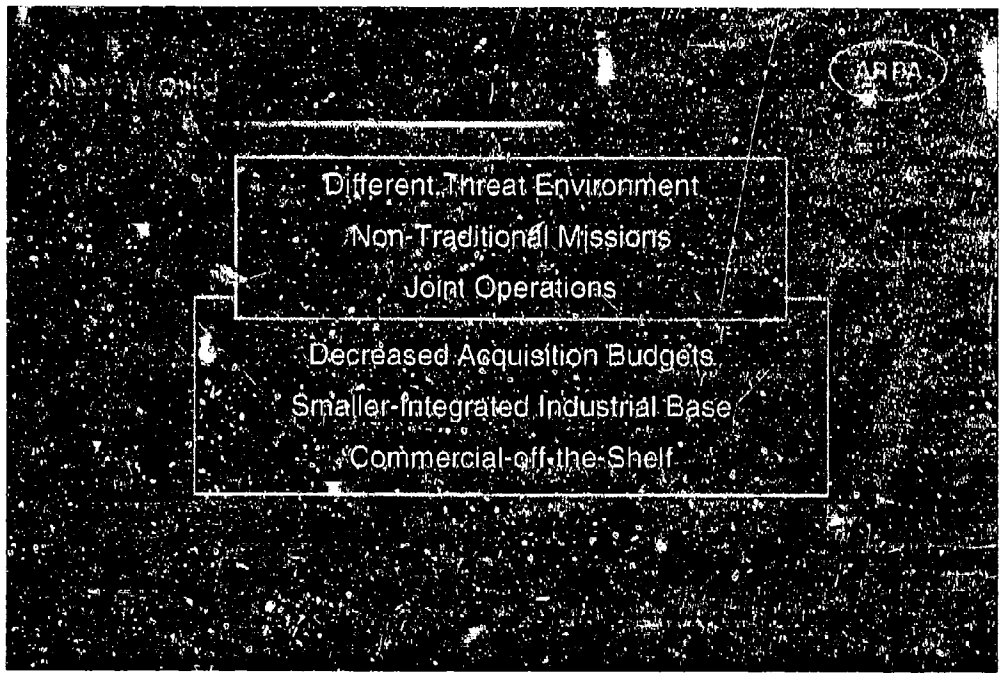

ARPA
Introductory Remarks
Dr. Gary L. Denman
Director



Welcome to the 17th ARPA Systems and Technology Symposium. To set the stage for three days of briefings that I hope you will find informative, it is appropriate to reiterate the ARPA Mission, which has remained essentially the same since ARPA's inception in 1958.

As the central research and development organization of the DoD with primary responsibility to maintain U.S. technological superiority over potential adversaries, ARPA pursues imaginative and innovative research and development projects having significant potential for both military and commercial applications. We are also chartered to support and stimulate a national technology base that serves both military and civilian purposes through technology sharing and collaboration with broad industry segments. Basic to our mission is a focus on scientific breakthroughs and revolutionary approaches which lead to fundamental change in DoD's ability to execute national security policy. The emphasis on fundamental change is vital to all ARPA projects.

We have a proud heritage of over 35 years of innovative technology development and transition. We have traditionally and will continue to undertake the challenging projects with potential high payoff--projects that will change the way DoD prepares and conducts missions in the future.

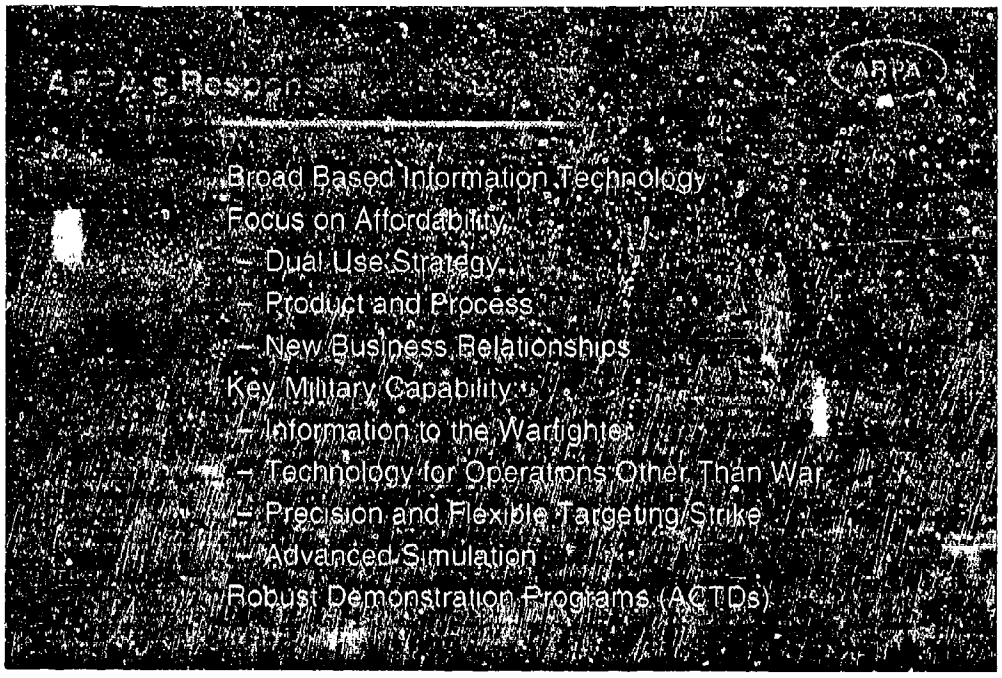


While our mission has essentially endured since 1958, the world continues to change. In the last 3 or 4 years we have seen drastic changes. The threat our forces must prepare for is very different and in many ways uncertain. Our military is called on to respond to non-tradtional missions such as peacekeeping and humanitarian assistance. The regional conflicts that our troops must face today, possible simultaneously, will be faced jointly with our allies, challenging our ability to train as well as plan and execute missions.

We must face the uncertain future with decreased budgets, fewer major weapon system procurements, and a smaller force structure. It is now more important than ever to find affordable ways to conduct effective defense. This is a primary challenge--and where a significant portion of our research is directed.

As the DoD downsizes so must industry. The challenge to industry is to consolidate or diversify toward commercial markets that will also be capable of serving defense needs. At ARPA we must encourage the development and transition of technologies that will enable industry to quickly produce and market products as commercial-off-the-shelf items that will significantly improve DoD's ability to acquire affordable products readily. Fostering an integrated military-commercial industrial base is an essential part of our strategy

The challenge to us all is to make the fundamental changes required to effectively respond to the new world.

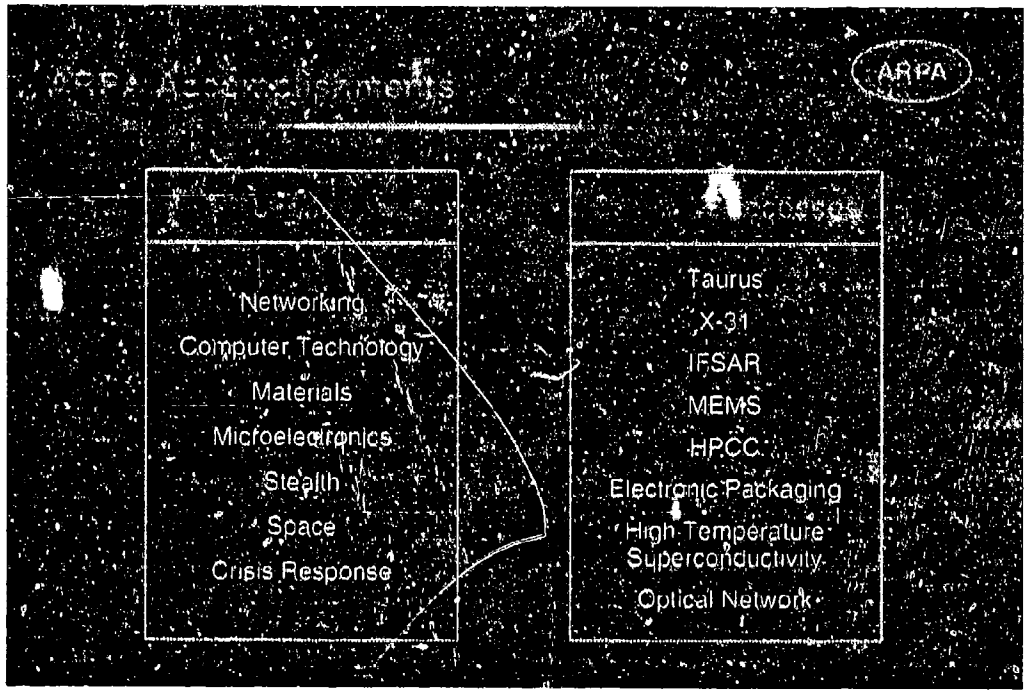


In responding to the new world order our number one investment priority is a broad based information technology program that will allow us to quickly ignite the advancement of ubiquitous information access and services. This afternoon we have an entire session dedicated to addressing our program.

We are also responding to the changed world by focusing on enabling affordable products. One part of this is our dual-use strategy that will ultimately allow industry to integrate commercial and DoD enterprises to in turn enhance the DoD's ability to procure the products it needs in a timely manner. In addition, our affordability focus encourages investments in both end products and new processes that will provide the capability we need to maintain technological superiority. New processes include management and business processes in addition to design and manufacturing processes. In the business area ARPA is experimenting with new ways of working with industry. We have been granted the authority to enter into agreements with companies, relieving unnecessary contracting burdens, eliminating non-value added activities, and enabling government and industry to define the way each party can work together most effectively.

We are continuing our focus on bringing forth key military capability, especially in bringing information to the warfighter, technology for OOTW, precision and flexible strike and advanced simulation. These areas will be addressed in several briefings over the next few days.

And, finally we will continue to maintain a goal of transition breakthroughs by demonstrating capability in robust demonstration programs.

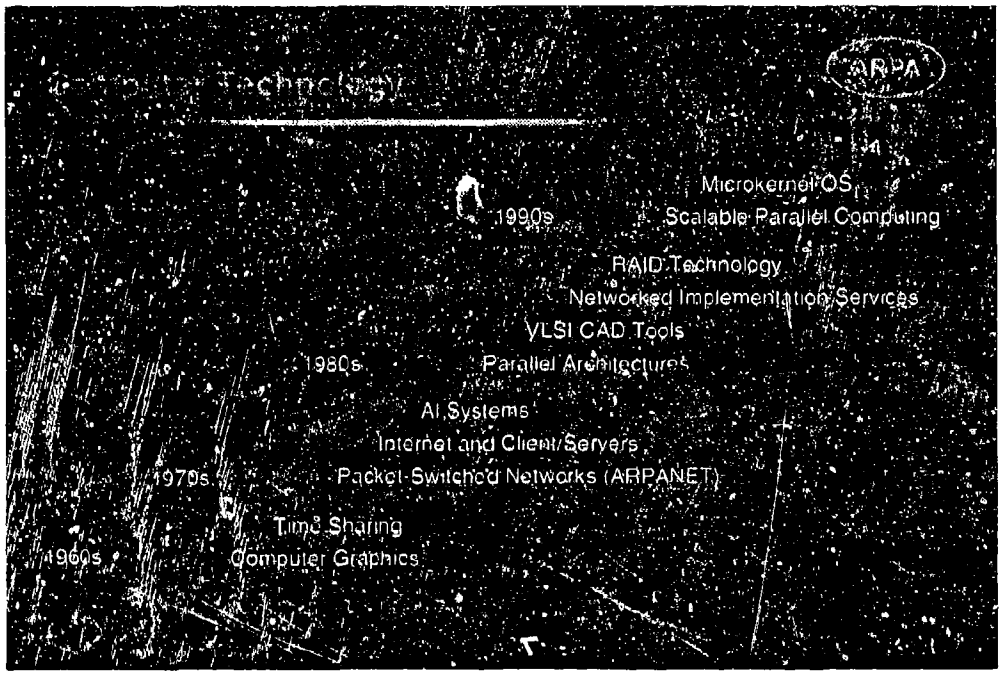


ARPA has a legacy of accomplishments over the last 35 years, resulting from its willingness to undertake challenging problems and the willingness to sustain the long term commitment necessary to find the best solutions.

The topics listed on the left of this slide are some of our long term successes. In many cases we can see entire industries that have emerged from our initial investments and sustained support.

The right side of the slide highlights some of our most recent successes. We continually strive to make a difference and accelerate technology innovation.

I will take a few minutes to relate a few stories in each category.

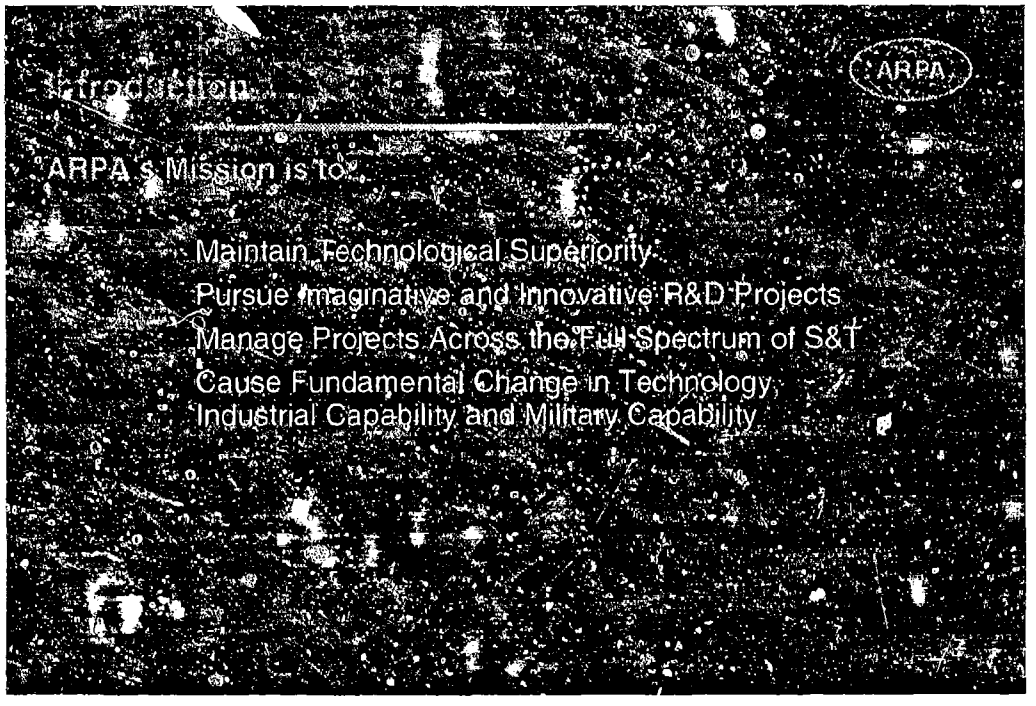


ARPA's sustained, strategically aggressive investments over the last 25 years in computing technologies have resulted in revolutionary capabilities for the DoD and the nation as a whole. The computing industry as well as the supporting industries that have emerged from many of ARPA's investments are too numerous to address in this forum. We can, however sight some examples:

- Cost-effective high performance architectures have evolved from our earliest RISC (reduced instruction set computing) research; scalable parallel systems are now being used in workstations, clusters of workstations and servers, and in even the world's largest supercomputers.

- Computer graphics technology, pioneered by ARPA over two decades ago, has evolved to innovative visualization technology and the creation of complex virtual environments.

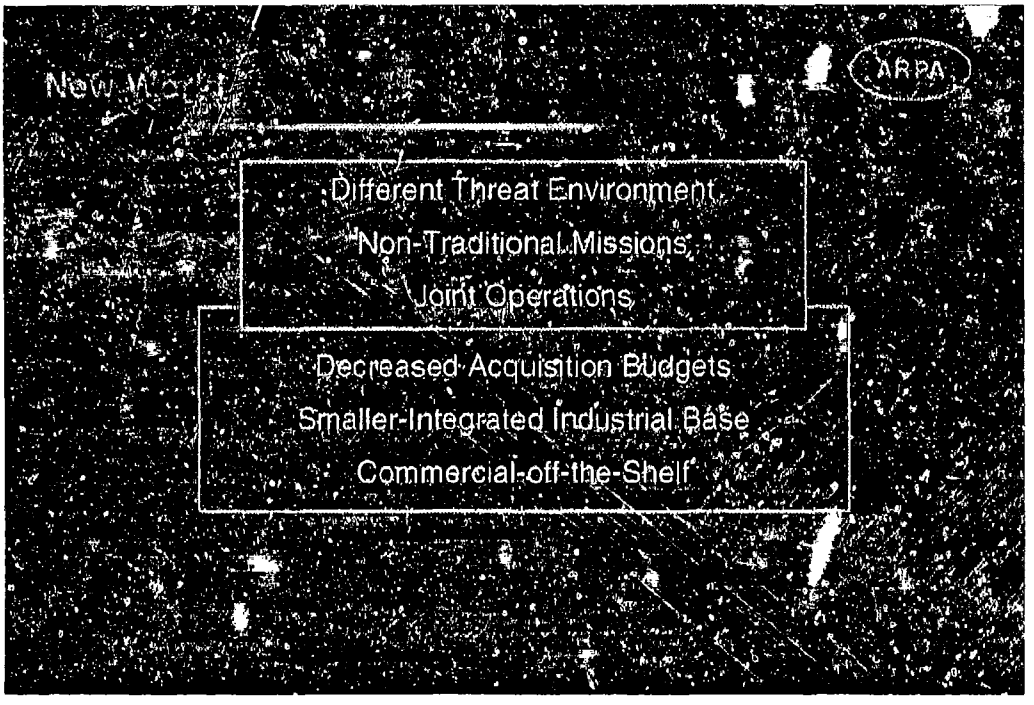
- Software technology in operating systems, compiler, library technology and parallel environments has evolved into important capabilities such as microkernel technology, distributed systems across local and wide areas, and approaches to architectural independent high performance software.



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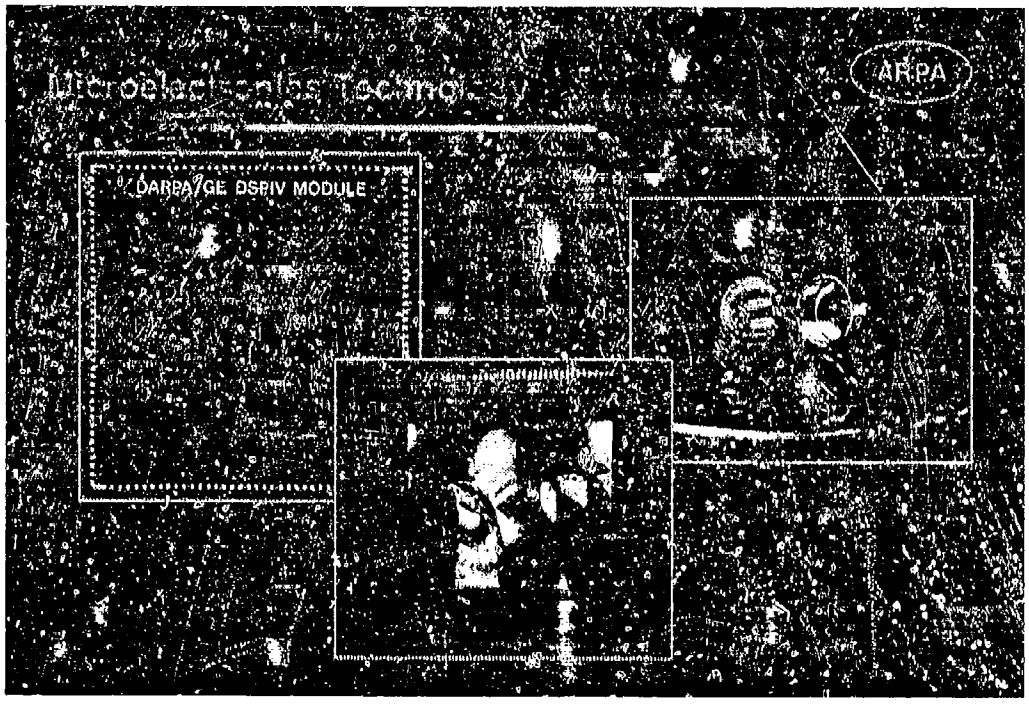


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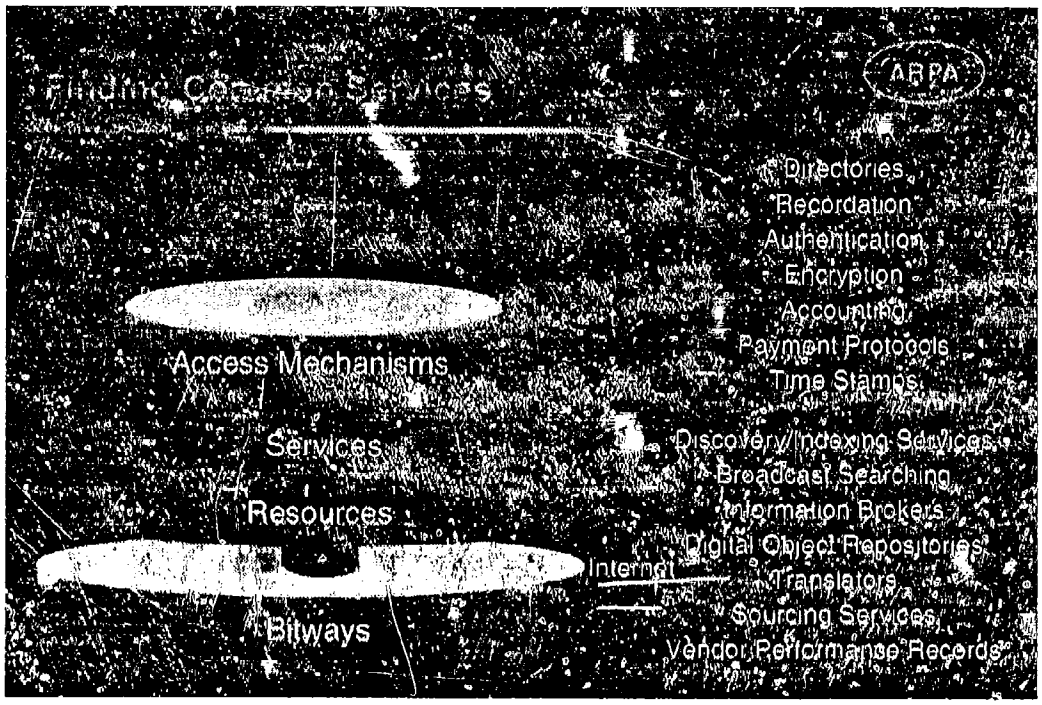
ARPA has made considerable investment in microelectronics in the last 10 years. Our greatest contribution has been in pushing the rate of innovation of microelectronic components through "infrastructural" efforts such as:

- MOSIS
- MMST
- Supreme

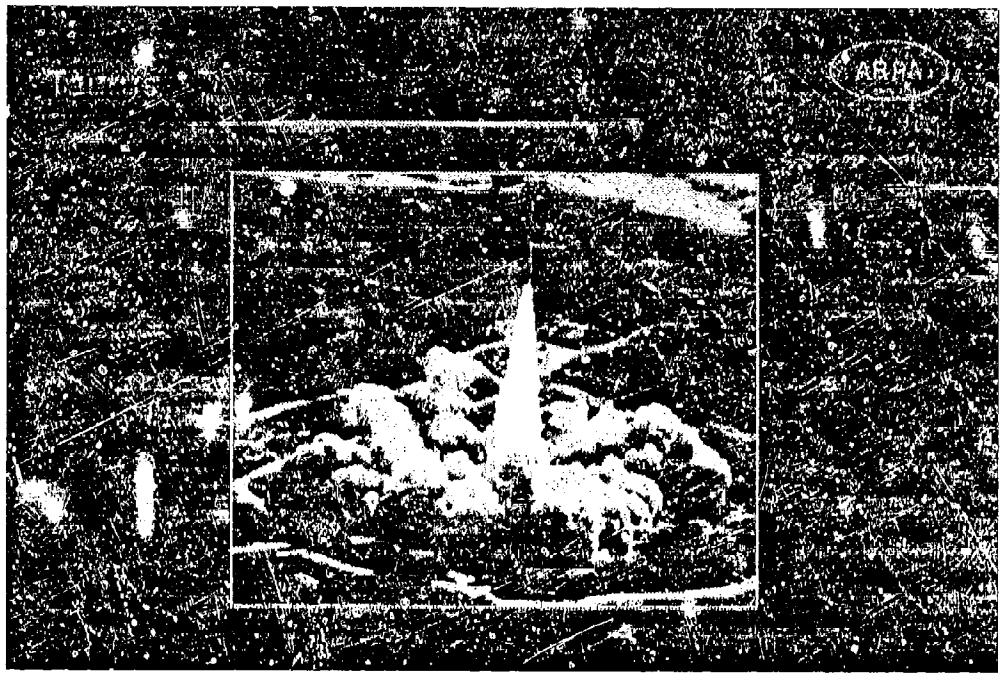
And a high profile and successful initiative

- Sematech

ARPA has also focused on specific technology and process development for enhancing military system capability. MIMIC and work in IR focal plane arrays fall in this area.

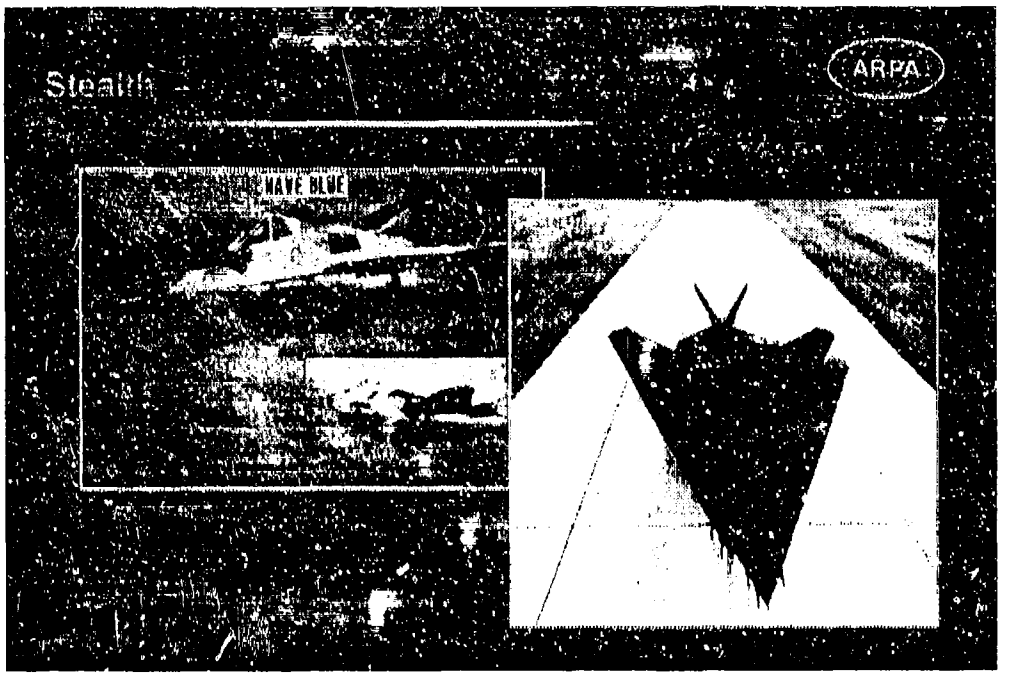


ARPA is working to understand the Information Infrastructure services layer. Activities are under way in areas such as: Universal Network Services, Integration and Translation Services, System Software Services, Data and Knowledge Management Services, Information Security Services, Reliable Computing and Communications Services



More recently we have seen a great success in the launching of the Taurus small launch vehicle. As a small launch vehicle, Taurus provides affordable, rapid launch capability for downsized satellites. It can deliver 3100 pounds into 100 nautical mile easterly orbits or 2500 pounds into 100 nautical mile polar orbits. On March 13th of this year Taurus successfully completed its maiden flight, placing two DoD satellites into low earth orbit.

A series of pathfinder demonstrations proved that a Taurus launch site could be established and a launch could be conducted within an equivalent of 8 days after equipment arrival and within 72 hours of encapsulated payload arrival. This rapid response of Taurus sets a new standard for launch base operations, significantly reduces "standing army" costs, and eliminates the need for expensive permanent launch infrastructures.



This chart depicts the Have Blue aircraft and the well known resulting operational F-117 aircraft. Today all major military aircraft since Have Blue have had stealth requirements in one form or another. ARPA efforts, in partnership with the Air Force, produced the first low observable aircraft. In addition, ARPA developed the first analytical methods to perform calculations of stealth vehicles, and ARPA's advanced material research contributed significantly to the advancement of stealth technology.

While the value of protecting vehicles, especially aircraft, from sensors (radar) was highly supported by the services, only ARPA could afford the risk to undertake the research and demonstrations necessary to lead to more survivable weapons systems with increased effectiveness. We are all aware of the great success of the F-117s in the Persian Gulf war.

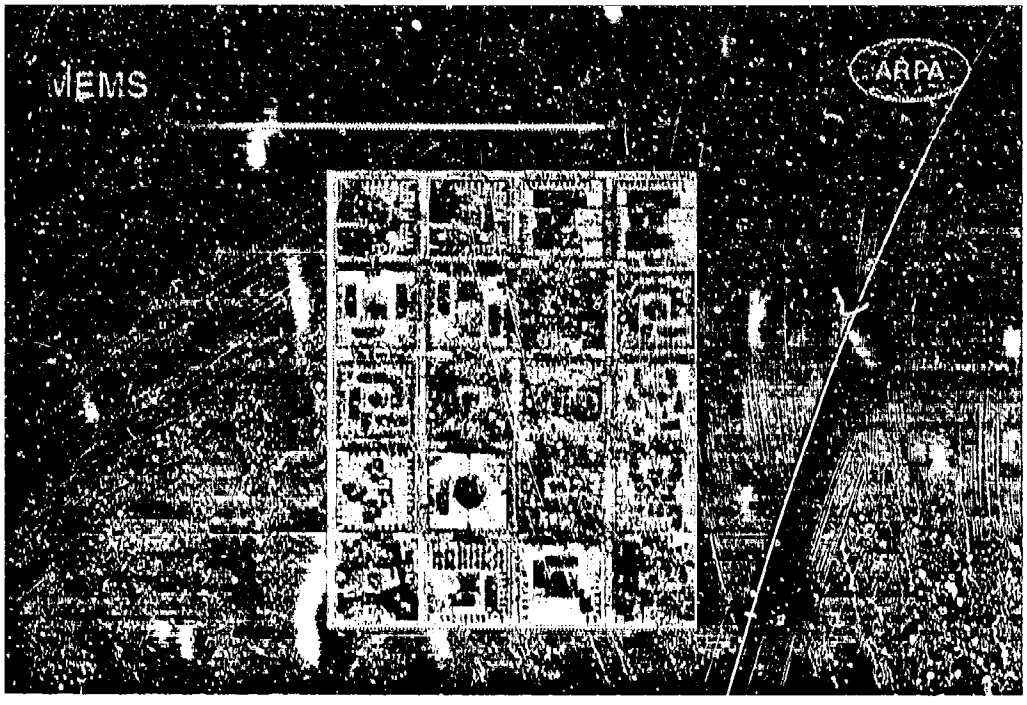


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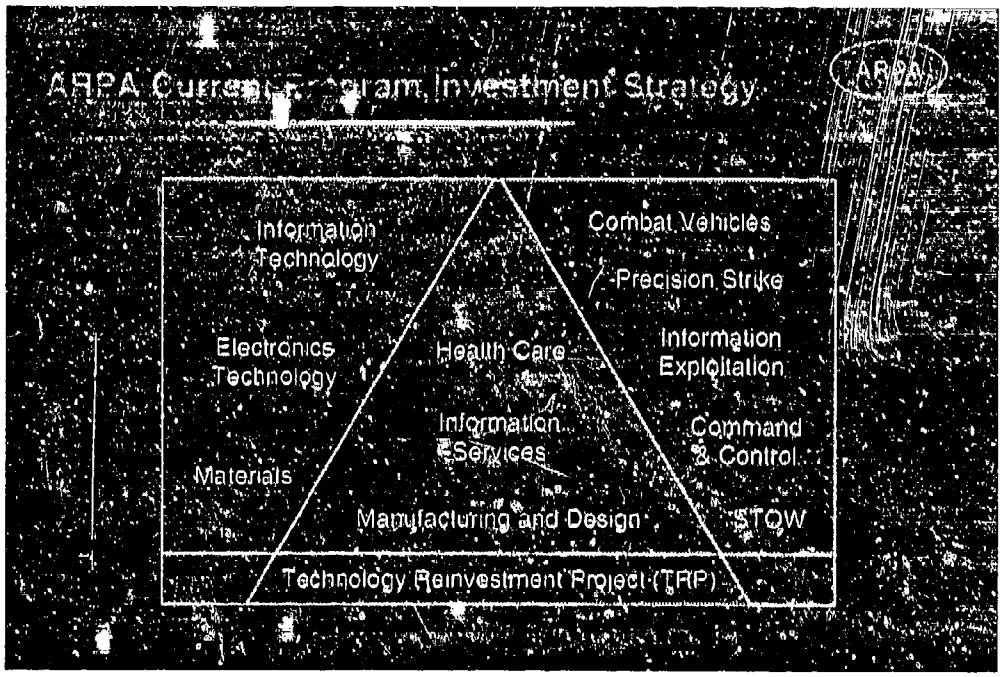
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The last current success I will address today is the establishment of an infrastructure for innovators of microelectromechanical systems or MEMS. MEMS are the enablers which will allow industry to leverage microelectronics fabrication for the purpose of making electromechanical devices for fluid sensing and control, optical components and displays, inertial measurement unit,s and so many other devices too numerous to mention.

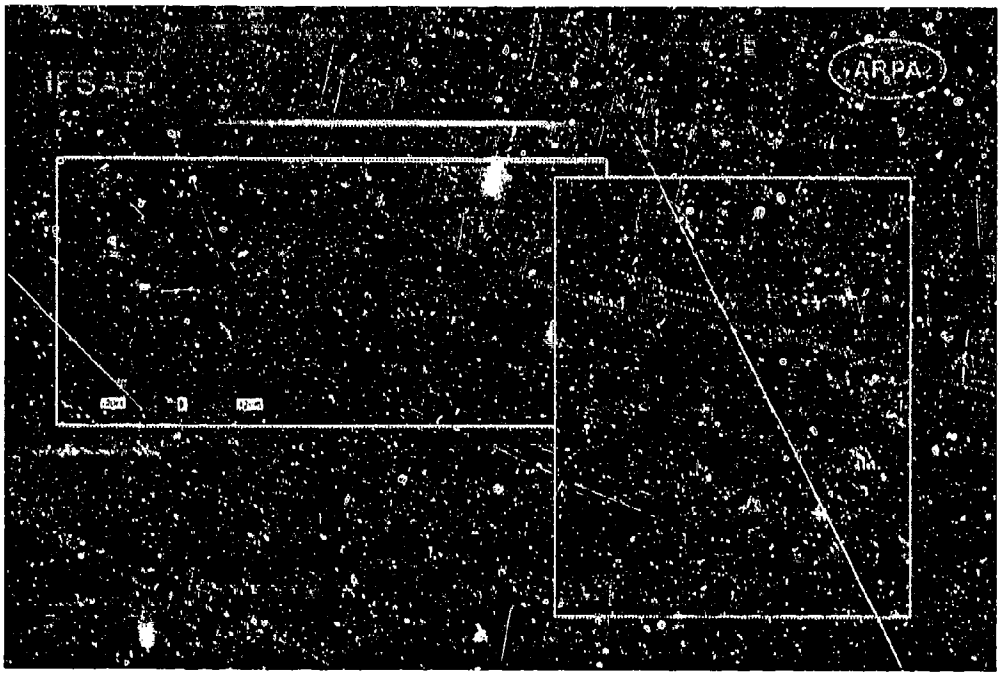
Depicted on this slide are 20 different MEMS devices that were produced in the last 6 months of this year. Five years ago MEMS was merely a laboratory technology and a curiosity. Today we are making relatively inexpensive MEMS fabrication services available to the general public.



Our successes are borne out of a clear strategy to make a difference. Today we are focused for tomorrow. Our research is loosely grouped into three categories: Core Technologies, Infrastructure and Military Systems. Core technologies are those technologies that provide the materials, electronics, software proces, computing, and components that are essential for meeting DoD systems needs. Today and in the foreseeable future, ARPA has made sustained investments in these areas and will continue to support these areas in order to develop and build the next generation military capability. By virtue of its nature, essentially all our investments in what we consider Core Technologies will serve to advance commercial products as well as military systems

Infrastructure refers to those technologies and capabilities that enable the DoD to produce its materiel and train and care for its personnel. The trend will continue to move toward a shared national infrastructure with greater reliance on the civil sector to support defense needs. ARPA will increase its investment on programs that can reduce the costs associated with the extensive DoD infrastructure.

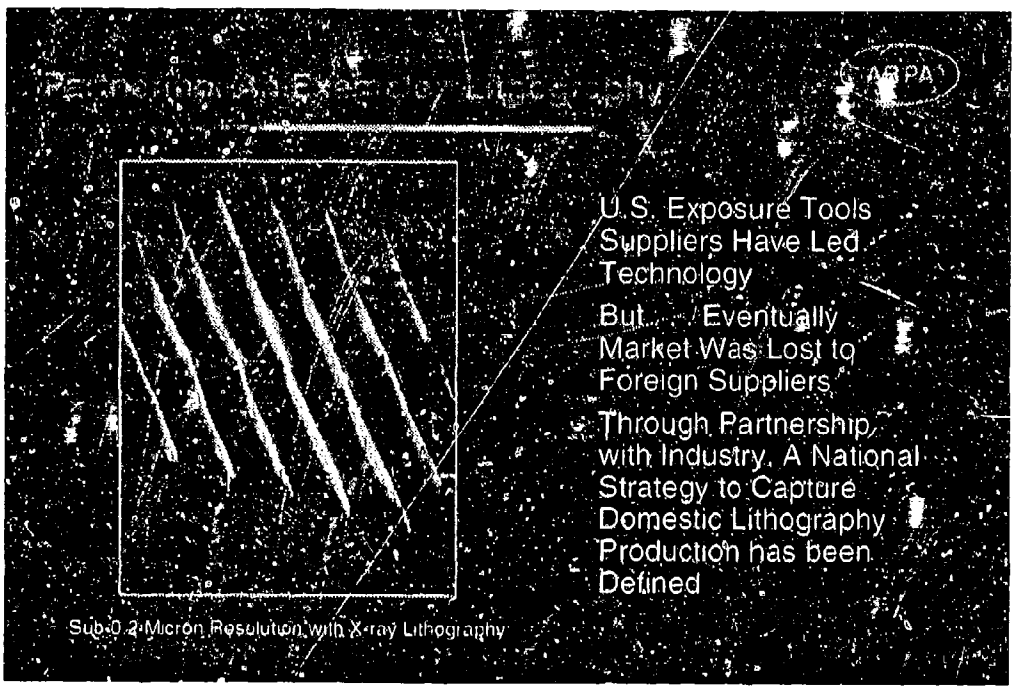
The final investment area, Military Applications, includes innovative technology development in support of improved, affordable military capability. Our main investments focus on combat vehicles, surveillance systems, command and control systems, advanced simulation, and precision strike.

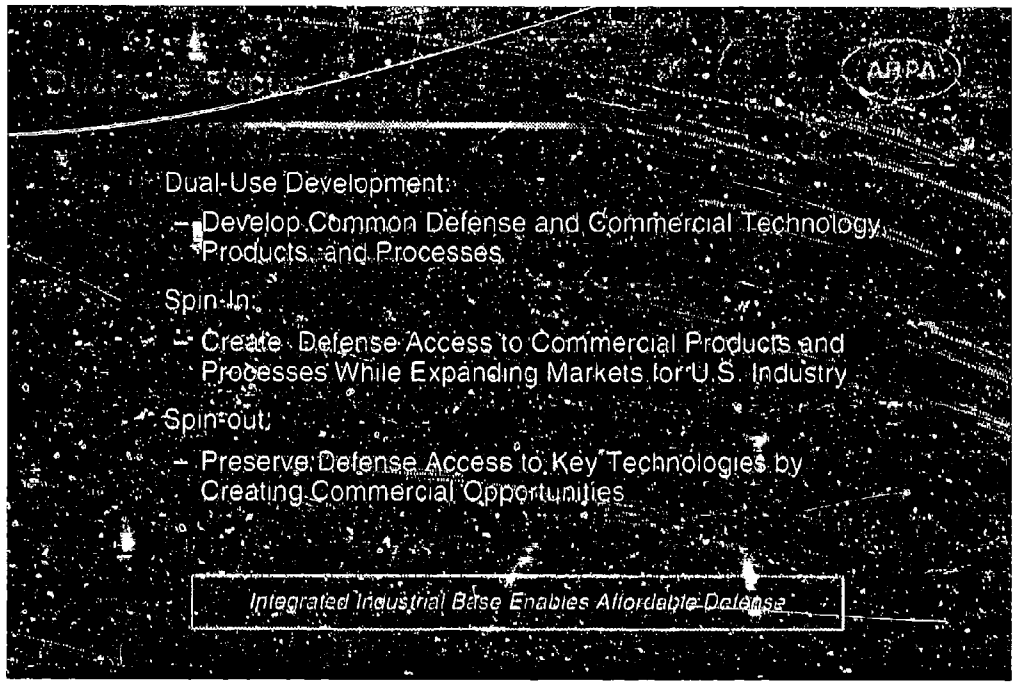


Another recent success is ARPA's Infrared Synthetic Aperture Radar (IFSAR) imaging capability. IFSAR fulfills both military and civil mapping needs. Using the ARPA/TEC quick reaction Learjet system we can now collect all-weather, low-cost, 3-meter accuracy digital terrain elevation data coregistered with SAR data. The processing time to obtain accurate ground truth is now hours versus weeks or months as is the case with competing systems.

The picture on the left shows the height difference between USGS and IFSAR digital elevation data from the National Training Center in Ft. Irwin, Ca. The data in this area were aligned and a post by post subtraction performed to obtain this difference map. The blue area depicts the portion of the USGS data where ground truth errors were relatively small. However, sharp edges at the boundaries of the USGS maps are clearly visible in the upper left hand side of the picture due to discontinuities in the USGS map edges. In addition, the larger errors shown in yellow and red in the mountainous areas indicate a horizontal offset in the the two data sets since the errors are consistently positive on one side of the mountains and negative on the other.

The picture on the right side of the slide is San Francisco and shows the Presidio, Golden Gate Park and urban areas just south of the Golden Gate Bridge. In this map blue represents water, green - forests, yellow - fields, and urban areas are red. The map was automatically classified from radar-measured attributes such as interferometric correlations coefficients, radar backscatter strength, pixel heights, and terrain slope.


ARPA
U.S. Exposure Tools Suppliers Have Led Technology
But... Eventually Market Was Lost to Foreign Suppliers
Through Partnership with Industry, A National Strategy to Capture Domestic Lithography Production has been Defined
Sub-0.2-Micron Resolution with X-ray Lithography



Central to our current and future planned investment is a focus on a dual-use strategy. We are investing in R&D in which the resulting products lead to simultaneous or complementary improvements in both defense and civilian products.

This dual-use strategy I see as having three components:

- Dual-use technology development
- Spin-out
- Spin-in

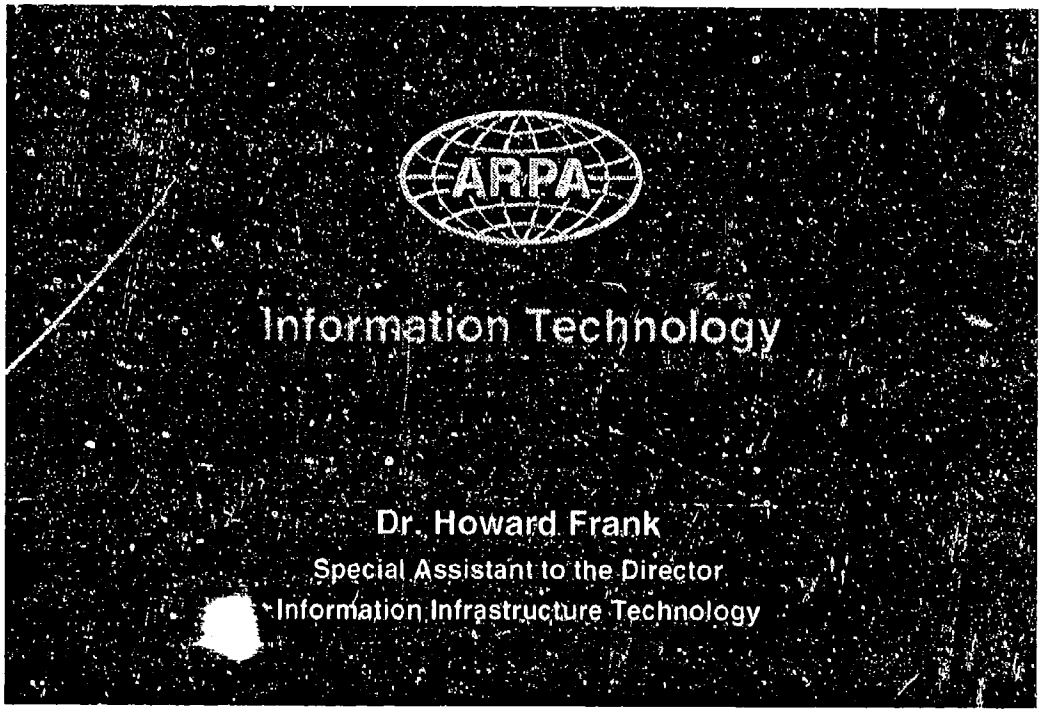
Dual-use technology development embraces almost our entire core program; it is the development of technologies that are required for both defense and commercial products. In addition to dual-use technology development, we are also concerned with creating defense access to commercial technologies or *spin-in* of commercial products for defense application. This "spinning in" of commercial products will increase the market for commercial products previously not targeted for defense. And a *spin-out* dual-use strategy seeks to preserve defense access to key technologies by creating commercial opportunities for defense products.

Taken together these dual-use components are one part of our affordability strategy.

ARPA has been Given a Critical Role in Maintaining the National Technology Base

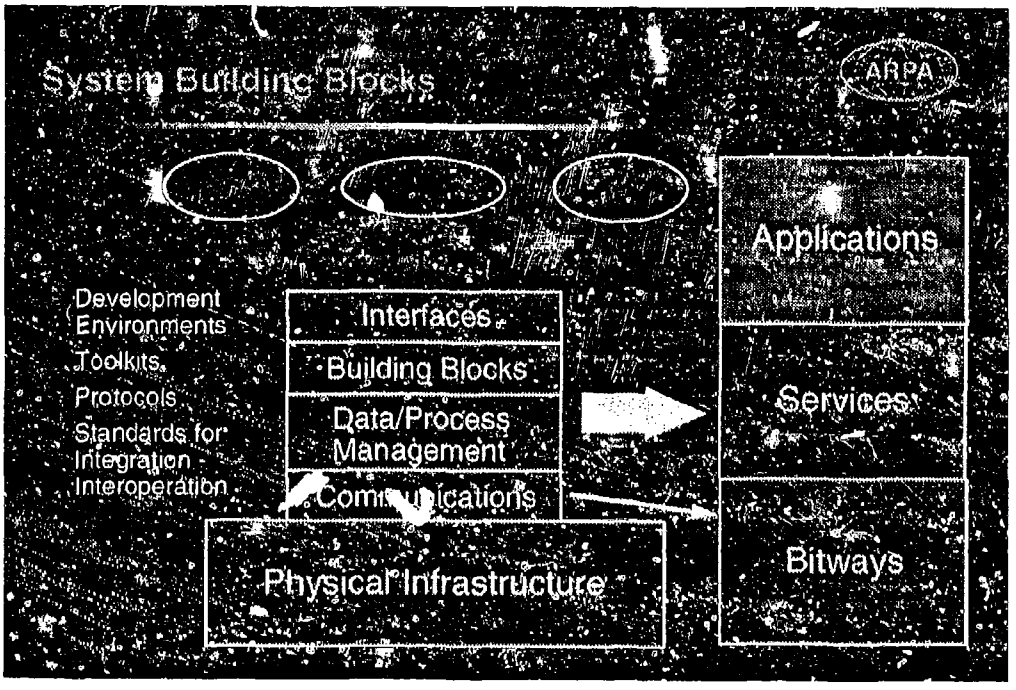
We Can Only Succeed Through Collaboration with Industry



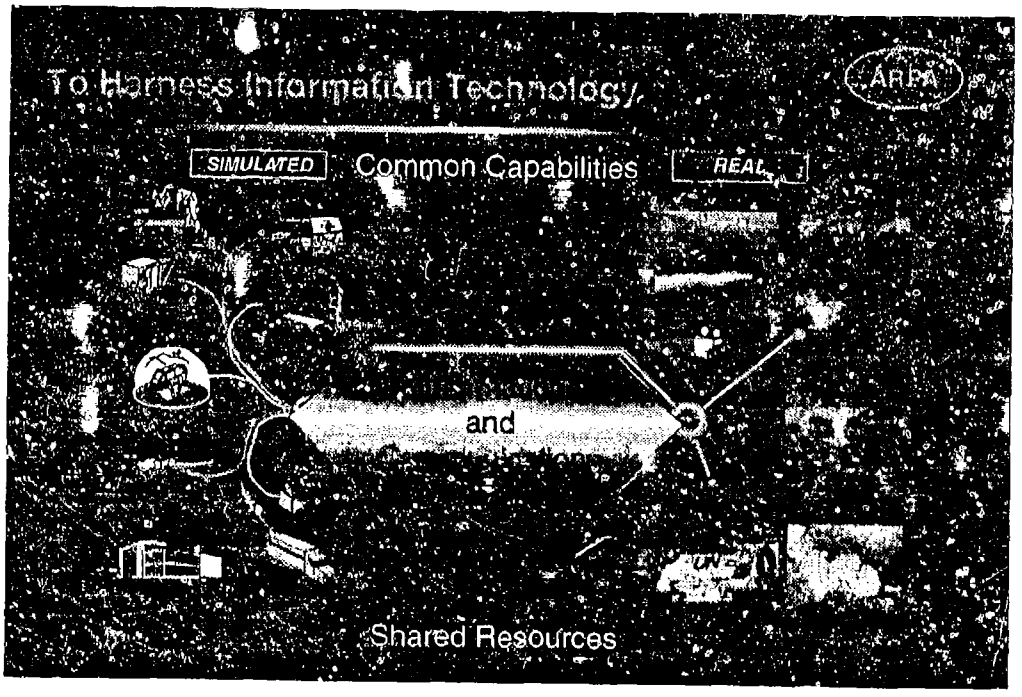


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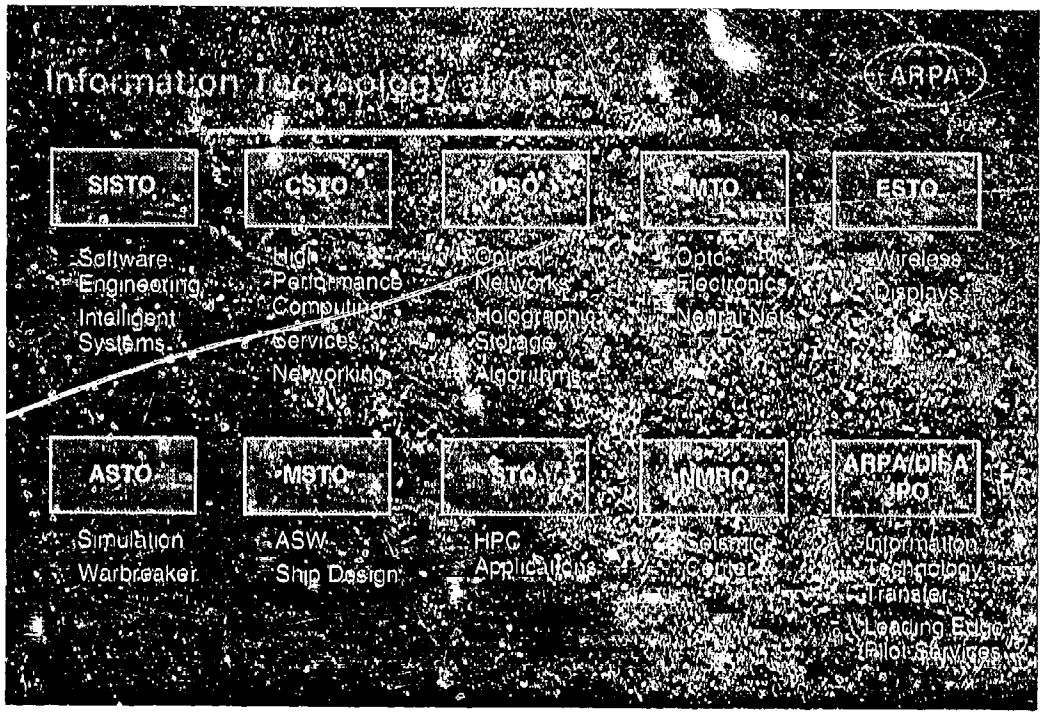
ARPA's Information technology activities are developing and integrating fundamental communications and computing technologies and infrastructure as well as automating key functions such as planning, decision making, and execution. The programs aim for rapid, user oriented, access to resources such as data bases, sensors, effectors, testbeds, anchor desks, mediators, associates, and computers. This enriched environment will expand human senses, extend our reach, amplify our intelligence, and increase our ability to do productive work. Achieving these capabilities will expand defense capabilities and the nation's information technology lead.



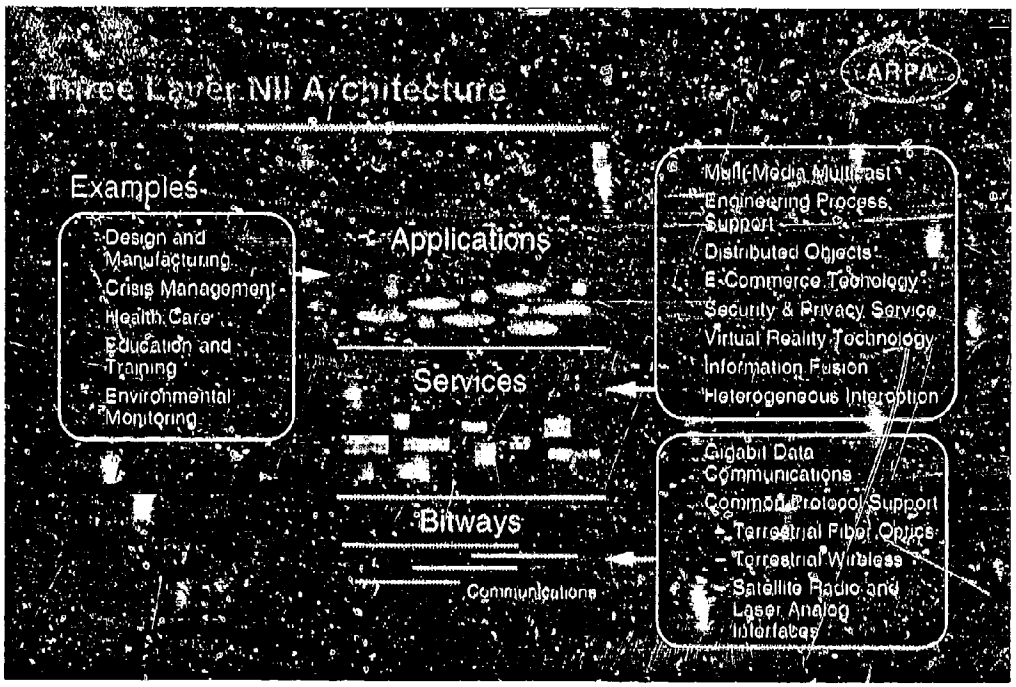
Modern information systems are built with building blocks. These include development environments, software toolkits, protocols and standards for integration and interoperation. These building blocks are often expressed in terms of a three layer architecture of applications (end user programs), services (building blocks from which applications are built), and bitways (communications mechanisms and technologies).



ARPA's vision is to harness information technology to expand human senses, extend our reach, amplify our intelligence and increase our ability to do productive work. Our programs our oriented towards creating an environment where the war fighter will be able to plan, train, rehearse and execute with the same tools and equipment using resources shared by either real or synthetic environments.



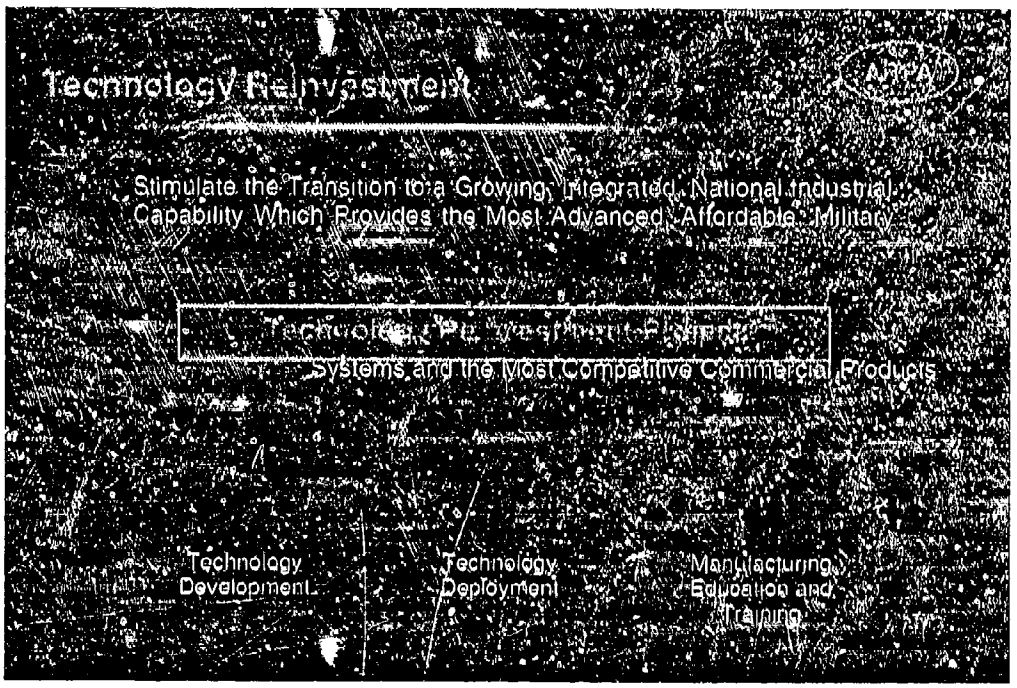
All of ARPA's offices are involved in information technology. The ARPA offices and their principle information technology activites are shown above.



The "Bitways" are the physical infrastructure - the collection of transmission channels such as fiber, cable, satellites and broadcast links and switching devices and computers which interconnect the channels into coherent communications and computing systems. The "Applications" layer represents the capabilities provided to the end user to address specific applications such as providing health care, manufacturing a product, dealing with a crisis, or educating a class of students.

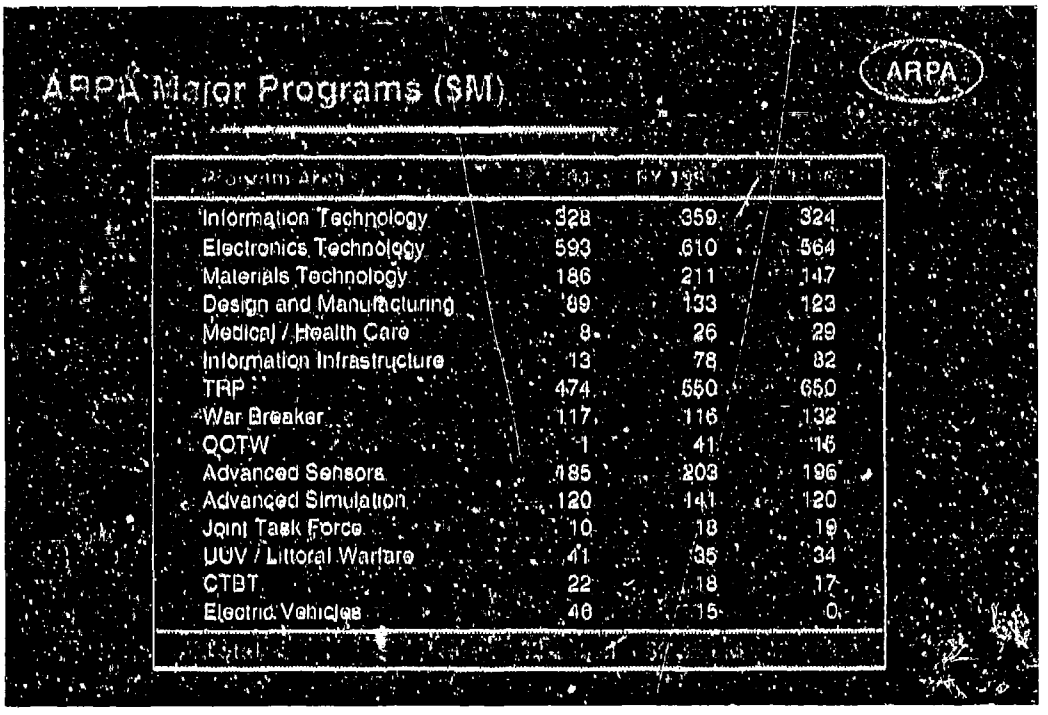
The "Services" layer is composed of those elements of the infrastructure that enable applications or manage the orderly flow of data through the system. Each of the three layers sustains a diverse base of technologies, supports a broad base of suppliers, and can continually increase in capability over time.

Services are the glue between the physical network bitways and the applications. Services provide data that can be accessed and shared by more than one application. Services manage the flow of data in the bitways, provide building blocks for applications, and provide the interfaces for displays, sensors, and other input/output devices. NII services provide capabilities for electronic creation and diffusion of information needed to satisfy a diverse set of applications.



One of the key changes in the ARPA program is manifested in the emergence of the Technology Reinvestment Program (TRP). We are now entering our third year of funding and beginning to see the first fruits of its initiation.

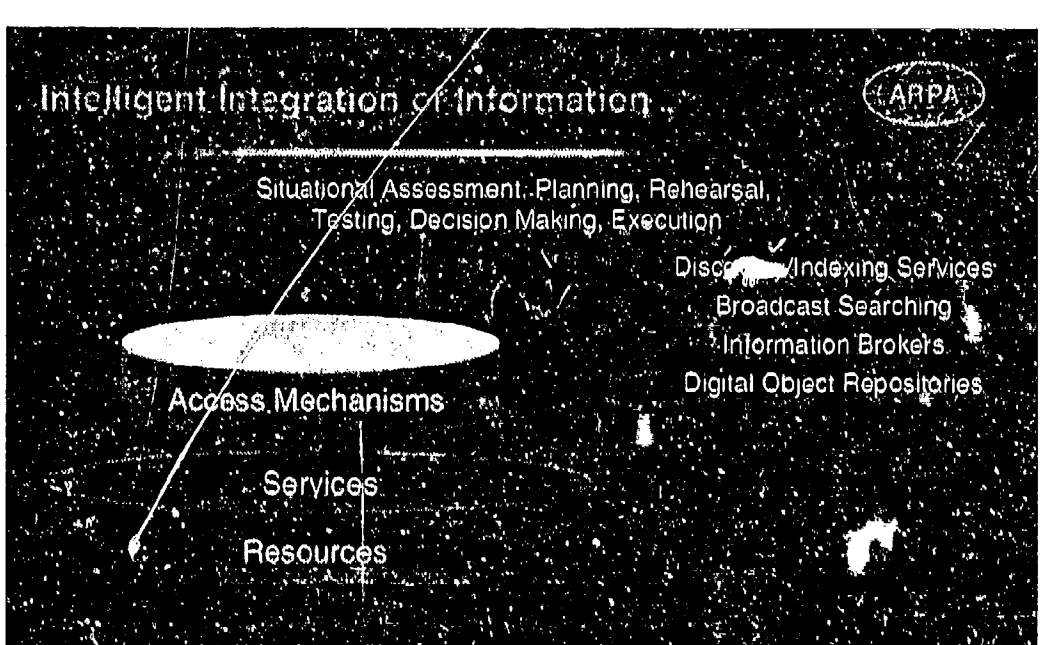
The goal of the program is to stimulate the transition to a growing integrated national industrial capability. To achieve this goal we have conducted two competitions to attain efforts in the three congressionally mandated areas of Technology Development, Technology Deployment, and Manufacturing Education and Training.



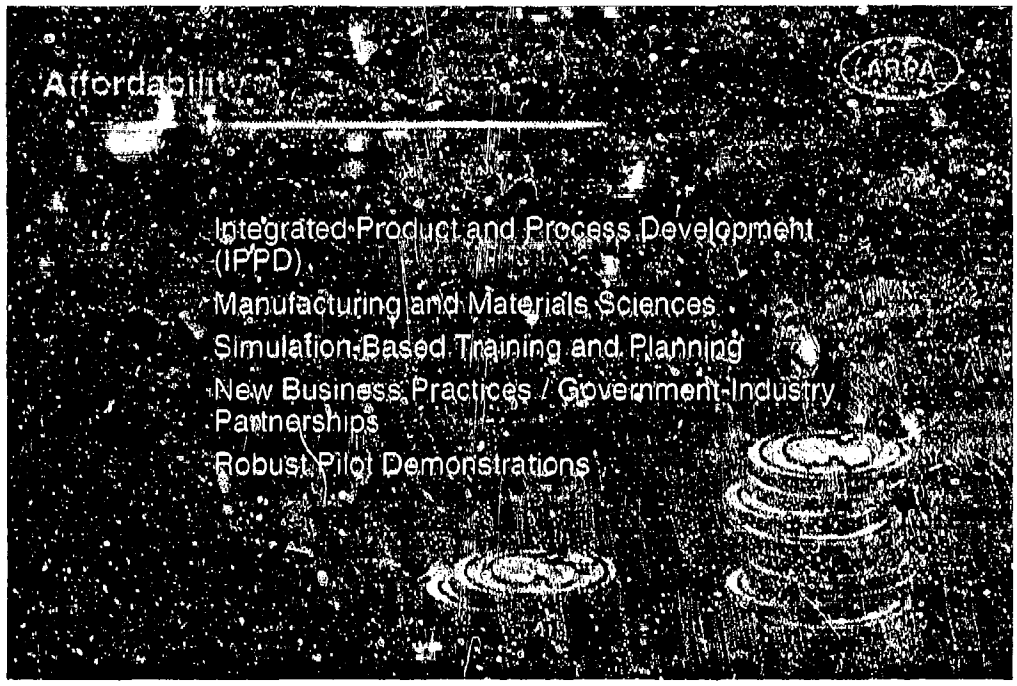
Program Area	FY 95	FY 96	FY 97
Information Technology	328	359	324
Electronics Technology	593	610	564
Materials Technology	186	211	147
Design and Manufacturing	89	133	123
Medical / Health Care	8	26	29
Information Infrastructure	13	78	82
TRP	474	550	650
War Breaker	117	116	132
QDTW	1	41	16
Advanced Sensors	185	203	196
Advanced Simulation	120	141	120
Joint Task Force	10	18	19
UUV / Littoral Warfare	41	35	34
CTBT	22	18	17
Electric Vehicles	46	15	0
Total			

Depicted here is our budget associated with the major program categories. While the DoD acquisition budget has declined significantly, DoD leadership has made a strong commitment to the future by sustaining a relatively constant Science and Technology budget.

The FY96 budget figures are preliminary and are subject to change. They are provided only to reflect ARPA planning.



The Intelligent Integration of Information Program seeks to apply the advanced software technologies to the problems of discovering, accessing, and utilizing information distributed throughout the infrastructure.



The elements that comprise our focus on affordability for future military systems are listed here. In addition to our dual-use investments we have undertaken several programs to support Integrated Product and Process Development (IPPD). These programs are bringing to bear critical cost driving elements early in system design to enable responsible performance-cost trades. Activities such as simulation based design are included here.

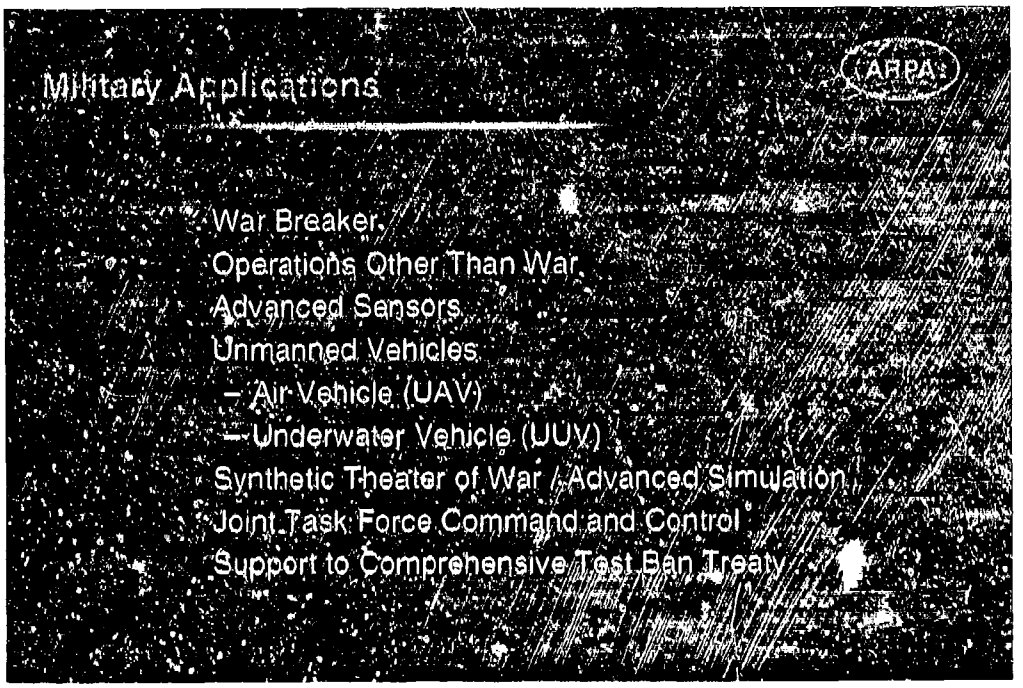
We have aligned our manufacturing and materials sciences research to not only expand the performance envelope, but to focus on ways to achieve affordable, lot size independent, higher performance products.

We see advanced simulation as a key enabler for reducing the exorbitant costs associated with training our forces, especially for non-traditional missions. These efforts also extend to improve planning.

Our ability to enter into agreements with industry is enabling us to experiment with new and innovative business practices-- explicitly aimed at reducing the costs associated with doing business with DoD.

More than ever, today we are undertaking robust pilot demonstrations with the objective of accelerating the transition of experimental systems into operational prototypes and operational systems. By pushing to field systems faster we can achieve marked cost savings.

Taken together, these elements of our affordability focus will foster DoD's ability to acquire the requisite military capability to meet our demands for effective defense in a changing world.



We have many investments in advanced development in support t of improved, affordable military capability. The investments focus on combat vehicles, surveillance systems, command and control systems, and precision strike capabilities. Applications cover the broad spectrum for military focused investments --from a component systems such as a radar, to a vehicle concept to a system created through the integration of assets designed to address complex military operations, processes and challenges.

Some of the major programs are listed here:

• The War Breaker program's goal is to support national and theater commanders with sensors that can locate time-critical targets, information processing technology that provides timely intelligence to enable forces to operate inside the strike cycle, and the next generation smart weapons that will enable a wide range of manned and unmanned strike options.

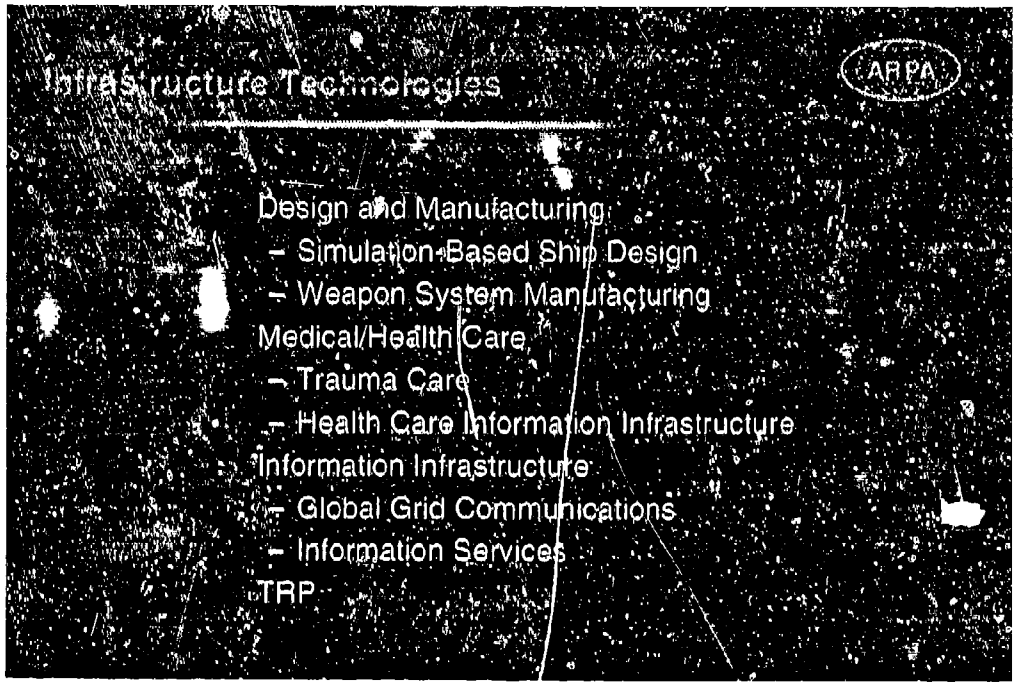
• ARPA's OOTW program supports military general operations and also provides potential dual-use technologies for the civilian law enforcement agencies. We have a comprehensive program to address operational shortfalls in poor situational awareness, slow information processing, inadequate surveillance of urban, night and jungle operations, vehicle/person identification, body/vehicle protection, and appropriate weapons for use in OOTW environments.

• We have several unmanned vehicle programs: Tier II+ and Tier III UAVs, and a UUV system. Tier II+ is aimed at developing an affordable high endurance vehicle for reconnaissance and targeting. Tier III is a high altitude UAV with low observables to improve survivability in high threat environments. The UUV program is focused on clandestine mine hunting and neutralization operations in shallow water

• The STOW development is the lead element in ARPA's ADS program which is designed to exploit rapidly evolving communications, software, and computer technologies into a simulation-based system which will significantly alter the the way the DoD acquires, trains and operates in time of crises.

• The JTF is a system of distributed collaborative computing that provides information needed by the JTF commander and staff. The vision is to provide information support anywhere in the world and at anytime it is needed. The focus is on distributed collaborative information technology that can support both situation assessment and planning.

• In support of the CTBT ARPA has been given the responsibility for the development and demonstration of a global monitoring system. This system involves networks of sensors, including ultra-sensitive seismic arrays, radionuclide detectors, and hydroacoustic systems. The heart of this system is a prototype International Data Center which automatically searches the integrated monitoring networks for signs of a nuclear test



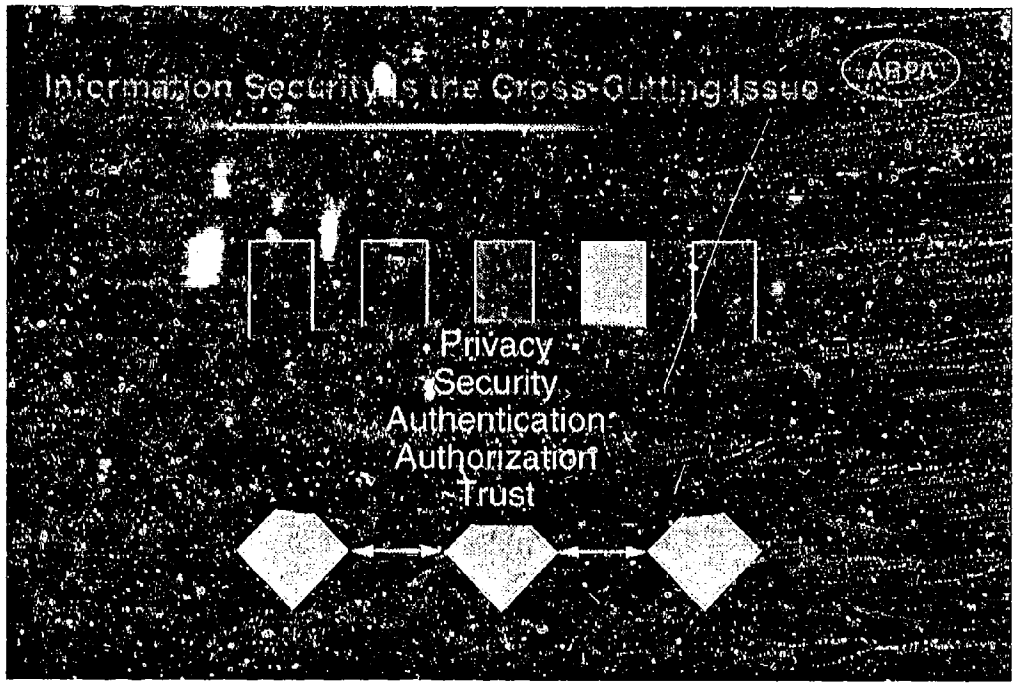
With the draw down of forces and decreasing defense budgets there is a critical need to invest in R&D that can make the DoD infrastructure effective, efficient, and affordable. The trend will continue to move toward a shared national infrastructure with greater reliance on the civil sector to support defense needs. Our investments include design and manufacturing, health care technologies, and information infrastructure technologies.

In design and manufacturing technology efforts our goal is to invest in technologies that will reduce product life cycle costs. We are developing and demonstrating integrated Computer Aided Engineering/Computer Aided Design workstations leading to integrated product and process development (IPPD) for ground vehicle and ship systems. In weapon systems manufacturing we are demonstrating the ability to substantially reduce cost and schedule of high performance electromechanical devices such as missile seekers.

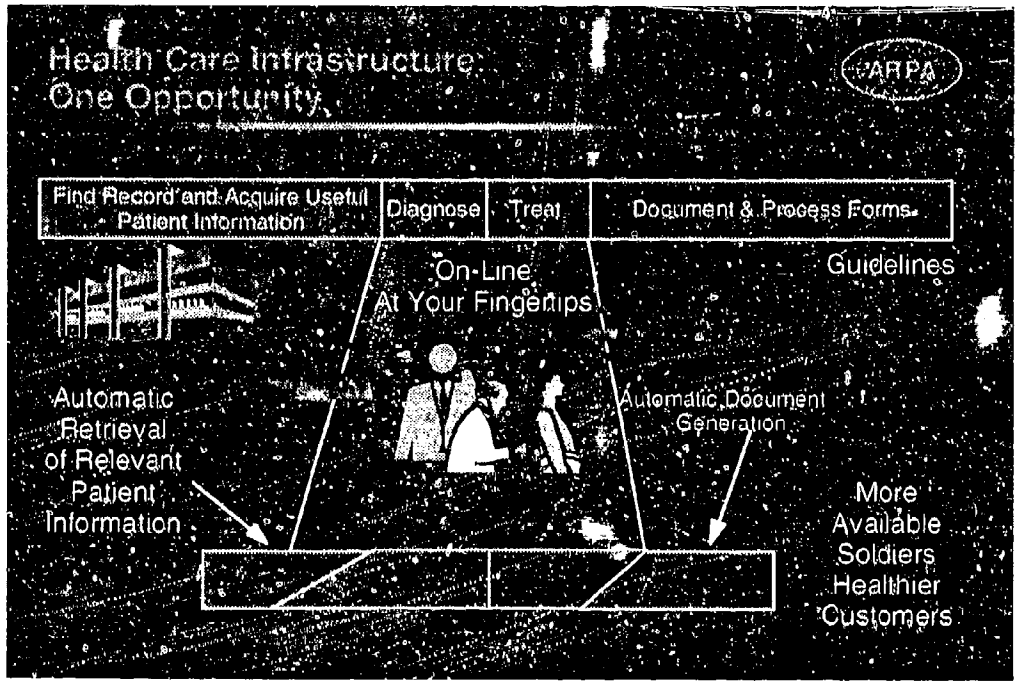
In health care we are focused on battlefield combat casualty care and a synergistic effort for a health care infrastructure. Our goal is to enable remote diagnostic and imaging capability, telesurgical mentoring, and remote telepresence medium. The health care infrastructure program is enabling the transfer of critical information in the battlefield through the development of a clinical associate that will connect proactively to medical and health knowledge bases to support its users.

In information infrastructure we are investing in a number of network research efforts to develop proof-of-principle demonstrations, generally in the form of advanced network testbeds in cooperation with industry, to accelerate the transition into affordable commercial-off-the-shelf products and services for end users. Information privacy and security will be a key part of these investments.

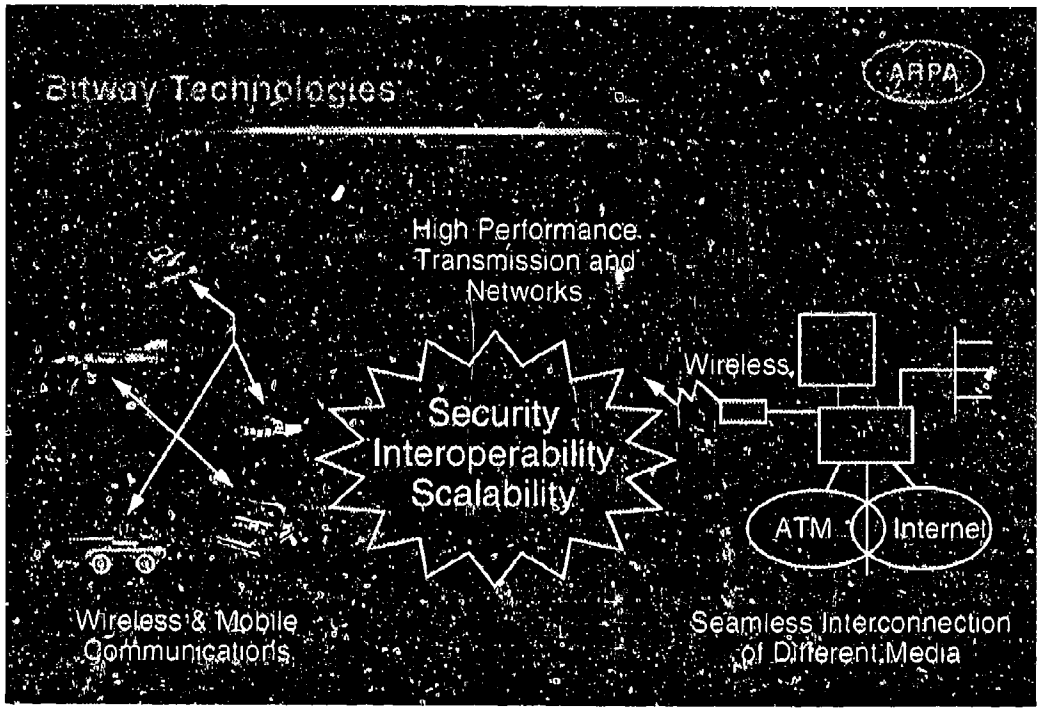
And finally, the Technology Reinvestment Project (TRP) is specifically aimed at stimulating the integration of a defense and commercial industrial base that will significantly enhance the ability of DoD to obtain infrastructural products and services affordably.



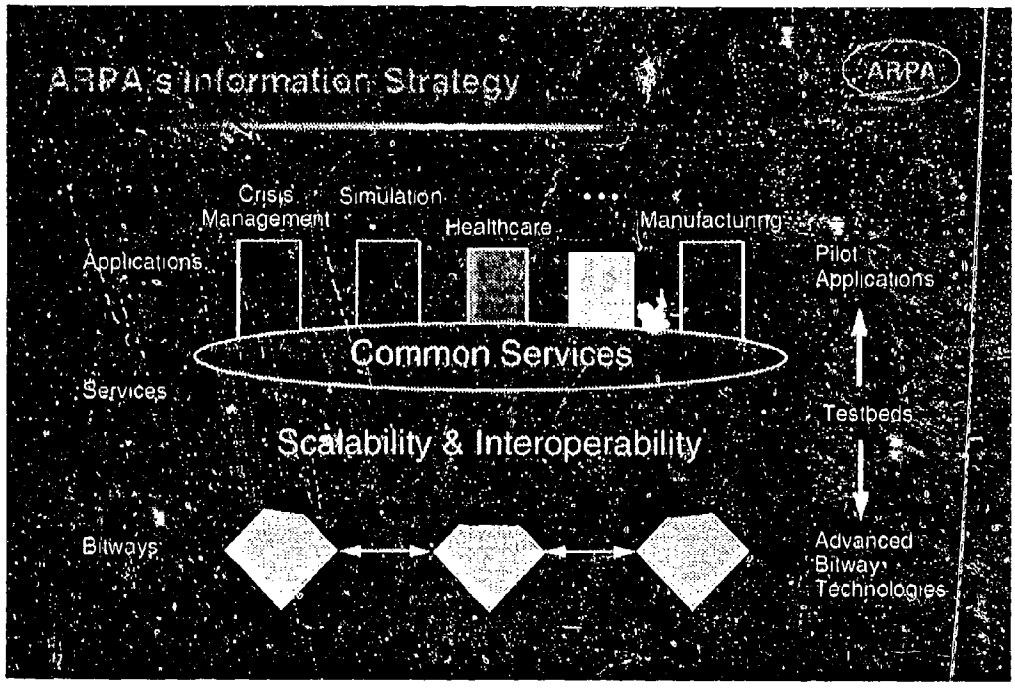
Security is the single cross cutting issue that will determine the ultimate success of the vision of a National Information Infrastructure that can grow into a seamless web of communications networks, computers, data bases and consumer electronicswhich places vast amounts of information at user's fingertips.



The Health Information Infrastructure Program is using advanced software technology to extend the available window available for doctors to diagonse and treat patients.

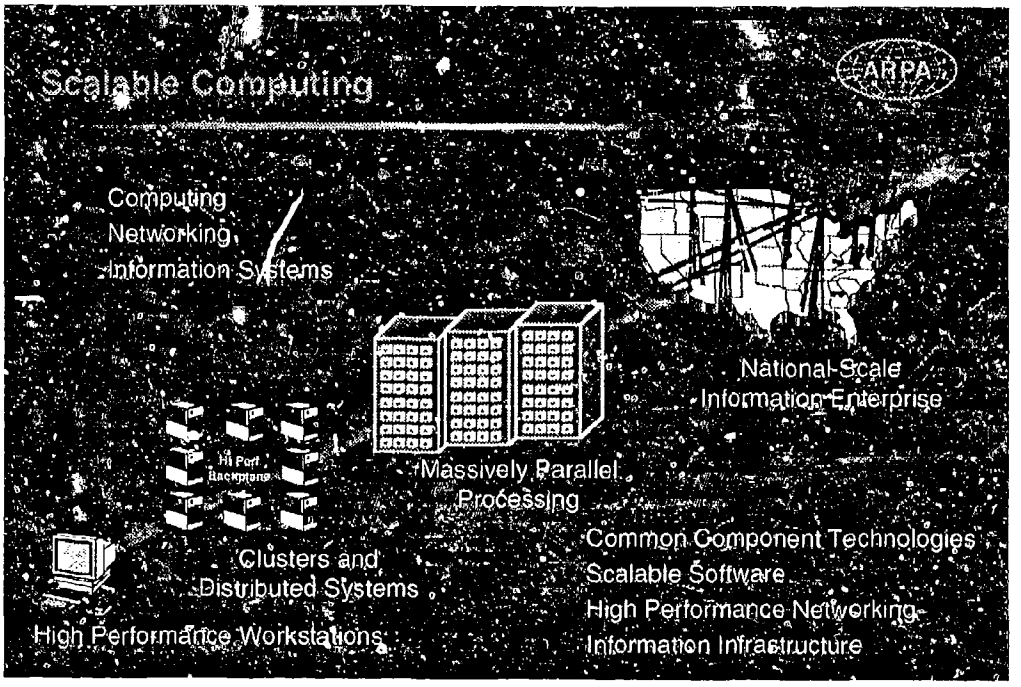


ARPA's bitway programs cover many issues. In some programs, ARPA is looking to leverage technology to find order of magnitude improvements in the basic performance of networks. These efforts cover electronic and optical systems and the data handling, switching and protocol issues associated with tieing physical information channels together. In other programs, ARPA is considering the future of networks where possibly millions of wireless and mobile nodes may be tied into an fixed systems. In still other programs, ARPA is creating technology to seamlessly interoperate between networks built from different media and technologies.

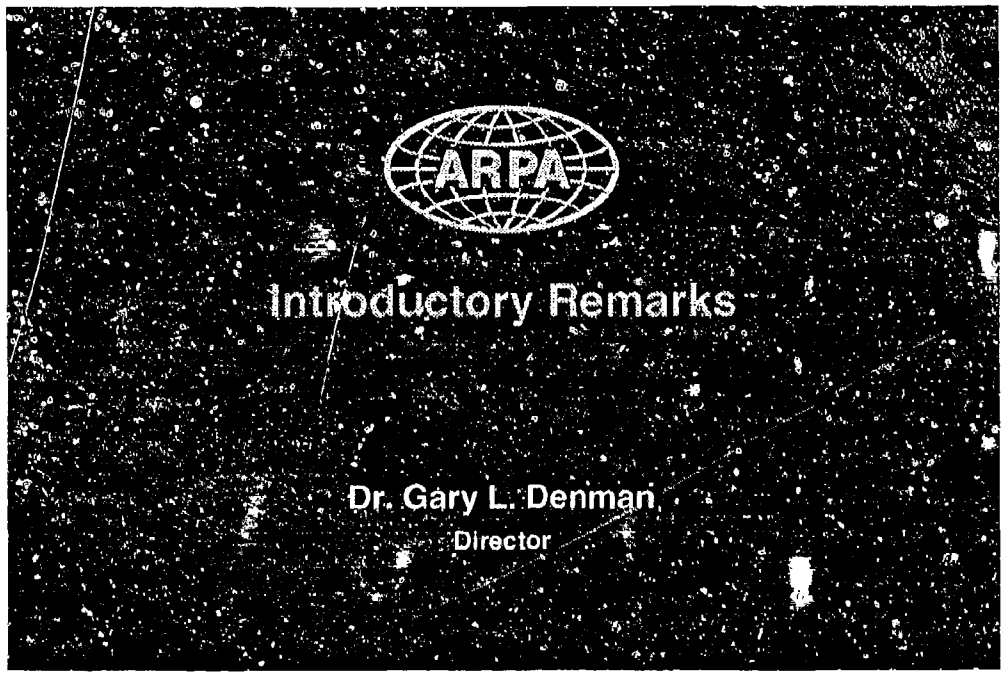


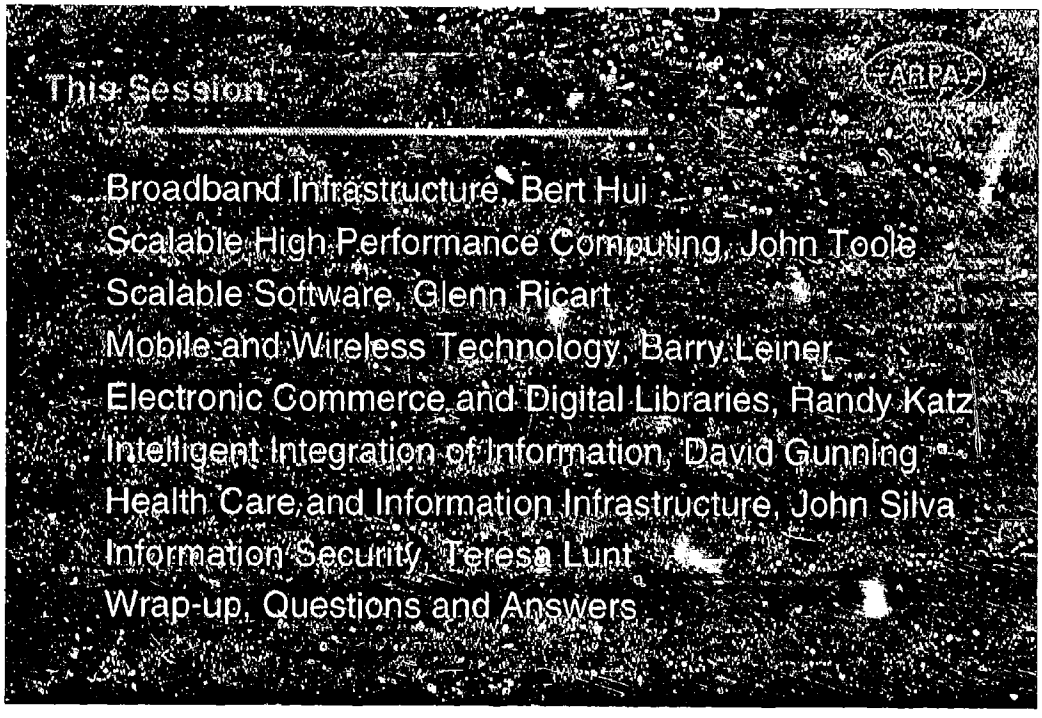
A key impediment to the growth of information infrastructure is the time and cost required to develop applications. While developers have shortened the development cycle by building software that is more modular, reusable and interoperable, the dream of being able to develop software efficiently is far from realiz tion. An even more difficult problem will be to interface newer applications with the older, legacy applications of the past.

A problem of significantly greater proportions is inherent in the explosion of applications and services made possible by the propagation of computing and communications. This is the prospect that the NII may develop along lines where developers create multiple systems and applications that cannot interoperate. ARPA's research programs aim to create an environment of scalable, interoperable bitways and services upon which applications can be built.

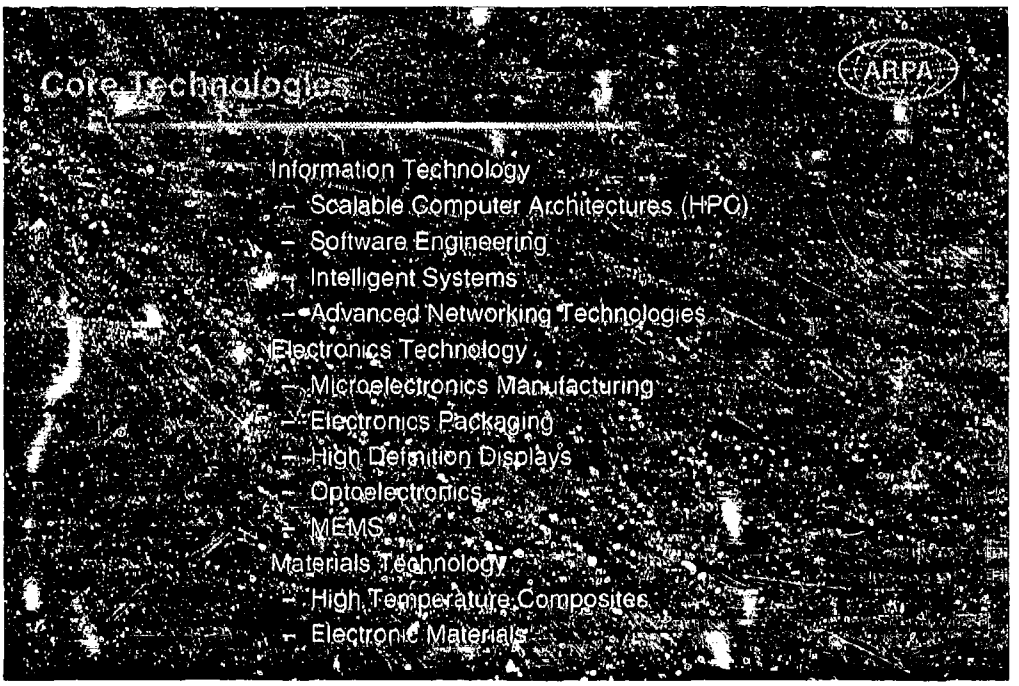


ARPA's Scalable Computing Program is creating technologies to develop common component technologies and scalable software to enable an expandable r[illegible] of capabilities ranging from high performance workstations that can be applied in command and control situations to massively parallel systems for solving computation problems of national scale.


ARPA
Introductory Remarks
Dr. Gary L. Denman
Director



These are the presenters in the session.

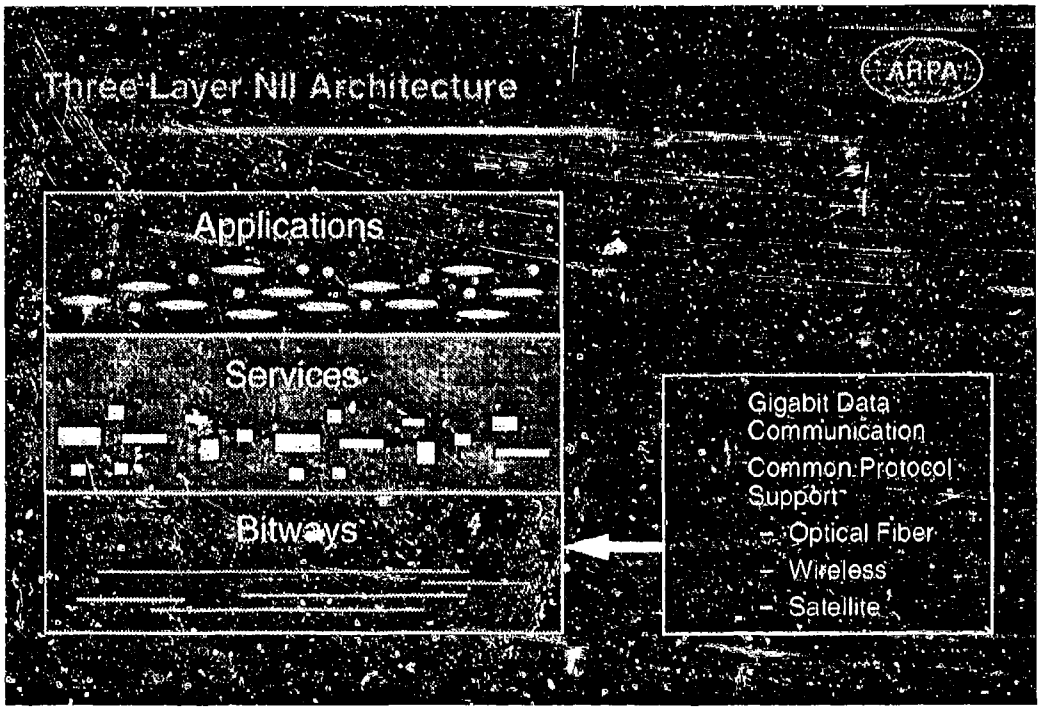


Our efforts in Core Technologies are focused on information technology, electronics technology, and materials technology. In information technology our strategy is to create enabling technologies for a wide range of application including simulation, design and manufacturing, health care, precision strike and many other areas. In the High Performance Computing (HPC) program, where the creation of a scalable computing technology base represents a a paradigm shift from sequential processing into a new use of parallelism, we are developing high performance computing elements that can be arrayed and scaled to achieve ever higher levels of performance.

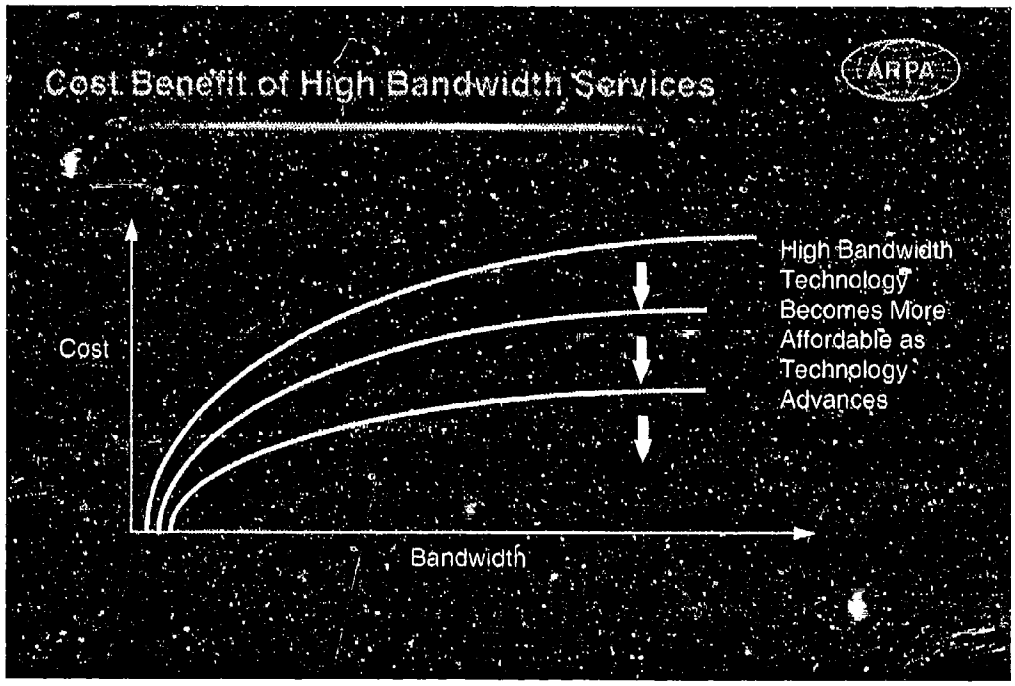
We are also investing crucial support in software technologies that will significantly improve our capabilities to cost effectively acquire, deploy and maintain operational software systems. Our research in intelligent systems is aimed at enabling intelligent systems development for assisting humans in solving complex problems in both military and commercial domains such as command and control and autonomous vehicle control. And also, as part of our information technology efforts, we are developing advanced network technologies that will enable the interconnection of HPC systems.

Supportive of our investments in information technology are the numerous investments we have in electronics technology. The goal of our electronics technology program is to develop the capabilities necessary to produce smaller, lower power, more mobile, and more affordable defense and commercial systems. MEMS, electronic packaging, High Definition Displays, optoelectronics, as well as manufacturing process technology are all part of this program.

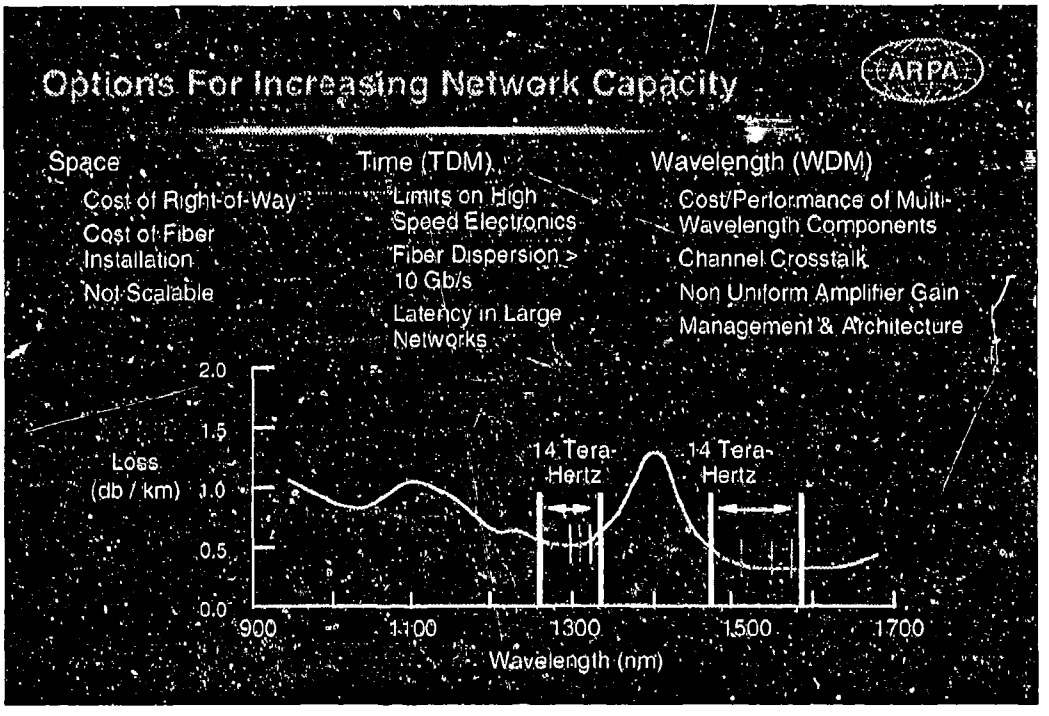
We are also investing in materials technology for improved manufacturability and performance of materials that will have the highest payoff for military systems. This includes both structural materials especially composite, and electronics materials. Our efforts in composites concentrate on achieving affordability in processing and manufacturing as well as improving the physical performance in terms of strength to weight durability, thermal capability, and geometric tolerances. Our investments in electronics materials are focused on improving manufacturability, reducing size and weight, increasing speed, reducing system complexity, and lowering cost for electronic and optoelectronic components and systems.



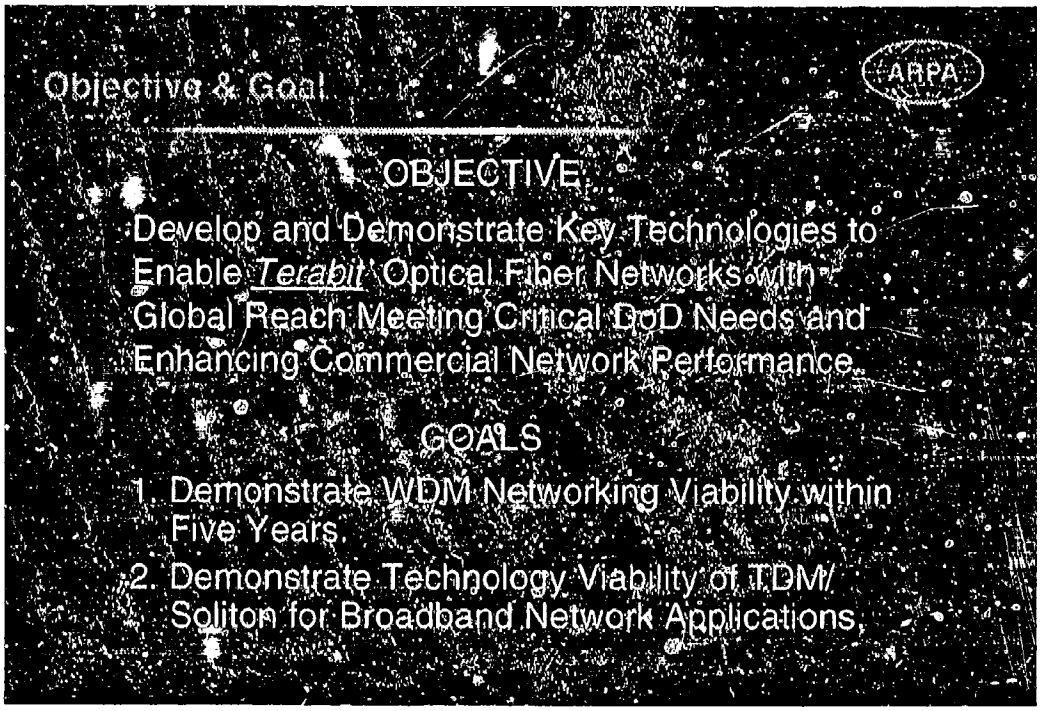
The Broadband Infrastructure Technology Program (BIT) addresses issues related to the Bitways layer of the three-layer NII architecture. The Bitways layer supports the development and demonstration of critical network technologies which enable common services that in turn support advanced applications. The Bitways technology consists of three areas: optical fiber, wireless, and satellite. The three technology areas are linked by a common protocol to ensure interoperability and seamless transmission of data information. The BIT program emphasizes the technology for high bandwidth transmission in optical fiber.



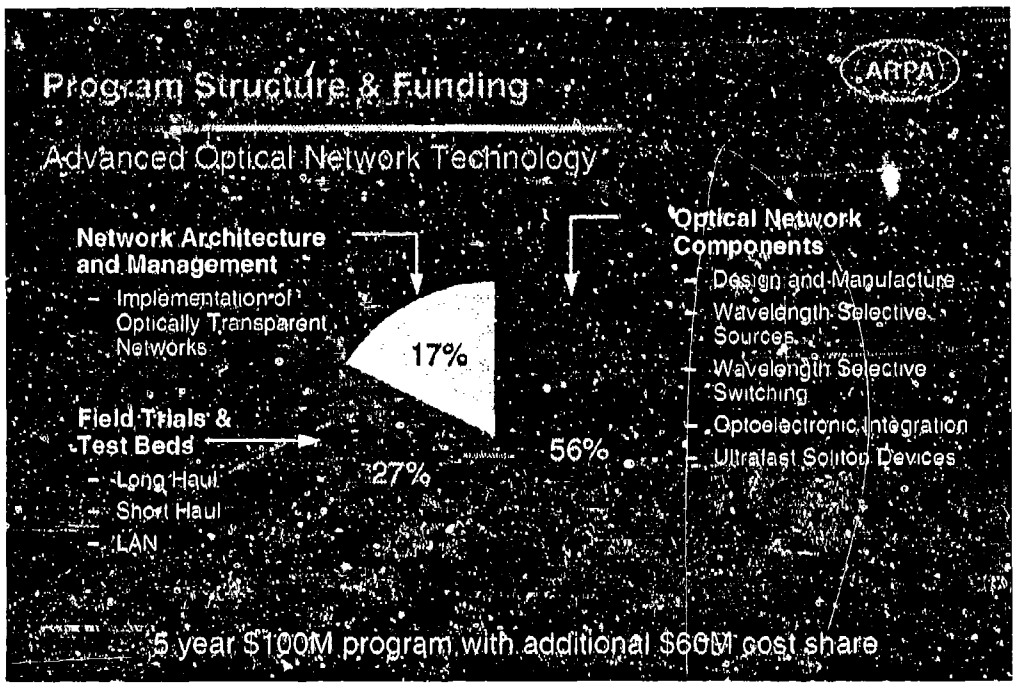
There are many reasons for moving up to higher bandwidth. The obvious ones are that high bandwidth can support more efficiently simultaneous transmission of high resolution images (a critical DoD requirement), teleconferencing, and movie-on-demand. The not-so-obvious reason is that broadband services can be very cost effective. It can be shown that cost does not go up linearly with bandwidth, but instead, it goes up closer to the square root of bandwidth. For example, to lease a OC-12 line does not cost four times higher than a OC-3 line, in fact. it costs only about twice as much. Also, as broadband technology becomes more mature, the overall cost will also come down.



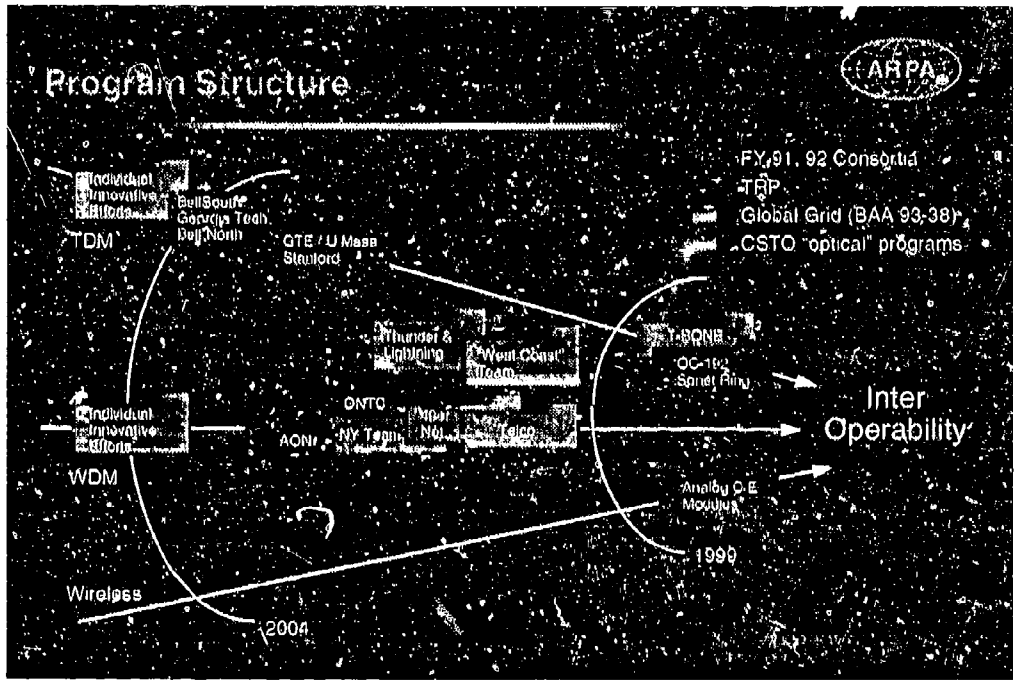
There are at least three ways to increase the network bandwidth capacity: Space - lay more fibers, Time-Division-Multiplexing (TDM) - use faster electronics, or Wavelength-Division-Multiplexing (WDM) - use multiple channels. Installing additional fibers may not be cost effective or practical. Moreover, it does not scale efficiently with bandwidth. The use of faster electronics is the most direct approach, but the electronic switching speed may not go much beyond 100 GHz. Also transmission above 10 Gb/s in a single channel may suffer severe dispersion. The discovery of soliton transmission in optical fiber opens the door for THz transmission, but most of the applications today have been limited to point-to-point links. Research in switched soliton network is till at its infancy. Finally, the use of multiple channels or wavelengths shows great promise in expanding the network bandwidth capacity in the near future. Data is transmitted throughout the network in multiple wavelengths without regeneration (all-optical or optically transparent network). Amplification is performed by optical amplifiers where signals in multiple channels are amplified simultaneously. Critical issues in WDM are channel cross-talks, uniformity of amplifier gain, management and architecture of a WDM network.



DoD needs high bandwidth services, but cannot afford to build its own network. To overcome this hurdle, DoD is providing some seed investment in the commercial sector and encourage commercial investment in the high bandwidth market. Both the government and the private sector will benefit -- DoD can leverage on the commercial network, and the industries can reduce their risk in R&D investment in WDM technology. The main goal of the BIT program is to demonstrate the viability of WDM in five years and establish a vertical path of transitioning WDM to markets.



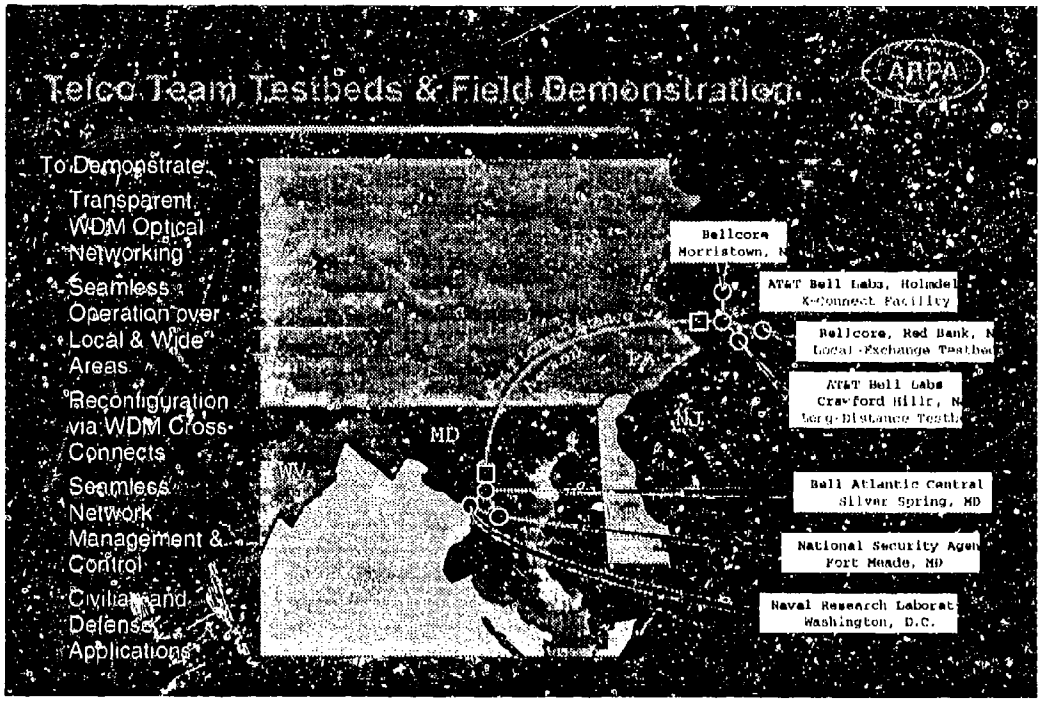
The Global Grid Optical Network effort is the major component of the BIT program. It has a 5-year budget of about $100 M, and an addition $60 M is cost-shared by the industries. About 56% is invested in the development of optical network components and their manufacturing process. The goal is to develop high performance and affordable devices. Since WDM is a departure from conventional TDM network architecture, about 17% of the program resources are invested in the areas of WDM architecture, management, and implementation to ensure a smoother transition to the communication market. The remaining 27 % is invested in realistic field trials and testbeds for long-haul, short-haul and local area network transmission in order to gain practical experience and knowledge in operating such a network.



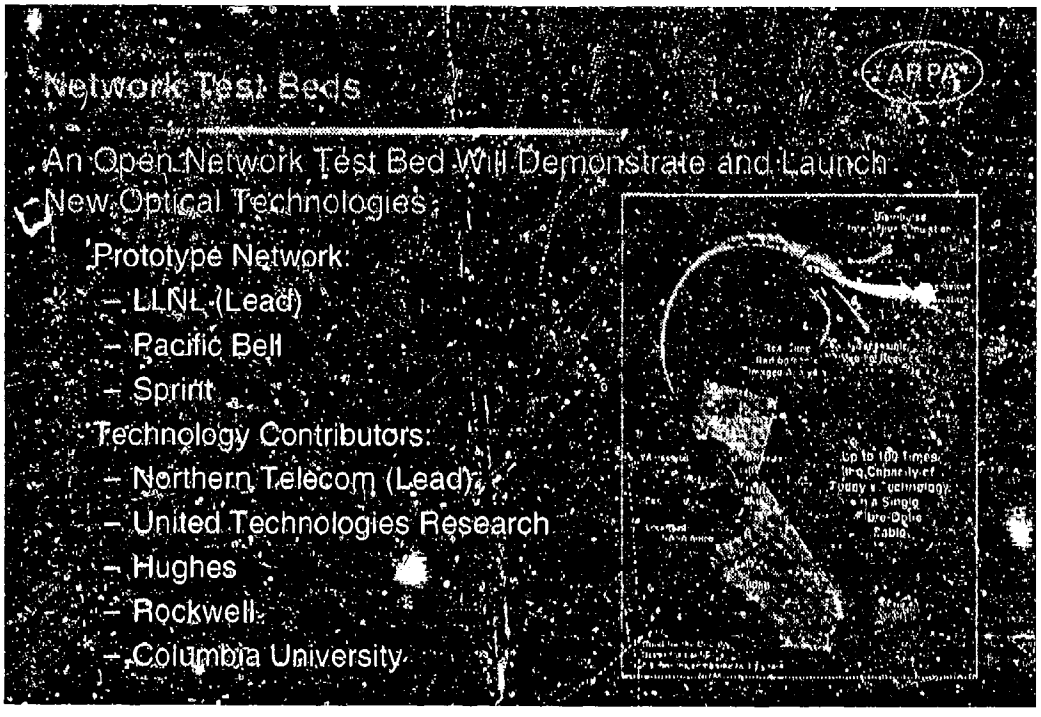
The resources of the optical network effort in ARPA can be divided into four catogories. The majority of the resource is in the Global Grid Optical Networks Program which had a BAA in FY 93 . Four major teams have been selected for negotiation. The program also includes some other innovative but smaller efforts. The precursors of the Global Grid Optical Network Program are four precompetitive consortia started in FY91 and FY 92. The third category includes broadband network technology efforts funded by the TRP program . The last category includes efforts funded under the HPCC program. The BIT program encompasses just the first three catagories.



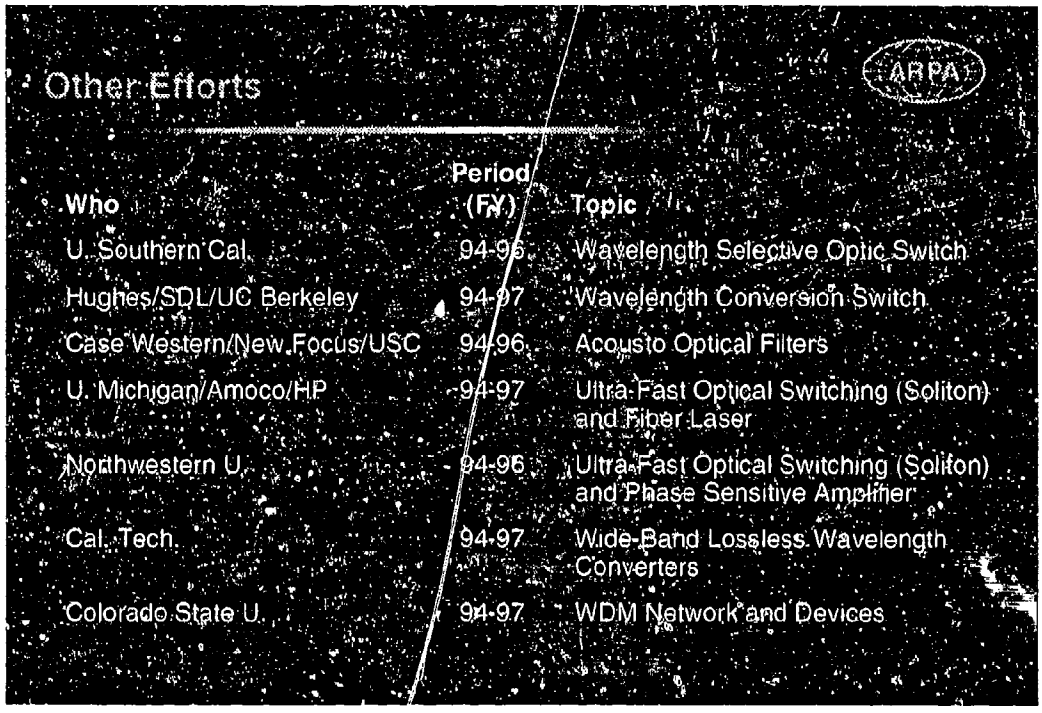
The teams (consortia) are composed of members from industries, academia, and national laboratories. Each team is vertically integrated: research, manufacturing, and users. The first team also has explicitly included members from DoD. Their role is to make sure DoD's interest is served and in some cases, the DoD players participate in the field trials. The funding for each team is heavily cost-shared by the team members.



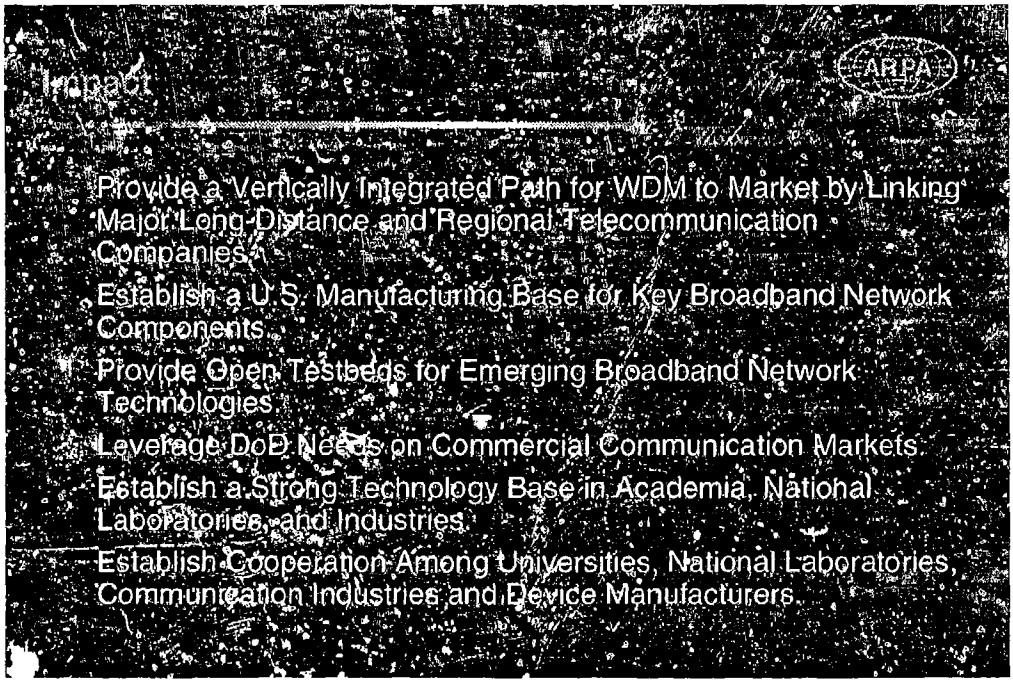
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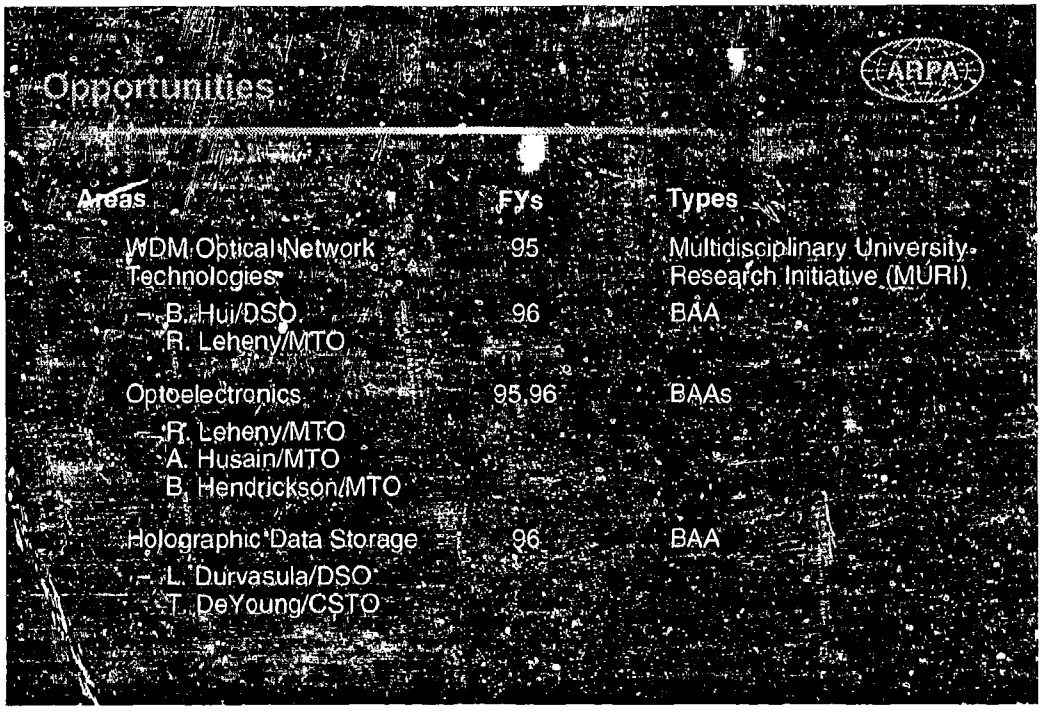
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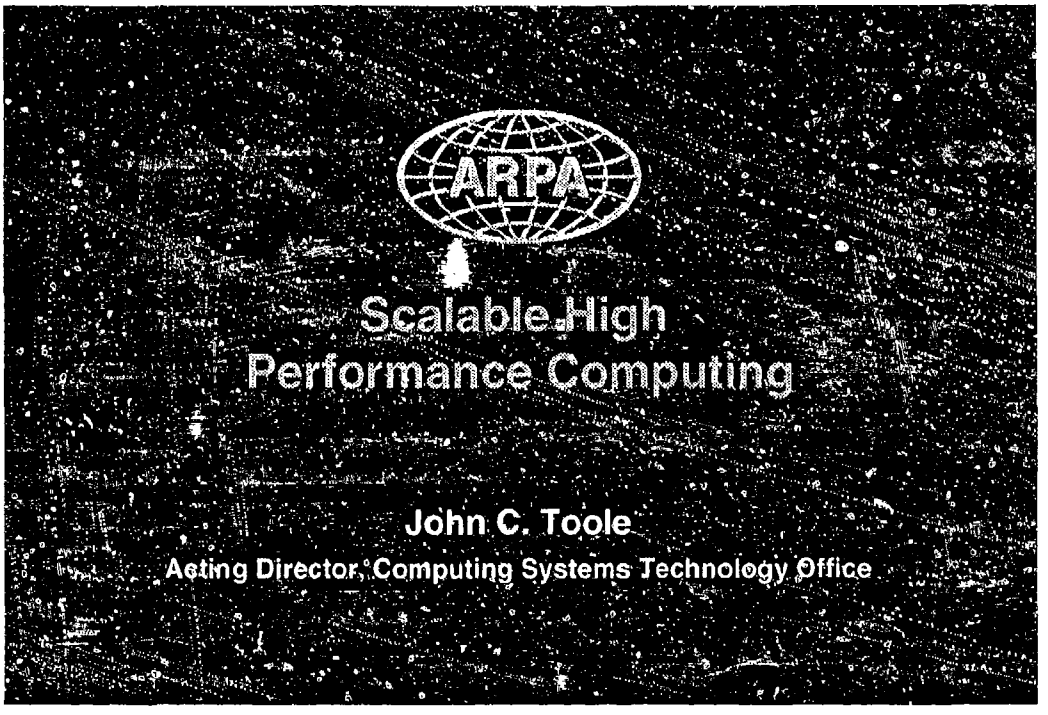
Listed are some smaller, very innovative efforts that are focused on specific topics related to advanced broadband networks.



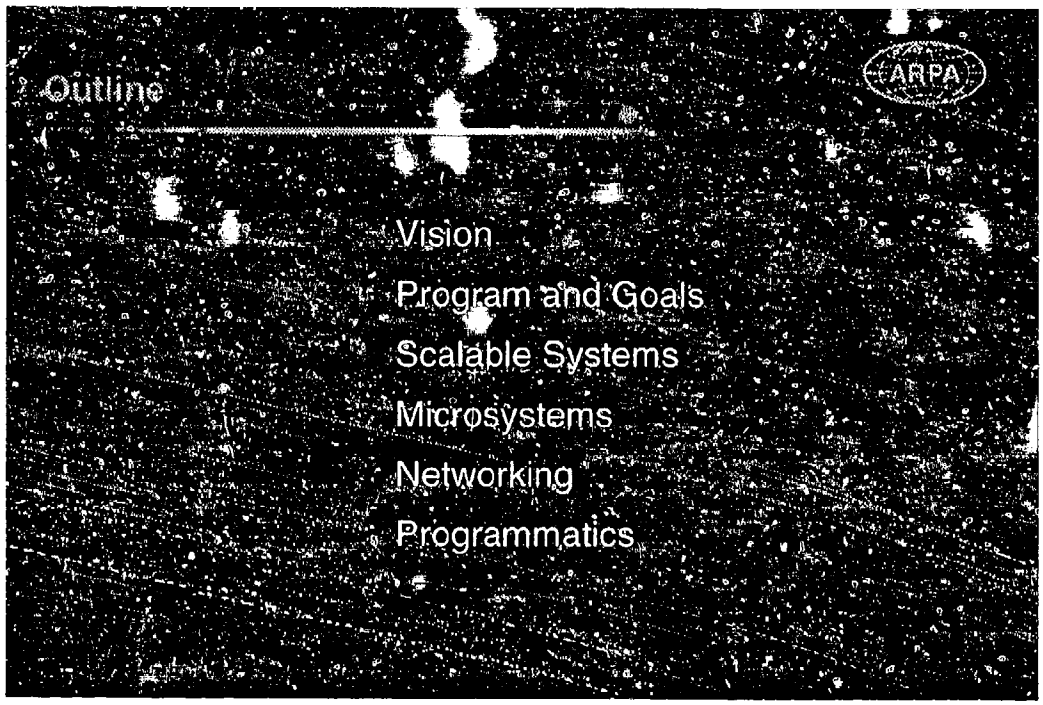
The potential impact of the BIT Program is listed.



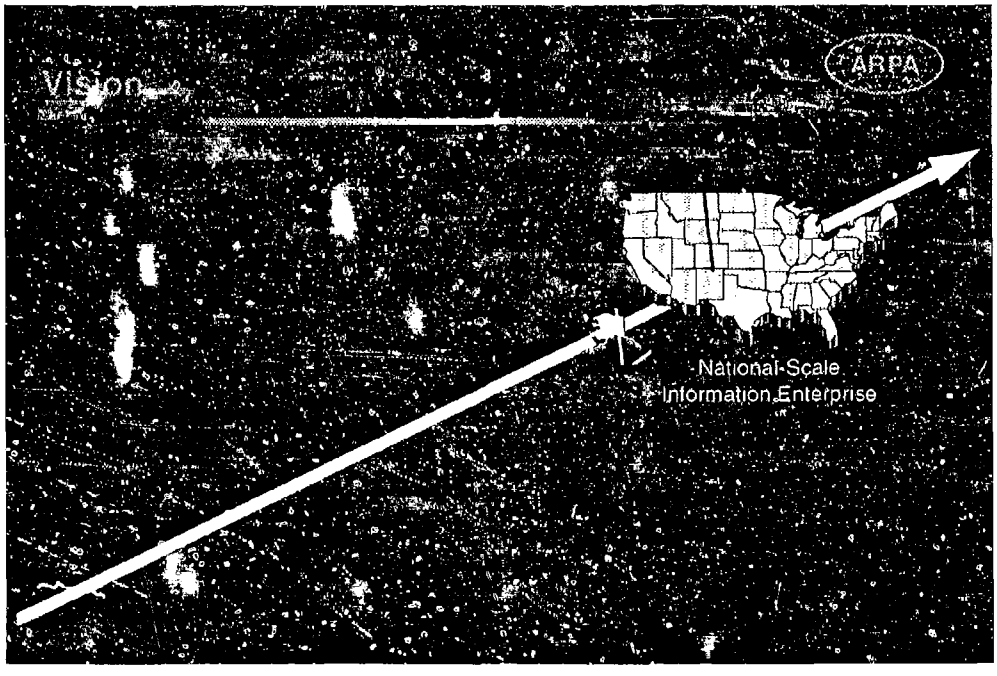
Opportunities for funding are listed. Besides the BIT program, we have also included some related technologies: optoelectronics and holographic data storage.



Thank you for the opportunity to present one of the most important components of future information technology for ARPA - scalable high performance computing.



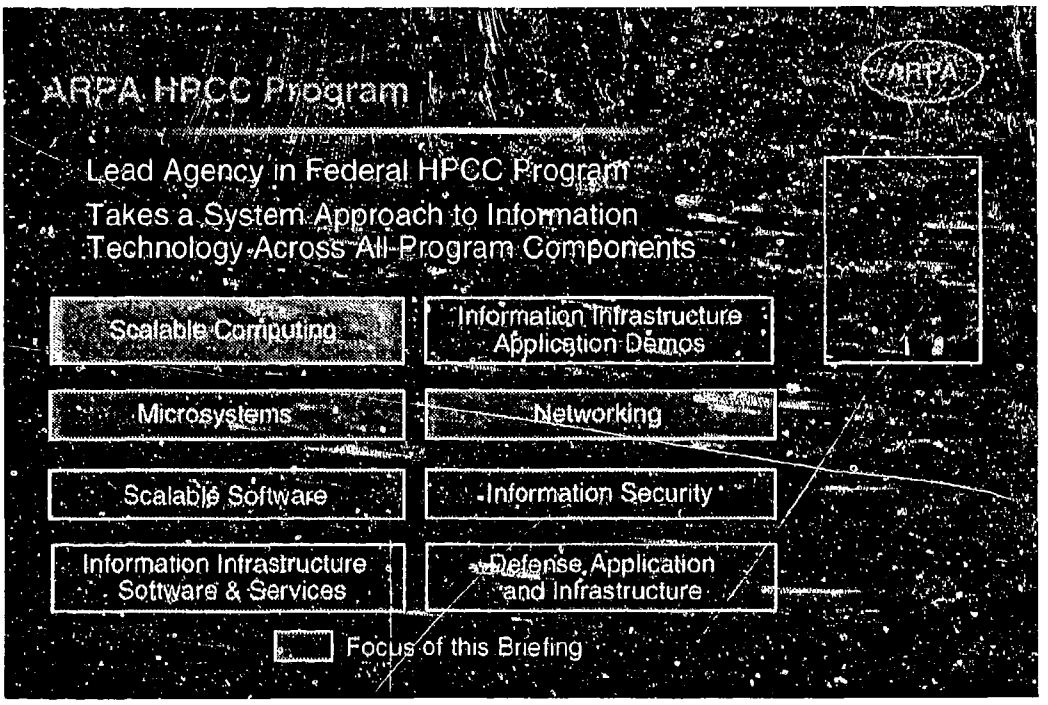
As many of you already know, there is an incredible depth and breath to ARPA's initiatives in High Performance Computing and Communications. They cut across several offices, and you will be hearing many of these later in the program. Today, however, I'd like to focus this short presentation on some of the important elements at ARPA related to the computing systems, their evolution, and their future in system networked environments. After describing the overall vision and goals, I'll focus on the scalable systems, microsystems, and networking programs. As Office Director, I'm really representing several program managers who are responsible for these programs.



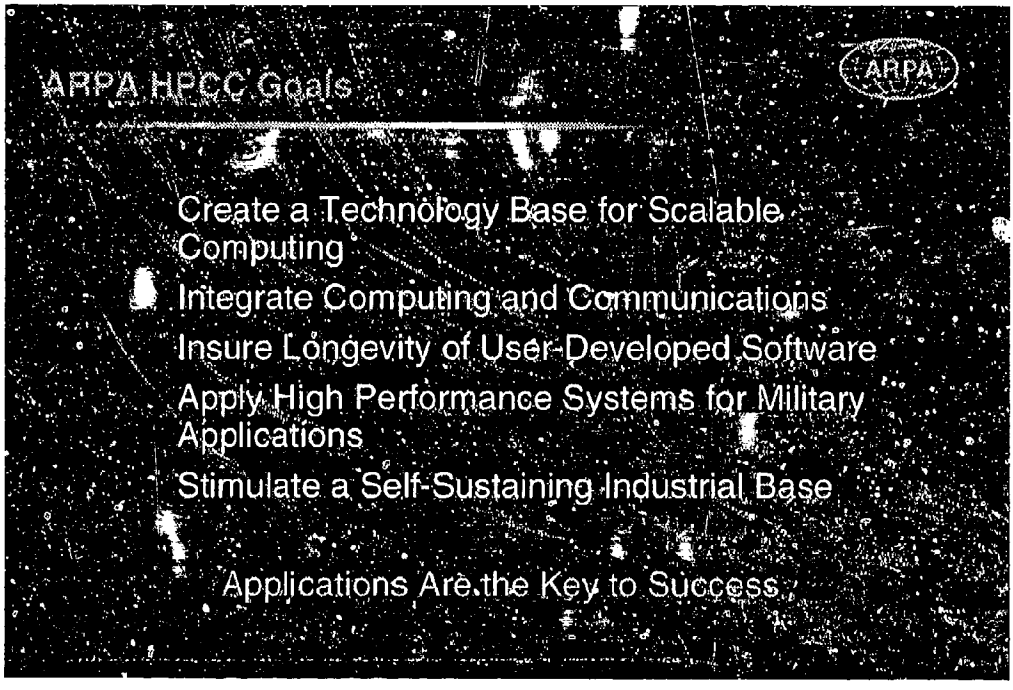
Over the years, our R&D investments have supported long term enabling technology for computing technologies. The Strategic Computing Program, which began in 1983, was the foundation for ARPA's High Performance Computing program.

The long term vision continues to center around the ability to build scalable technologies - investments that users can make in hardware and software systems which can incrementally add capabilities without totally replacing those investments. This involves a radical approach to the suite of technologies, including common component technologies, scalable software, high performance networking, and information technologies. Results of our programs have spanned the range from invidividual components to workstations, to clustered systems, to massively parallel processing - all networked and accessible through appropriate networks.

Of course, as this national-scale information enterprise evolves, we must rely on a number of emerging technologies from microelectonics and packaging to access this heterogenous and computational world. But the system approach to computing and communications must evolve is critical to build a scalable approach. Finally, the DoD need for these technologies should be obvious - from the highest computational and information intensive requirements to using scalable modules in embeddable systems (presented later).

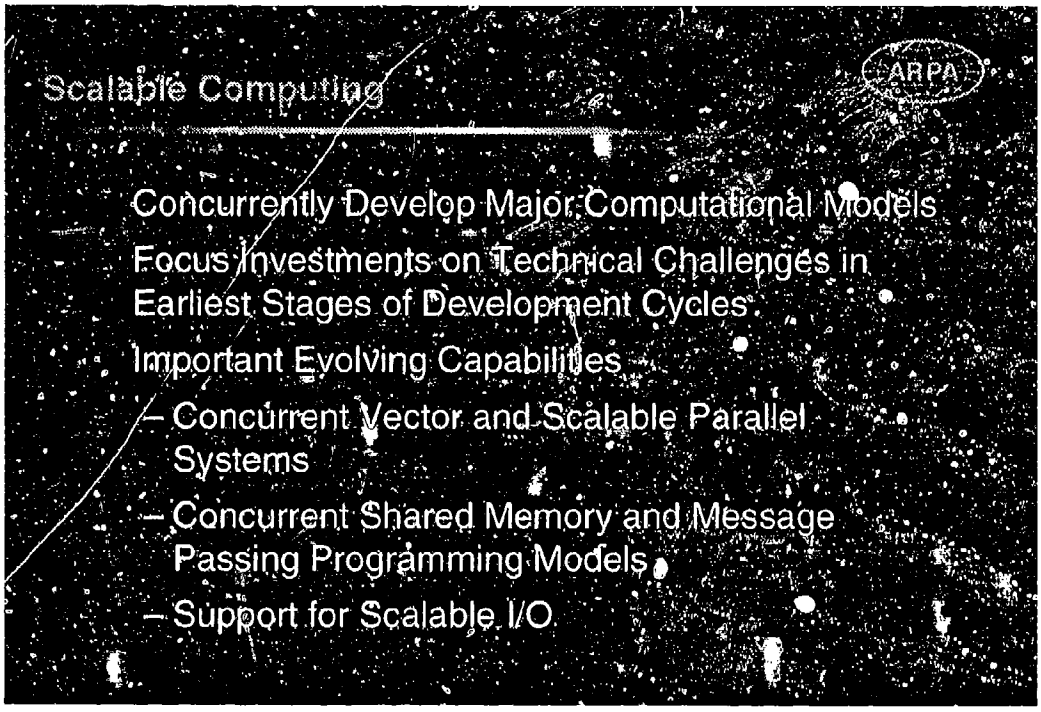


ARPA is a lead Agency in the Federal HPCC Program, a Federal R&D initiative coordinated across 10 agencies. ARPA has a lead role in advanced development across the major components., which complements the roles of other agencies. There are a number of programs within ARPA, and some which you will hear in other briefings. Today, I'd like to focus on the scalable computing and microsystems programs, and describe how our networking component enables systems of people and resources to be remotely connected.



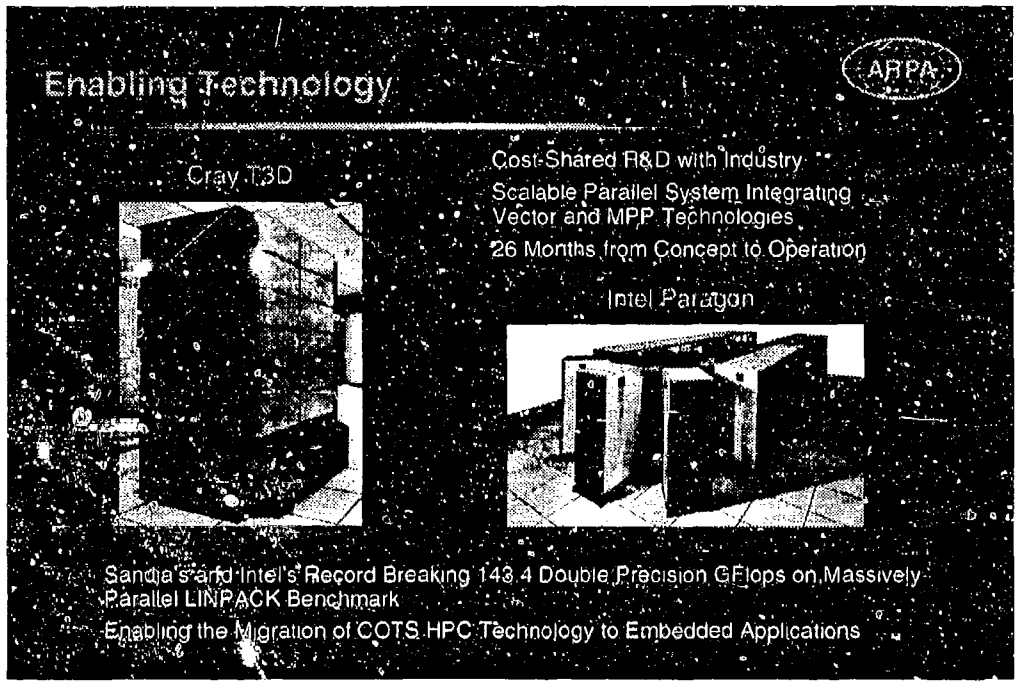
There are 5 overall goals of the ARPA HPCC program. First, our mixed investment strategy is aimed at creating a scalable computing technology base. This provides a key intellectual and technical focus to move the field forward. Second, we are accelerating the integration of computing and communications to see what the future will be like. These rapidly converging fields are providing the foundation for the future information technology. Third, we want to insure longevity of user-developed sofware. The next talk on scalable software will talk about some of the key technologies that can help make this happen. Fourth, we are applying high perfomance systems for military applications. You will hear many presentations throughout the symposium that are relying on the enabling technologies of this program. In addition, we are creating scalable components to embeddable systems. Finally, we would like to stimulate a self-sustaining industrial base, which involves getting the technology into the hands of real users and vendors which will evolve these important technologies.

As the R&D of high performance computing continues to mature, getting applications running on scalable systems is the key to success.

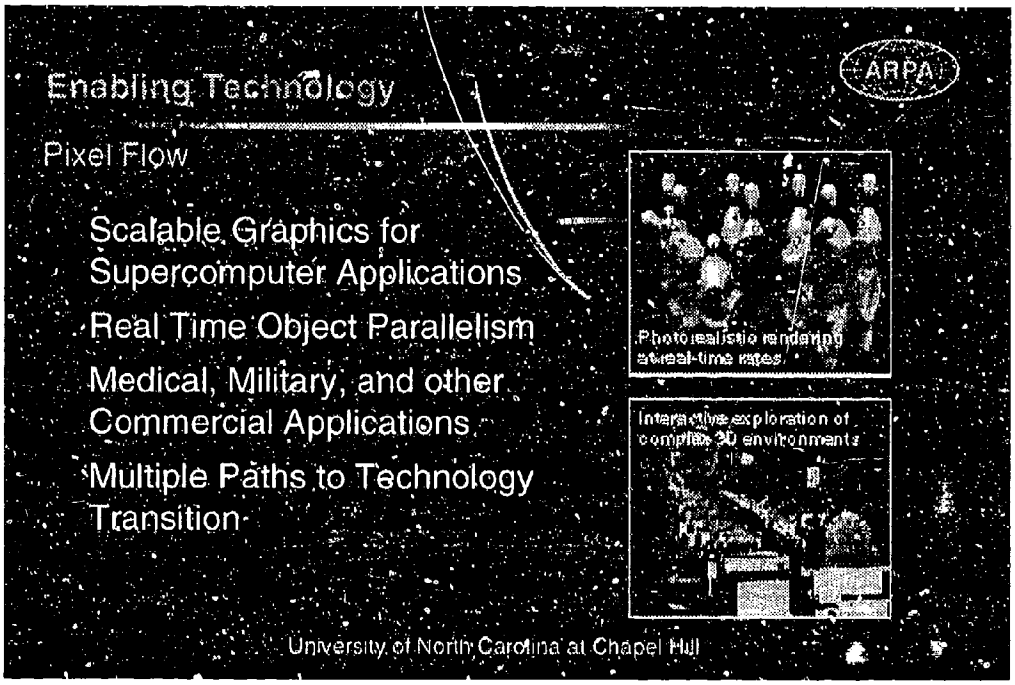


Scalable computing stratey has been focused at concurrently developing maior models of computation. It focuses on the technical challenges in the earliest stages of development with transition strategies to insure they wind up in real systems.

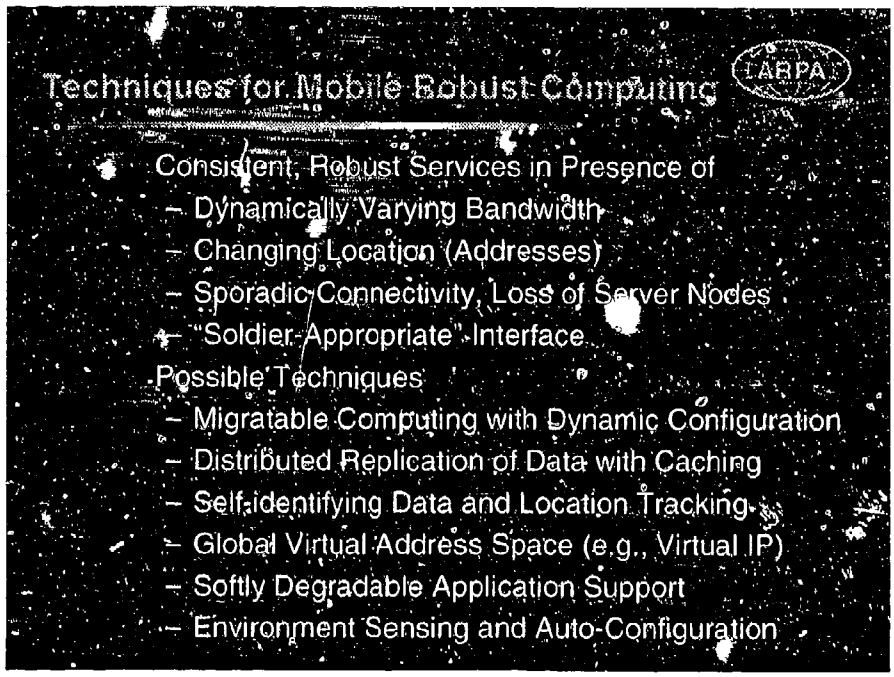
Several important trends are occurring. Vector and scalable parallel systems are converging and being supported in a variety of systems. Shared memory and message passing programming models will also be supported on the same platforms. Finally, scalable I/O is taking a more prominent view to provide a balanced system, and is an important component of our research.



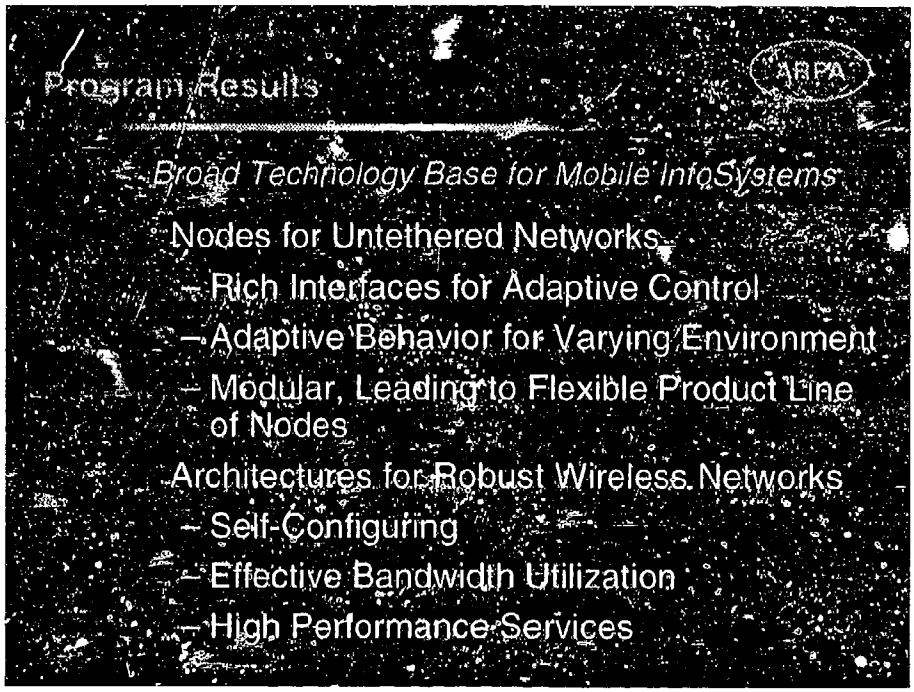
A couple of examples illustrate recent results. The CRAY-T3D embodied technologies developed in a joint cost-shared arrangement with ARPA and Cray Research. This system integrated vector and MPP technologies and was developed in 26 months. Another joint cost-shared effort with Intel led to incorporating key technologies into its Paragon system, which regained the world record in performance, at least temporarily. Furthermore, the component technology of the Paragon is being used in embedddable systems, and example of rapidly adapting these systems to military requirements.



Another class of example is the exceptional work that is funded through universities, in collaboration with industrial groups. Pixel Flow, at the University of North Carolina is an ARPA/NSF program to develop scalable graphics for supercomputer applications. It relies on a unique integrated architecture to render real time object parallelism. Medical, military, and other commercial applications are being developed to exploit this powerful capability. Multiple vendors interested in commercializing the technology for advanced simulation and displays are working with these groups.

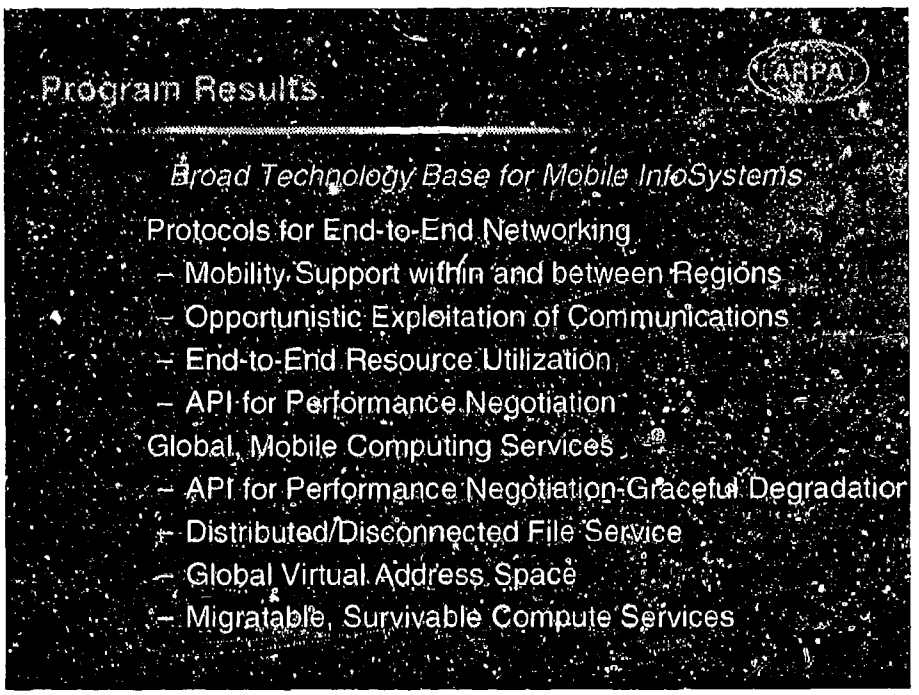


At the top of the infrastructure, applications must be given the support required to dealing with sporadic and changing connectivity as well as movement within and between networks. This portion of the program is developing the computing support services required in a mobile environment.



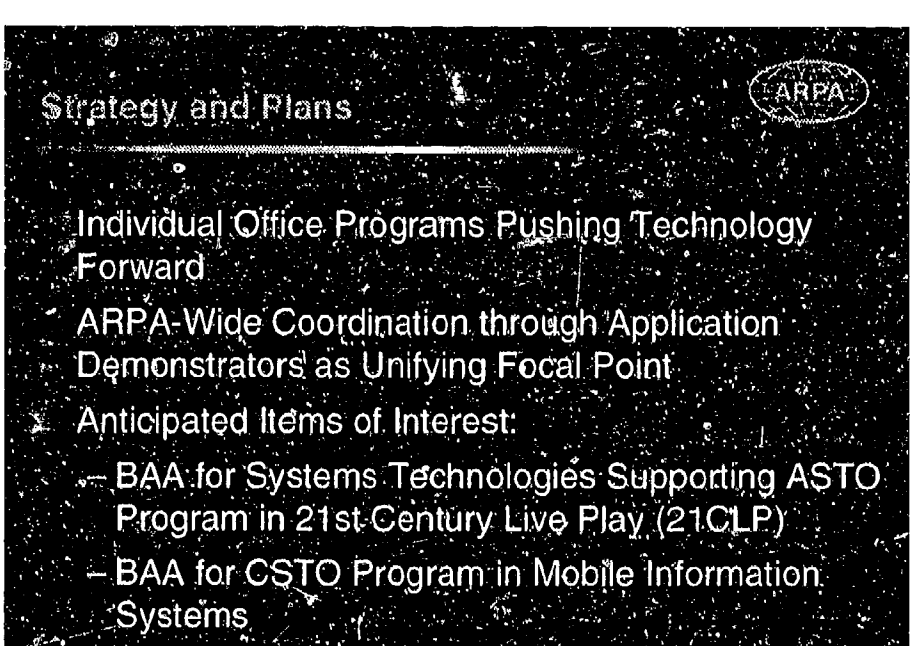
Resulting from these efforts will be new technology for designing nodes of a wireless network that are open in architecture,with adaptive and open interfaces. This will allow the kind of flexibiliy and modulatrity needed for military and similar civilian needs

this will provide the nodes for developing and demonstrating the needed techniques for a wireless network that responds to the requirements for rapid deployment and effective specrum utilization as well as high performance



The end to end networking will provide support for mobility between regions and allow whatever communications is able to be exploited. It will provide for an enriched interface between applications and the unerlying network

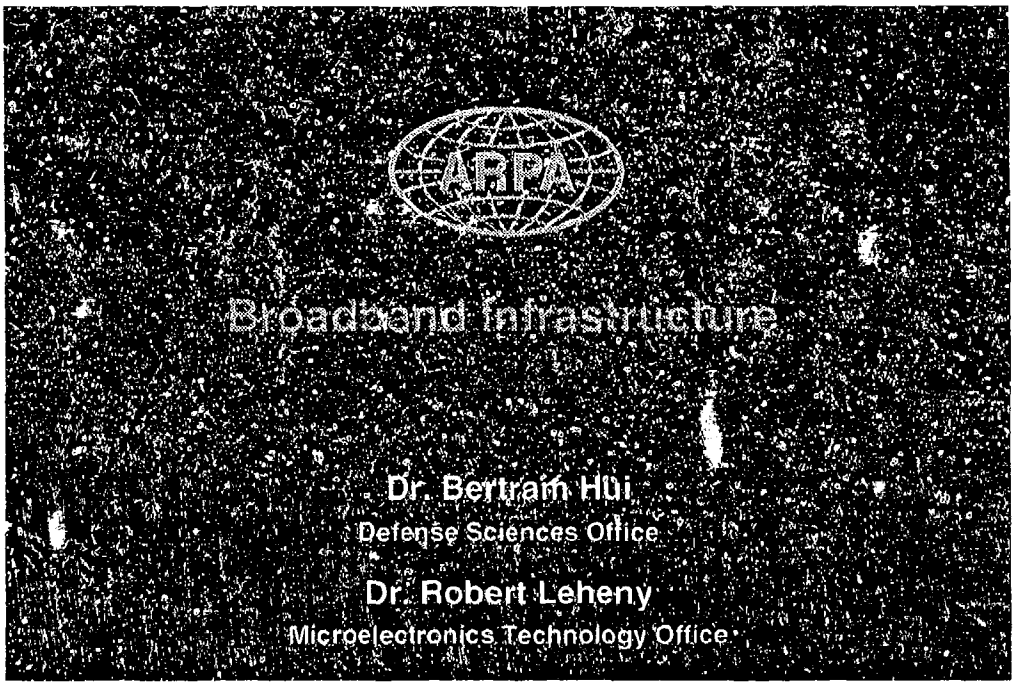
Finally, these underlying networking services will be exploited through an enhanced set of computing services that allow applications to utlize the available bandwidth and ability to move within and between networks



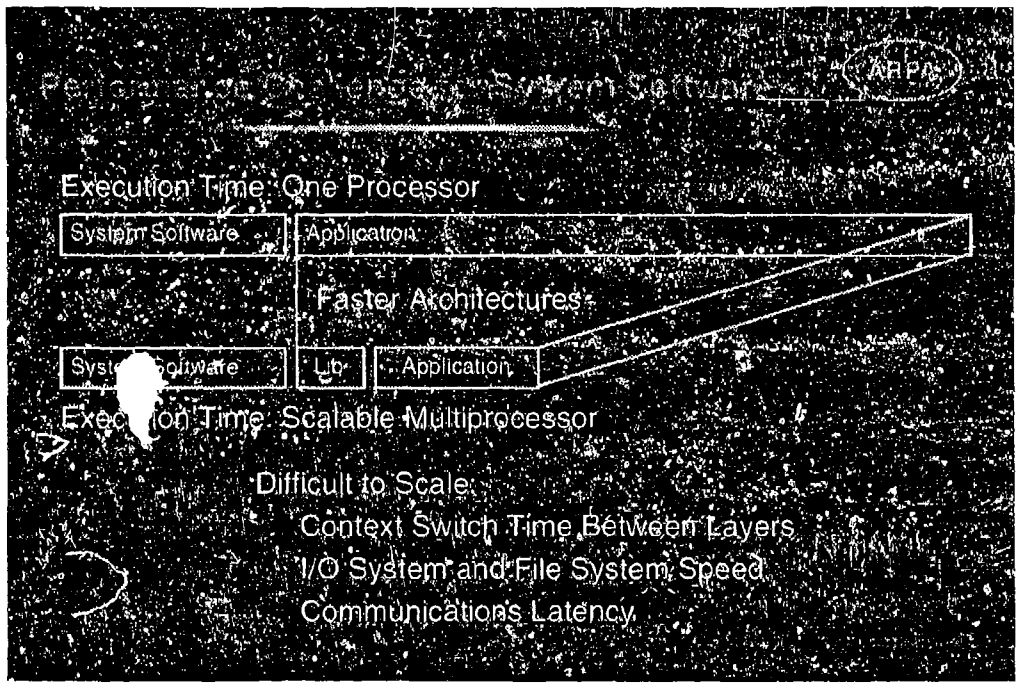
As I indicated above, activity in Mobile Information Systems cuts across many ARPA offices and programs. In each of these programs, the technology base is being pushed forward to provide a capability for the future. It is valuable to coordinate this across ARPA to assure maximum leverage. The technique planned is to use application demonstrators, mainly driven by offices such as MSTO and ASTO, as a focal point for integration and demonstration of the underlying technologies.

Some of anticipated upcoming items that might be of interest are upcoming BAAs as shown. ASTO is planning to release a BAA aimed at developing a mobile, wireless, seamless indoor/outdoor distributed interactive simulation network as an extension of an ATM/SONET backbone.

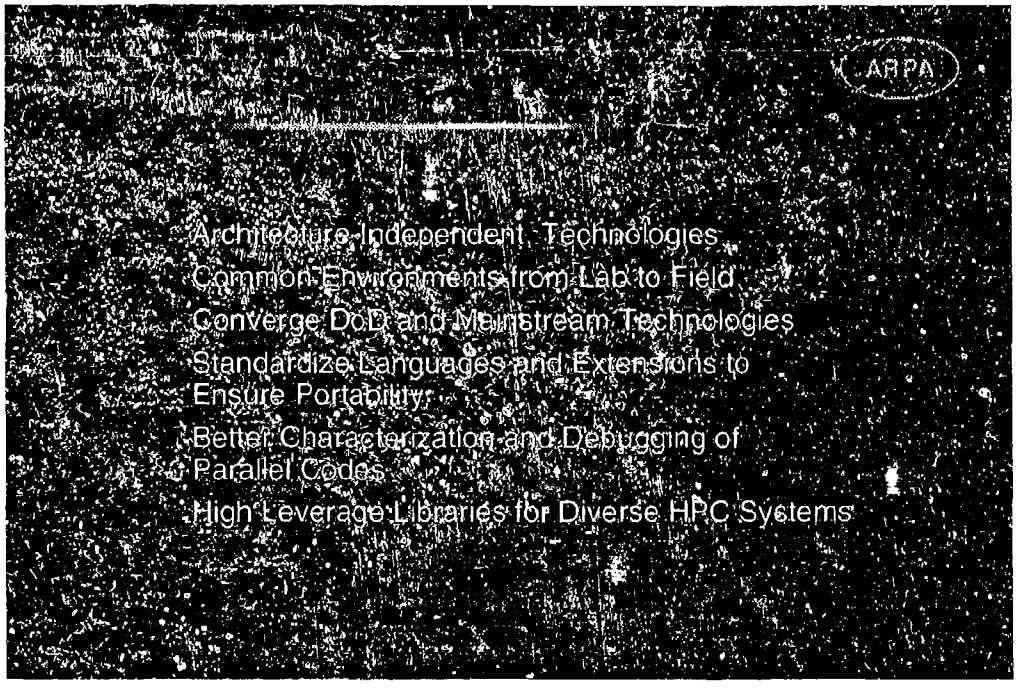
CSTO is planning a BAA addressing the four-layer architecture described previously and aimed at developing the underlying nodal, network, and information system technologies that will support the military requirements of the future.



The ARPA Broadband Infrastructure Technology Program (BIT) is jointly managed by the Defense Sciences Office and the Microelectronics Technology Office.



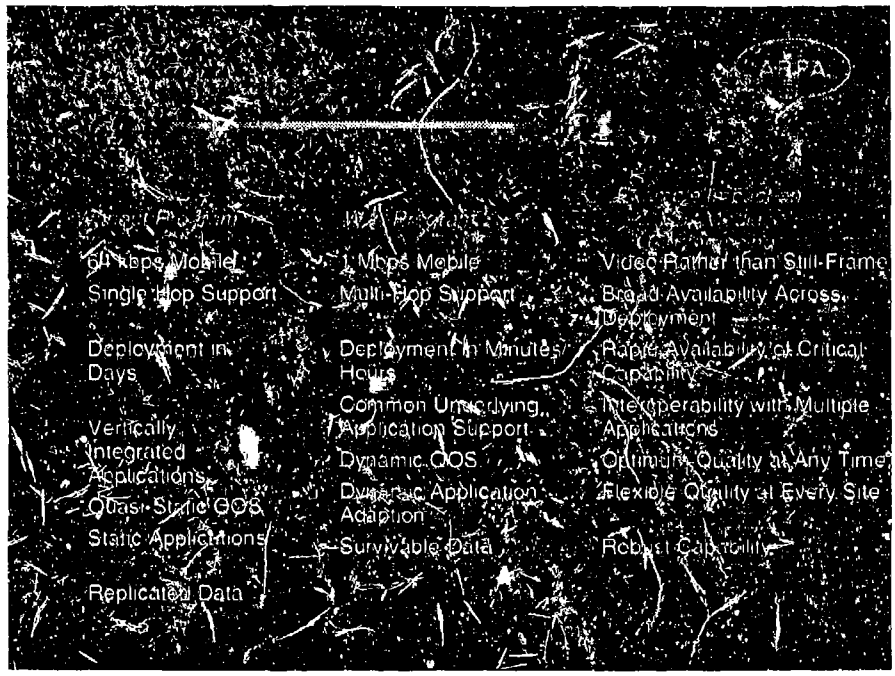
This chart shows the performance challenge we face in the system software area when applications alone are optimized for faster execution. The total execution time shown in the top bar is dominated by the application, but has a typical component of system software execution time. This time may be due to input-output, operating system boundaries, or synchronization with other processes. The second line shows the application speeded on a scalable multiprocessor but the system software time remains the same as before. However, it is now a much larger percentage of the total execution time. In addition, libraries used to help the application run on the multiprocessor now consume a non-trivial percentage of the total time. The overall speedup is therefore limited by the time needed to do such things as: context switch time between layers, I/O system and file system speed, and communications latency.



It is the purpose of the scalable software program to stimulate the technologies which will provide software with the ability to adapt to its environment and take advantage of parallelism and distribution.

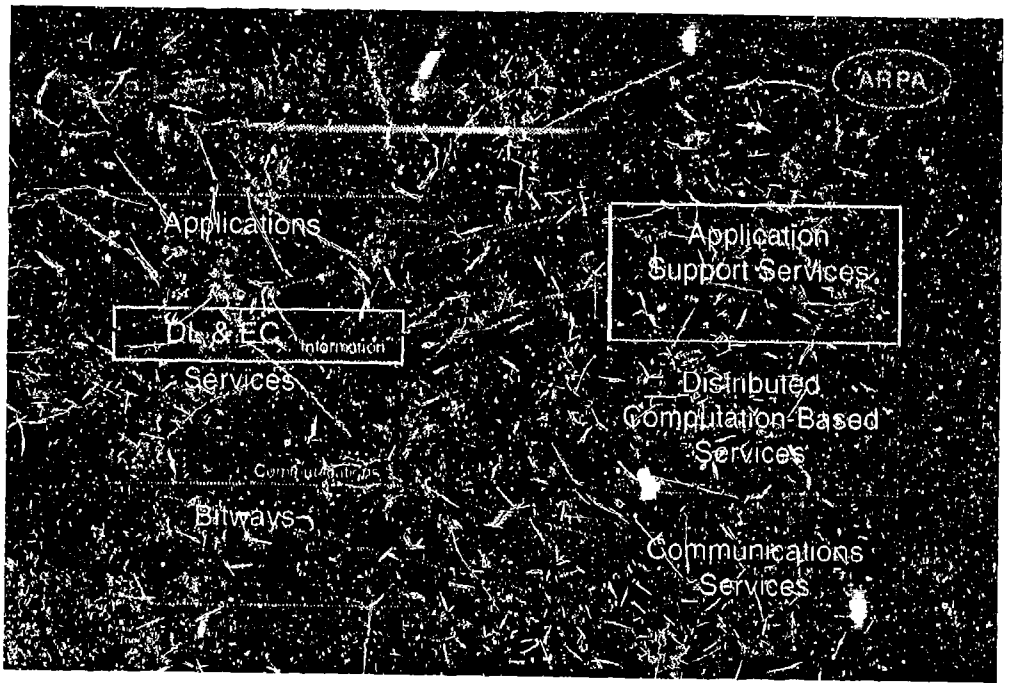
ARPA's strategy in this area has six points:

- develop the architecture-independent technologies I've just discussed
- provide a common environment from the developer's laboratory to the field where the solution is deployed
- provide for DoD requirements in mainstream technologies
- standardize languages and extensions that address adaptability, portability, and parallelism
- Provide mechanisms that permit better understanding of and debugging of parallel codes
- Develop libraries that will leverage HPC codes across the different environments



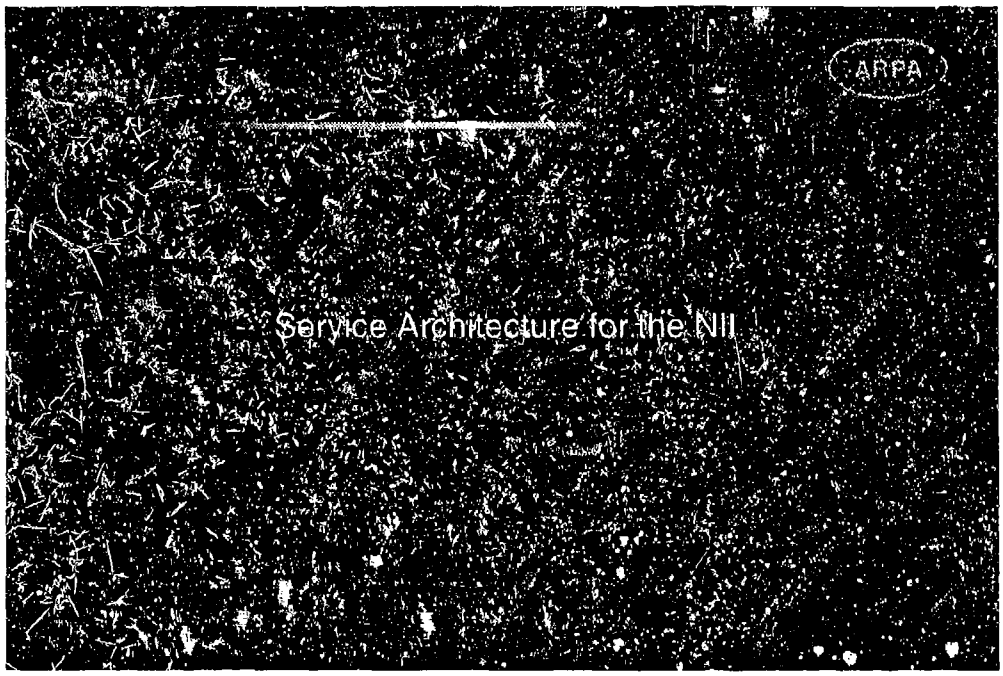
We can see the expected impact of the program by looking at the example application of multimedia conferencing. The end result will be a significantly enhanced capability in the field, which can have impact on our warfighting capability.

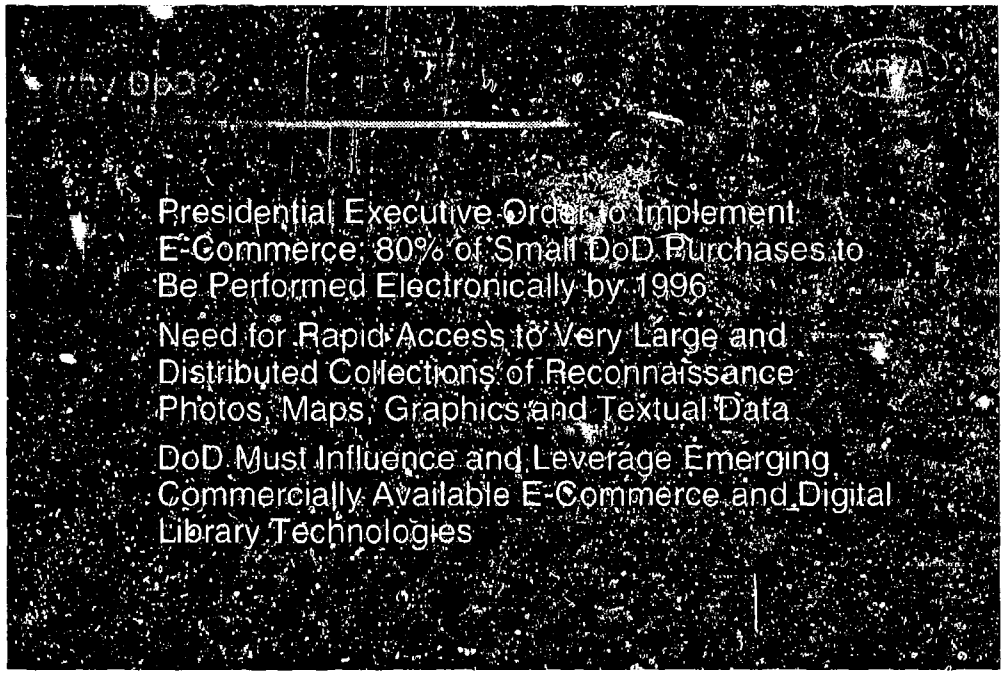
Thank you very much for your time.



The NII is often articulated in terms of a three layer architecture of applications (end user programs), services (building blocks from which applications are built), and bitways (communications mechanisms and technologies). Digital Libraries (DLs) and electronic commerce (EC) fit at the interface between services and applications; they are enabling capabilities from which more complex applications can be constructed if they have needs to access repositories of information or to engage in commercial transactions.

Services in turn can be decomposed into those that support applications, those that manage distributed computations, and those that interface to the communications bitways. This talk focuses on the former.


ARPA
Service Architecture for the NII



The Department of Defense has been an early and enthusiastic adopter of electronic commerce technology, as one of the world's largest enterprises. ARPA has funded several electronic commerce prototypes over the last decade, including MOSIS, FAST, and MADE, and several of these are in experimental use within DoD today. The President and the Secretary of Defense has placed great challenges on the Department to accelerate and expand the use of such services.

Digital libraries hold forth the promise for storing and indexing vast quantities of information. DoD is especially interested in non-traditional information access, such as to maps and photos, and to "active" documents that can be incorporated into simulation-based training. ARPA's research program will develop advanced digital library technology that will be responsive to the information management needs of the DoD.

The DoD must ride the "NII wave," and must seek to influence the commercial developments to insure responsiveness to the Department's mission needs.



Discovery/searching includes: information clearinghouses, catalogs, directors; critical for finding service providers; finding specialized repositories and information within them; distributed hierarchical directories and indexing strategies

Data interchange and format conversion: conversion services for interoperation; critical for electronic data interchange (EDI) and electronic forms processing; conversion between different documents and data formats

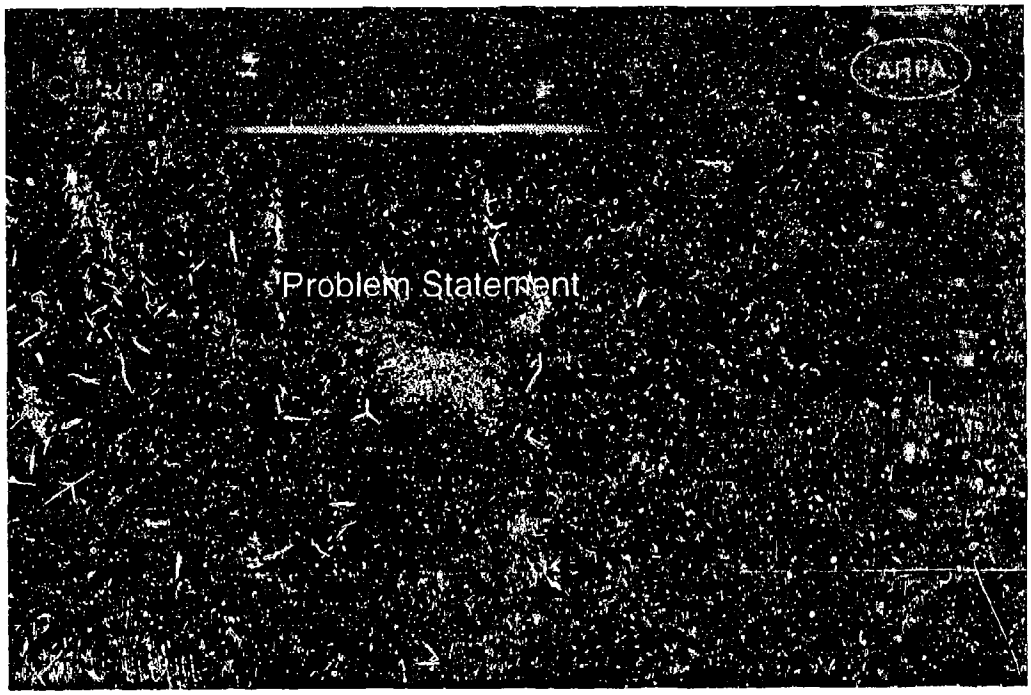
Authentication/security: authentication, authorization, confidentiality, privacy, integrity, protection against misuse, fraud detection

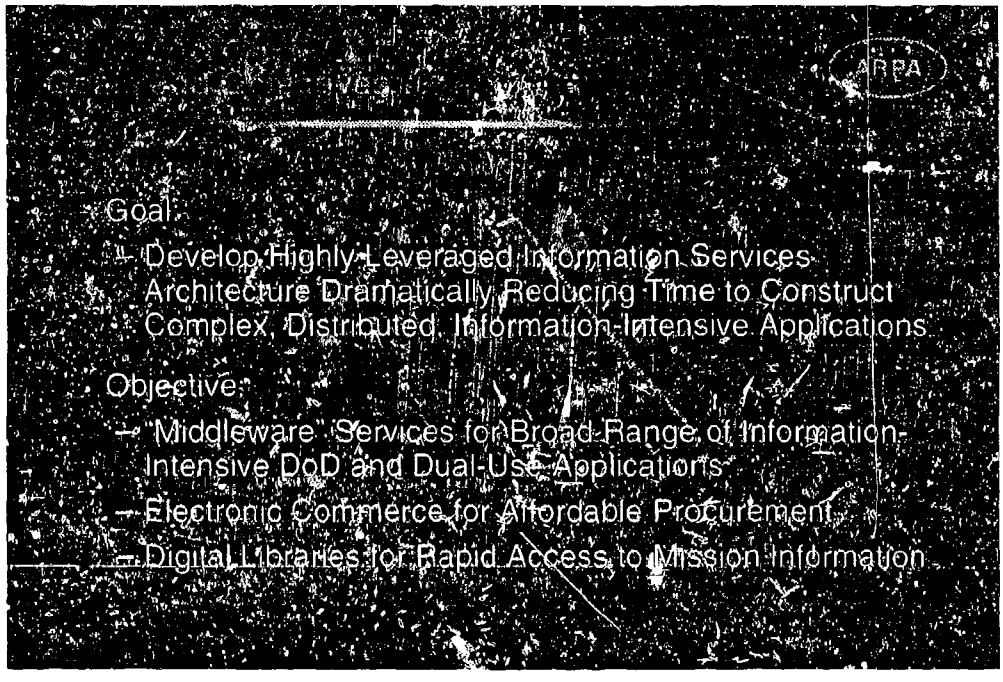
Electronic payments: digital money, payment orders, escrow, letters of credit, bartering systems, financial instruments, value exchange, interfaces to payment systems, micropayments

Linkage: pointers that link information, solving problems of long-term validity, granularity, and versions

Repository: long-lived, archival storage services

Registration and Publishing: creation, dissemination, and control of pointers across the network

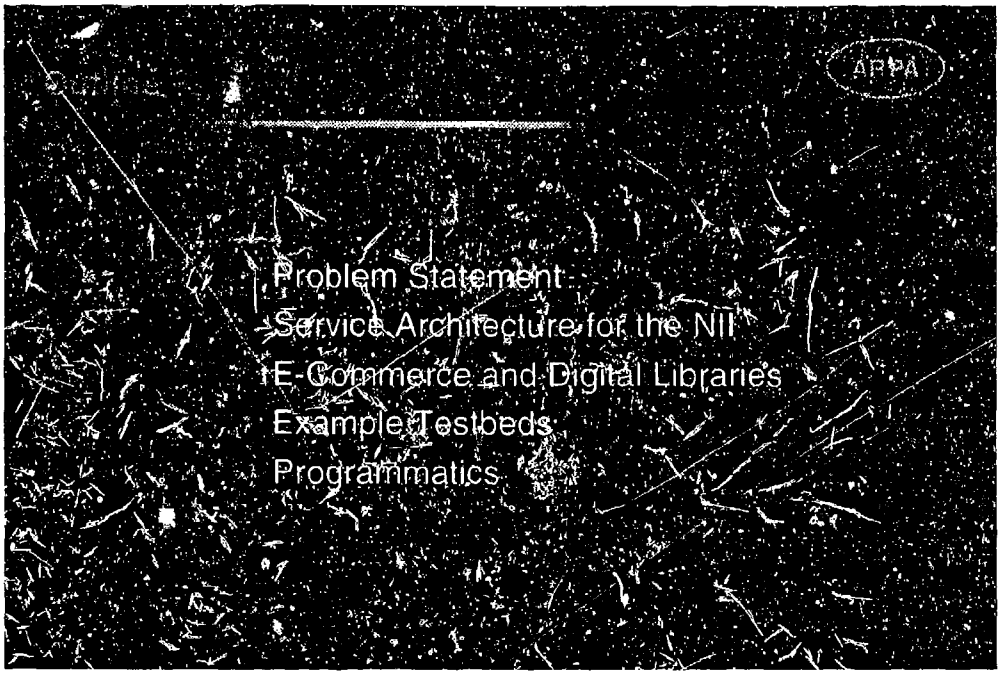

ARPA
Problem Statement

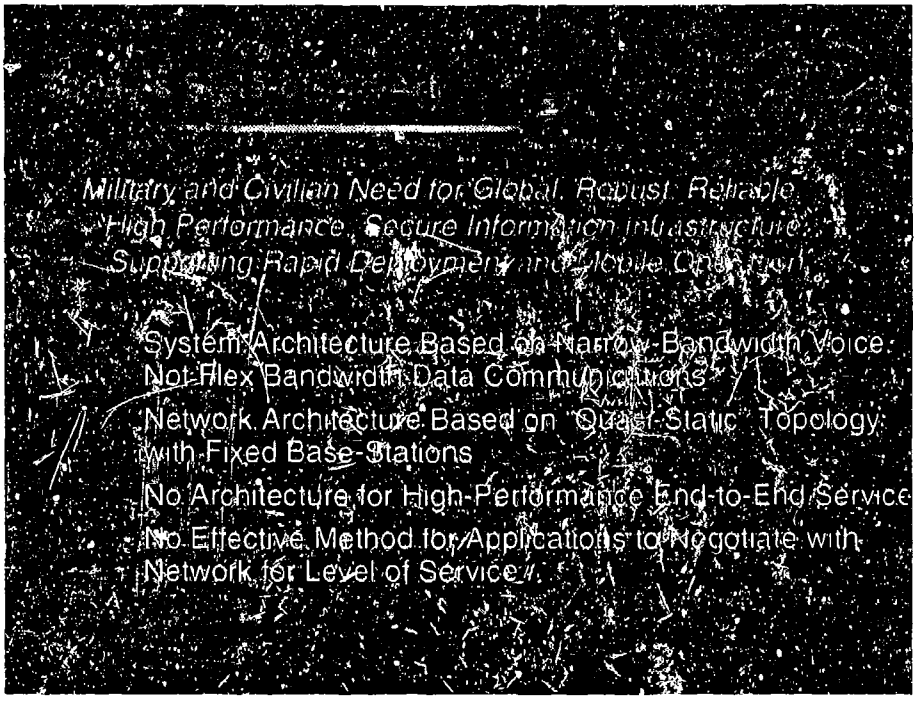


The NII will be successful only if the second "national challenge" application to be implemented is LESS expensive than the first. The goal of information infrastructure services is to develop a rich service architecture that can support multiple applications.

In particular, the ARPA program will focus on creating middleware information services in support of information-intensive DoD applications.

A special focus will be on the dual-use applications of electronic commerce and digital libraries, each of which is itself a critical building block of services for higher level applications like health care and crisis management.


ARPA
Problem Statement
Service Architecture for the NII
E-Commerce and Digital Libraries
Example Testbeds
Programmatics



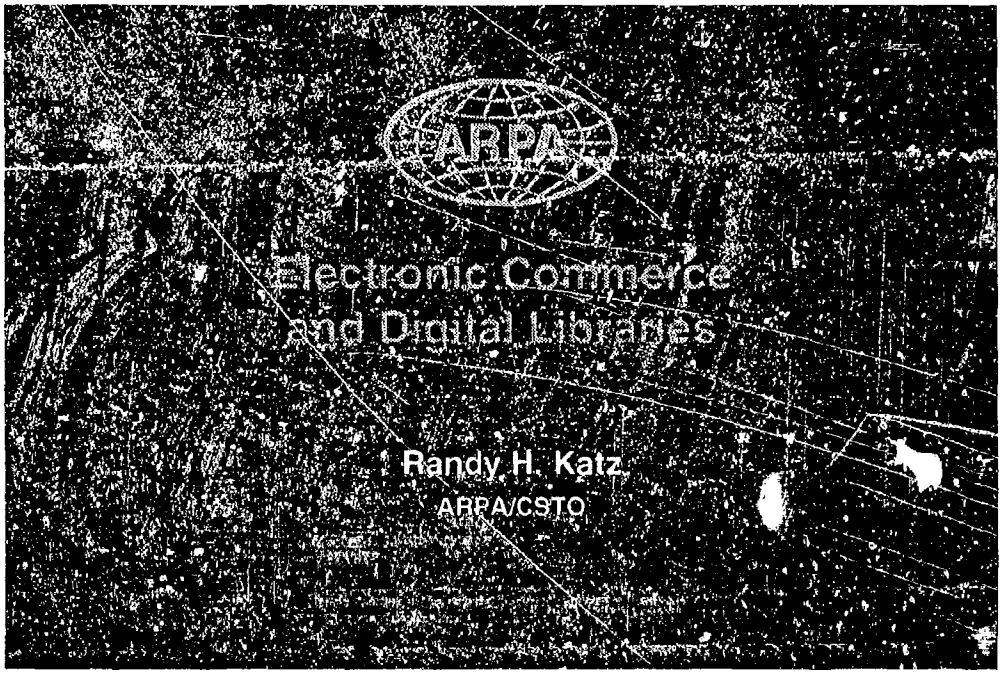
The military has a need for a robust, survivable, easy to deploy system that will support mobile operation in presence of sporadic communications and variable bandwidth.

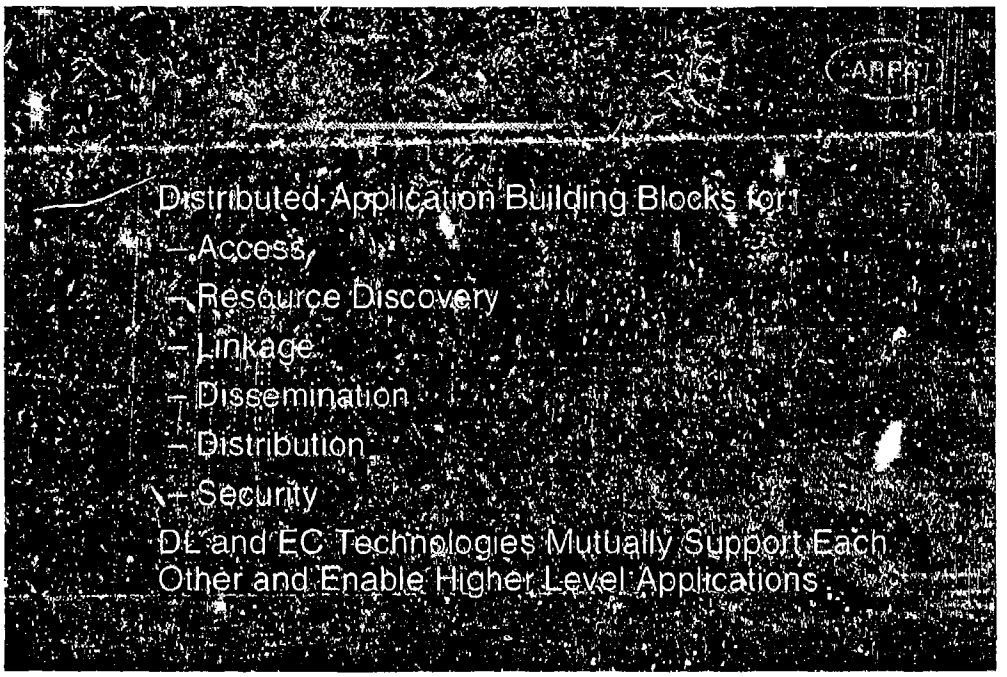
Current commercial and military systems are primarily based on providing voice communications in mobile environments. Data is typically overlaid on systems designed for voice.

Networks such as cellular are base-station oriented, not suitable for rapid deployment scenarios (although reasonable for commercial settings.

End to end service is typically voice oriented, so even though the wireline nets can support higher levels of service, it is difficult to tie them together with wireless networks.

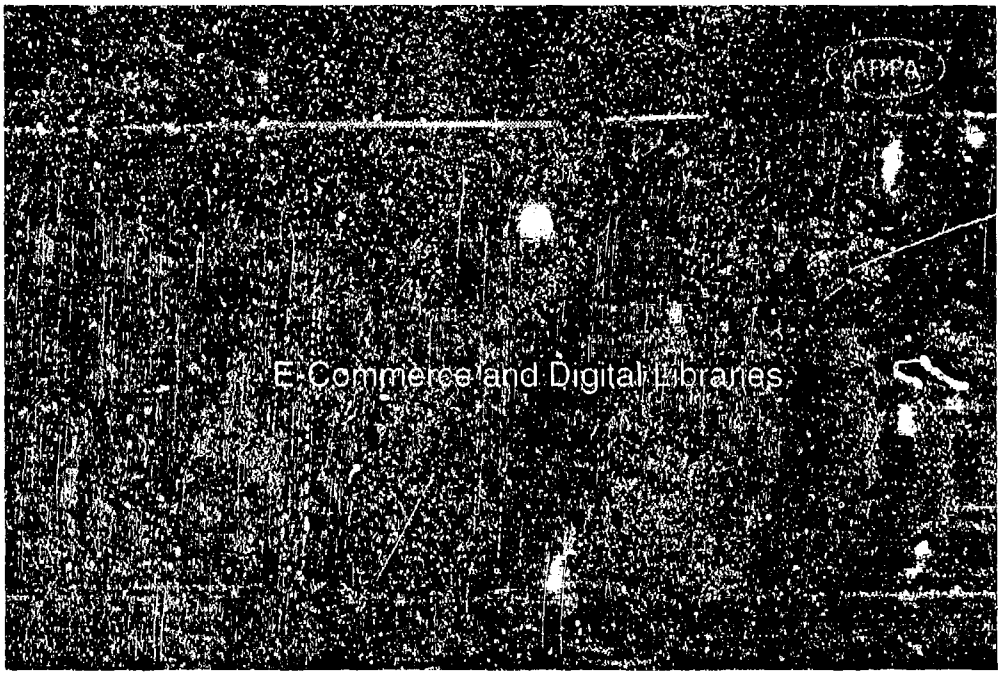
Finally, there is a need to be able to have applications negotiate for bandwidth and other resources (e.g. delay) and be informed as to the extent to which requests can be serviced.

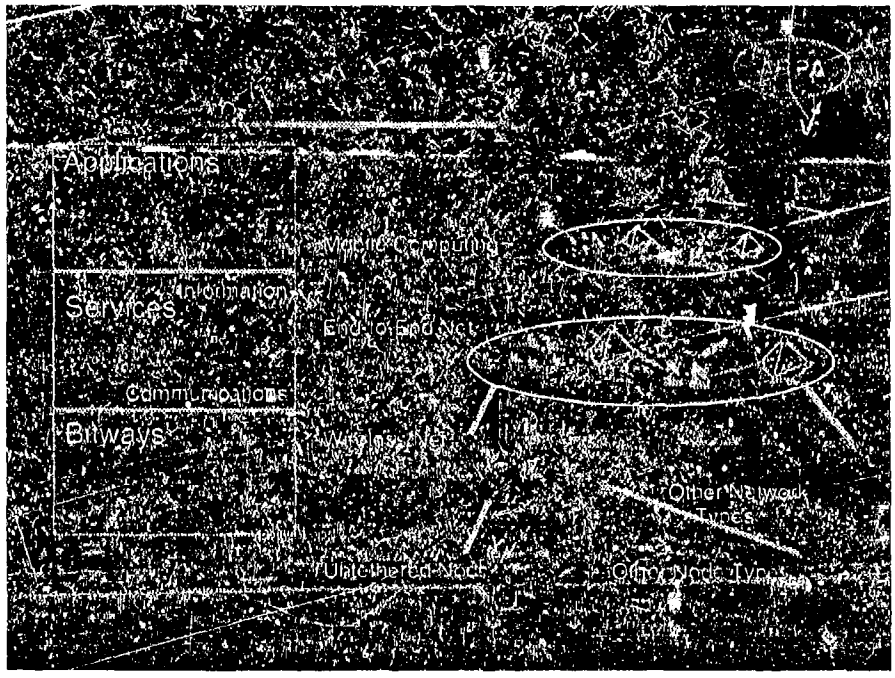

ARPA
Electronic Commerce
and Digital Libraries
Randy H. Katz
ARPA/CSTO



Services are building blocks for distributed capabilities for finding things, linking to them, accessing them, and distributing them. Security building blocks (including authentication, authorization, encryption, privacy, etc.) are a critical service layer capability.

Digital libraries and electronic commerce technology build upon each other, as will be illustrated on the next few slides.


DARPA
E-Commerce and Digital Libraries



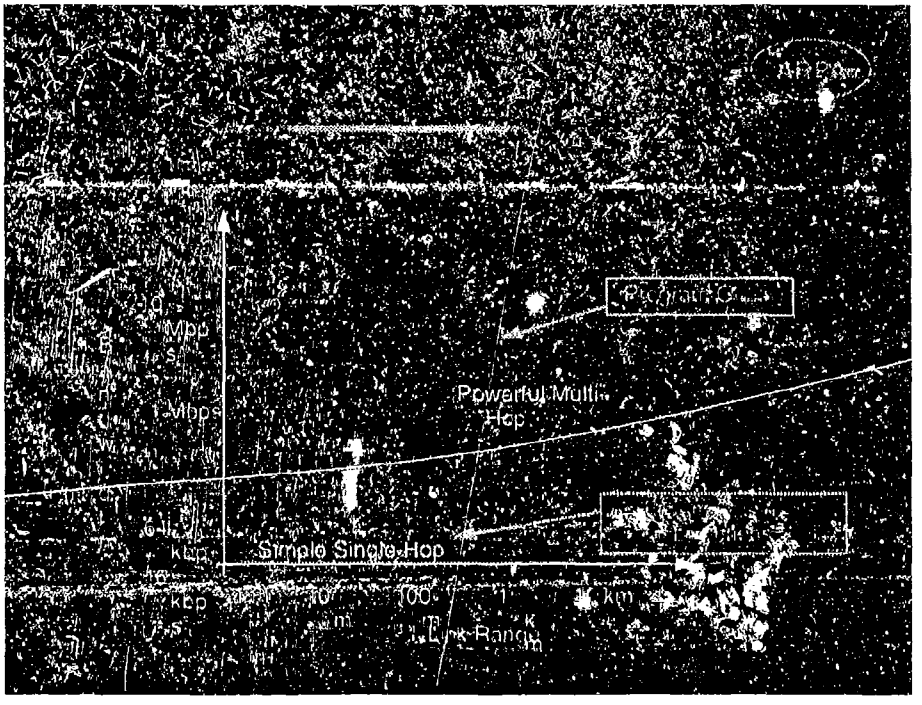
The basic infrastructure technology to support mobile operation can be thought of as four levels. At the lowest level, we have the basic low-power, highly capable hardware and firmware to permit operation in motion.

At the next level, the untethered nodes are tied together with networking technology to provide a robust communication network.

Since the need is for end-to-end communications across both wireless and fixed networks, an end-to-end networking architecture is required.

Finally, to fully exploit the mobile communications capability, an effective mobile computing environment is needed that can deal with changing and sporadic connectivity.

I'll now take a minute to talk about each of these areas.

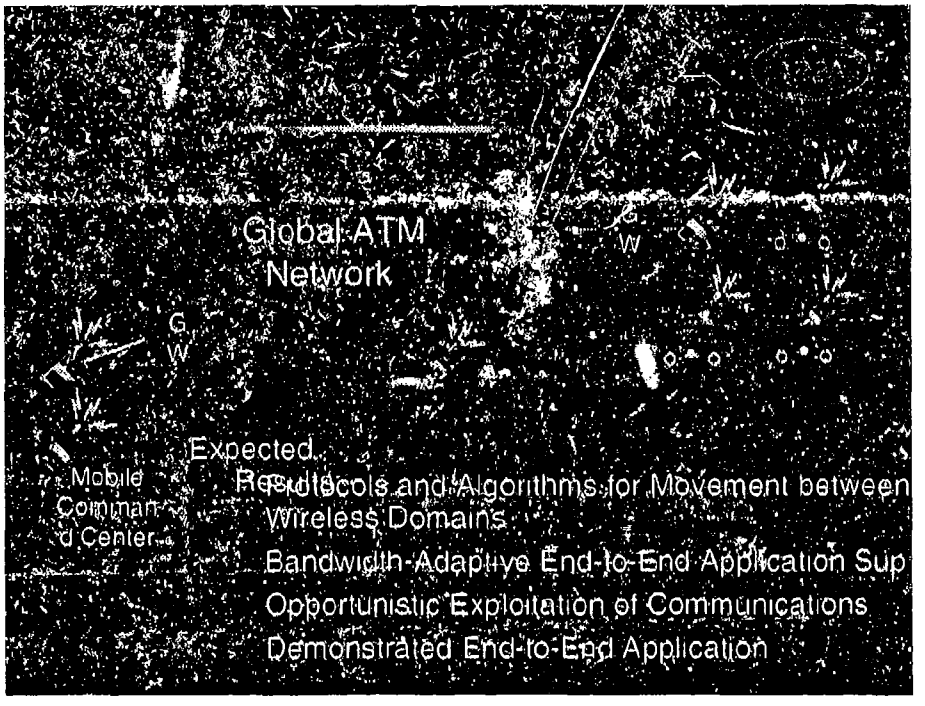


As I indicated, the commercial world is primarily driven by such applications as cellular telephone, and so the likely capabilities will be roughly bandwidths of 64 kbps at several km or, at the other end, multi-mbps in local environments, for example within a room. Furthermore, the networking capability of these nodes is likely to be oriented towards simple single hop architectures.

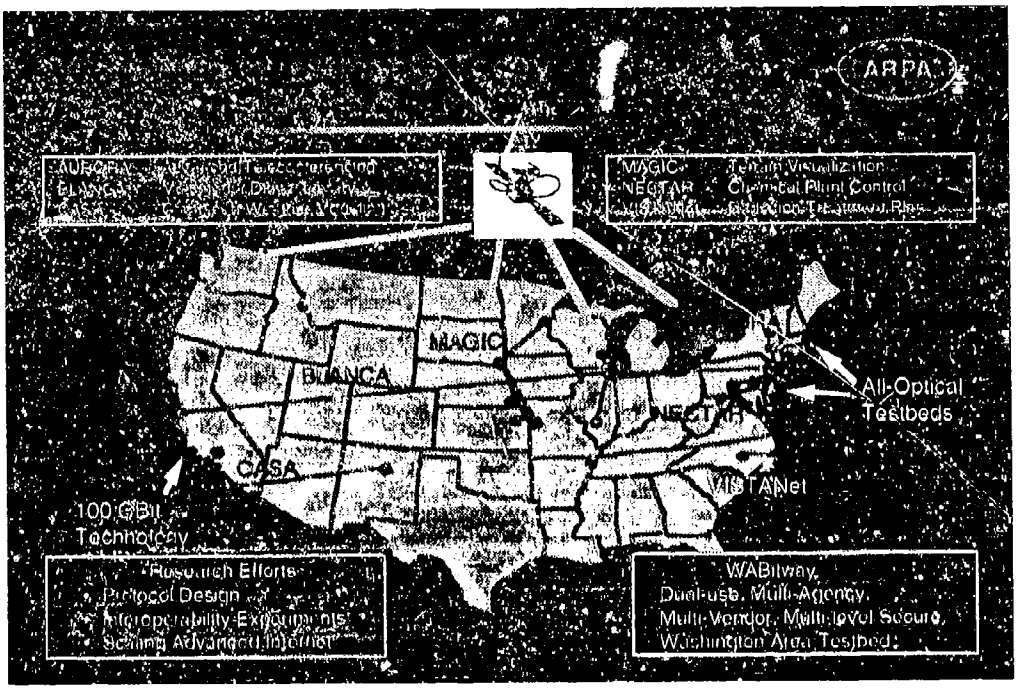
The goal of this portion of our program is to greatly increase the available capability for military applications. We are aiming at achieving 1+ Mbps at roughly 10 km in a handheld unit. Furthermore, it will have sufficient signal and computer processing capability to support robust and survivable networking.

This all needs to be done in the context of available commercial units. Hence, the planned approach is to work with industry towards the goal of a product line of radios so that 90% of the requirement is satisfied by the commercially available unit, and it is enhanceable for the remaining 10%.

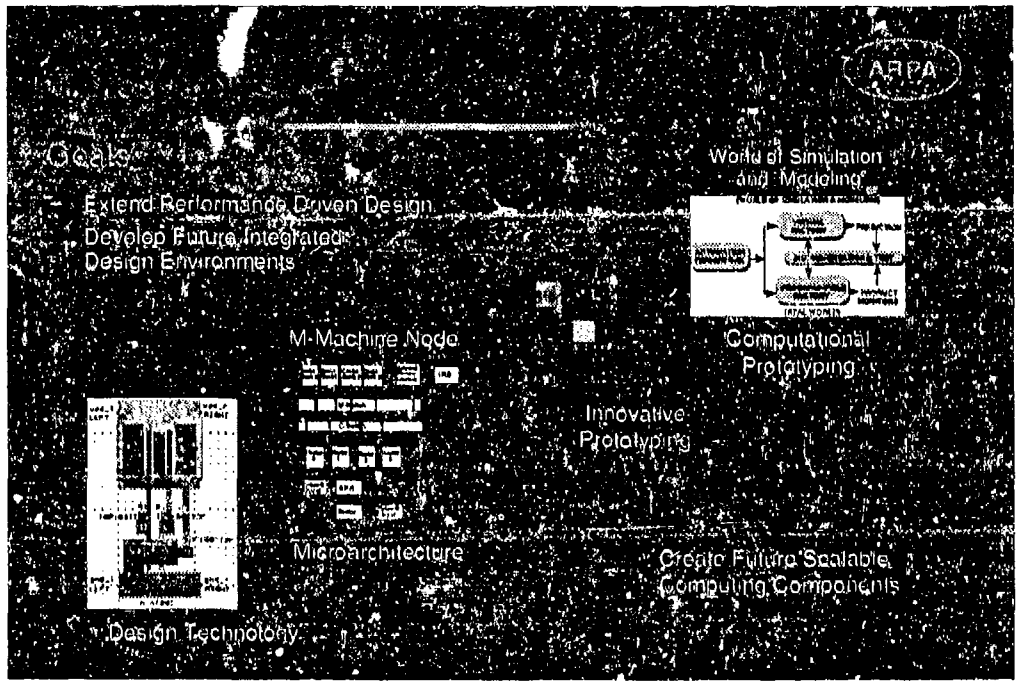
There are several other important issues to be dealt with at the node level. As frequency allocations are shifted from the military to the commercial sector, it will be important to retain military deployment capability. The military in the future will have to operate in a variety of terrains including urban. Modeling of propagation in such environments is difficult.



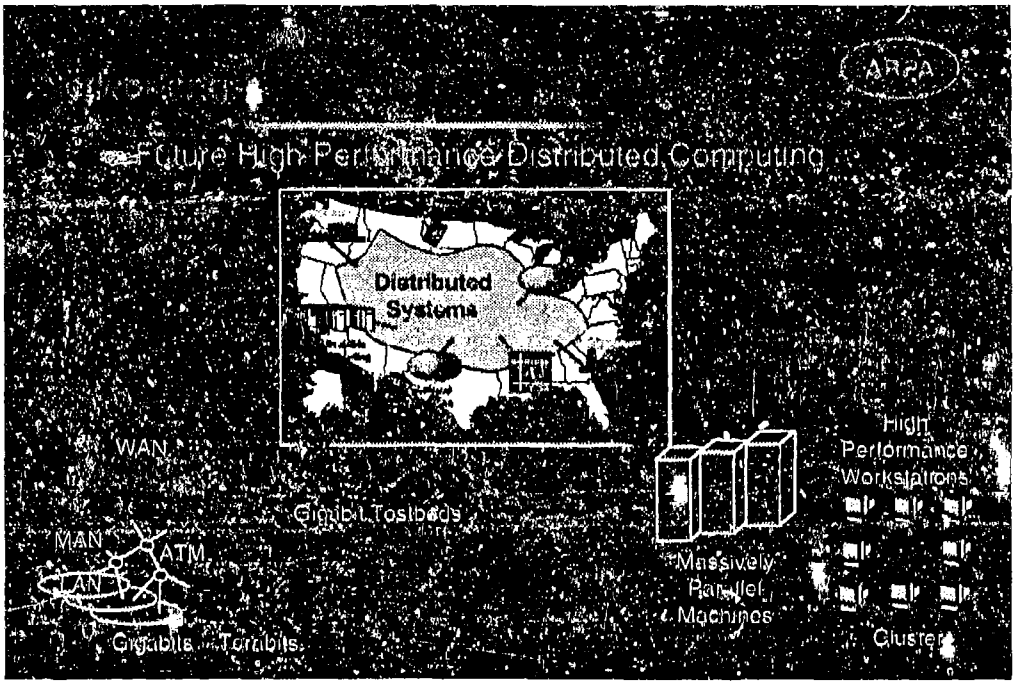
The requirement for communications is on an end-to-end basis, incorporating mobile radio, satellite, terrestrial wired networks, and whatever else is available. The military needs to extend its communications infrastructure to a variety of environments with little notice to support rapid deployment. Thus, while the commercial world is developing a ubiquitous infrastructure, the military needs a ubiquitous capability for rapid extension of the infrastructure. This part of the program is developing the end-to-end networking technology that will support mobility between networks as well as permitting applications to negotiate with the networks to obtain the required level of service.



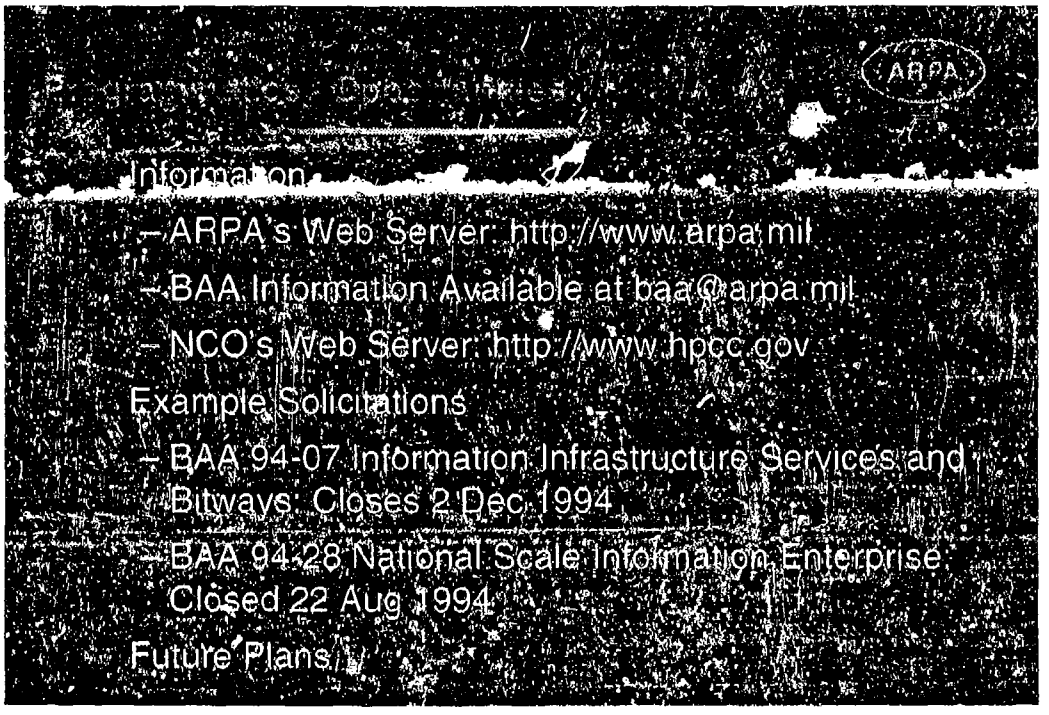
As computation becomes more and more distributed, networking becomes the important glue to put it all together. ARPA has of course been laying the foundation for high performance networking for a number of years. The Gigabit Testbeds, sponsored in partnership with NSF, provided numerous experimental results in high speed networking. ARPA continues to investigate this area and is working towards moving the results of its programs into the commercial infrastructure. For example, ARPA and the Defense Information Systems Agency are managing a multi-agency, multi-agency ATM/SONET, 2.5 gigabit per second system. These research efforts are addressing interoperability, application support, and network management.



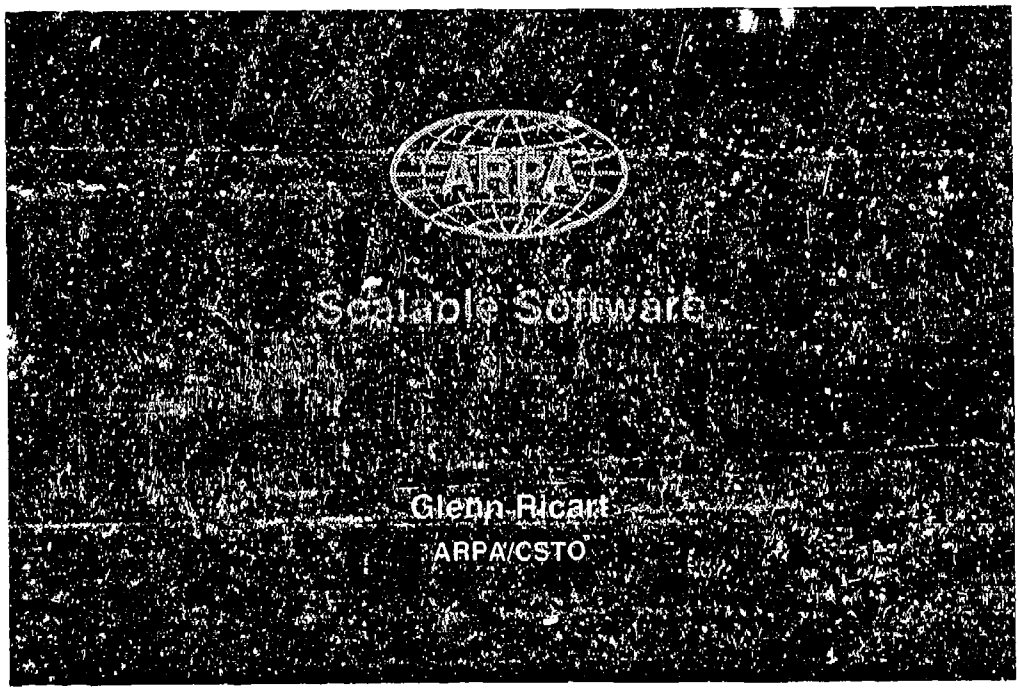
Microsystems provides the novel and unique capabilities to build and apply scalable units to computing, and build upon the industry's technology base. Extending performance-driven design to include reliability, low power, and other critical needs are important to the future design systems. Real components,with novel microarchtectures, become the drivers to prototyping systems. The ability to build a computational prototyping process using the high performance computing is a major goal of the future part of this program.

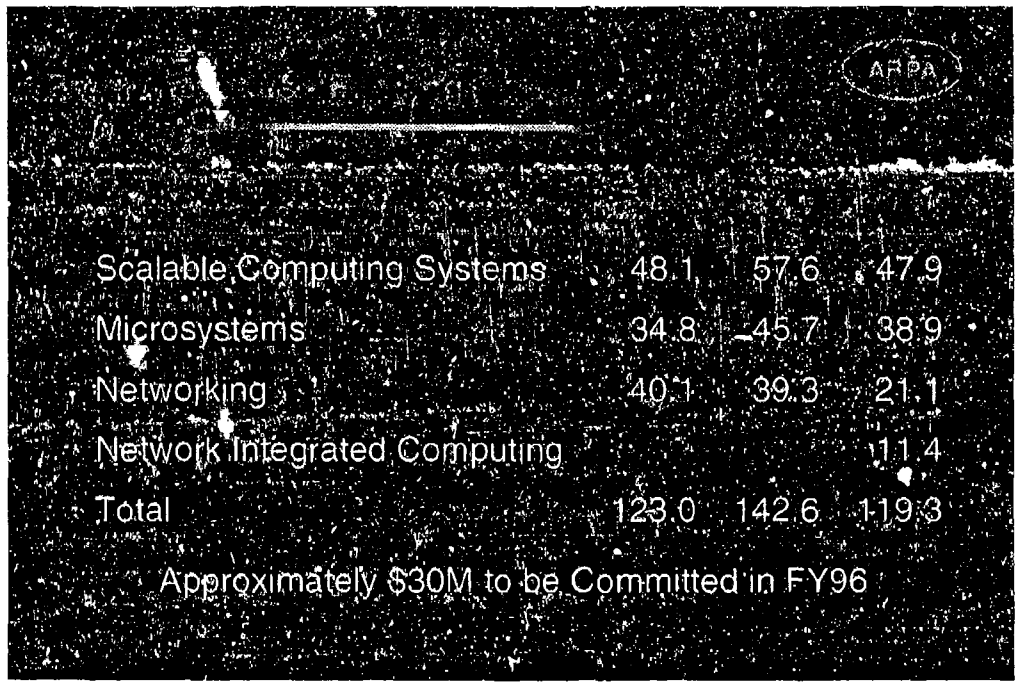


As networks become more powerful and distributed systems more extensive, scalabity in computing must address the limitations and interactions of the communications infrastructure. We are currently formulating a new program to consider issues such as the impact of network latency on distributed computing and the design of the computer to incorporate communications as an integral element. This program is being aimed at identifying and solving the problems associated with the convergence of processing and communications into future high performance distributed computing systems.

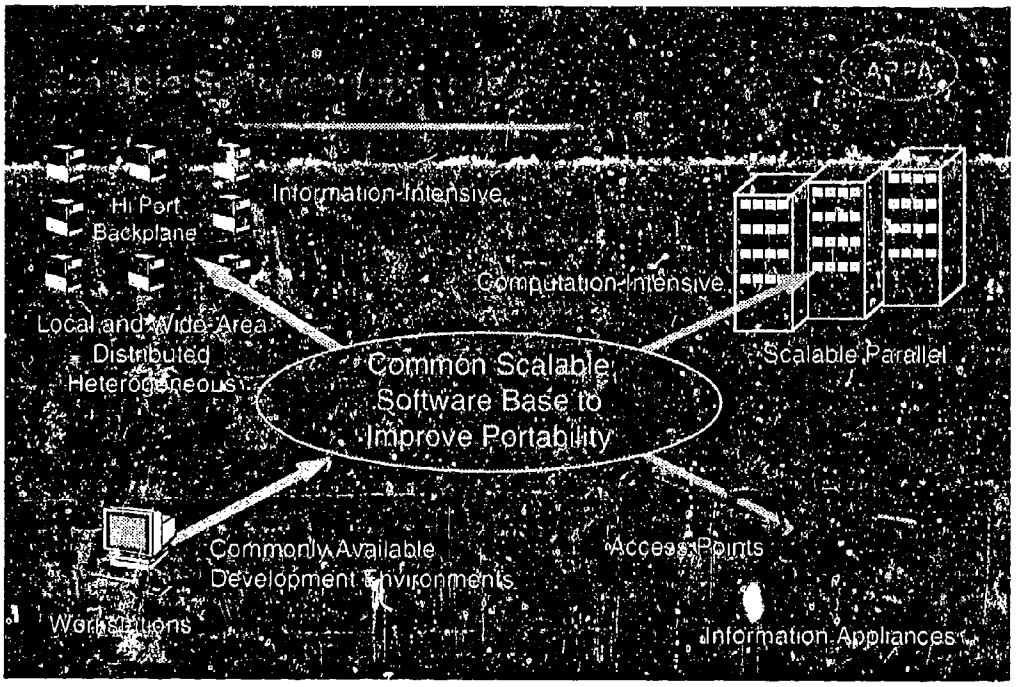


Here are some places you can gain more information about the Computer Systems Technology Office's programs. Examples of recent solicitations are the two BAA's listed. We expect to issue additional BAA's, for example, in the area of Networked Integrated Computing.


ARPA
Scalable Software
Glenn Ricart
ARPA/CSTO

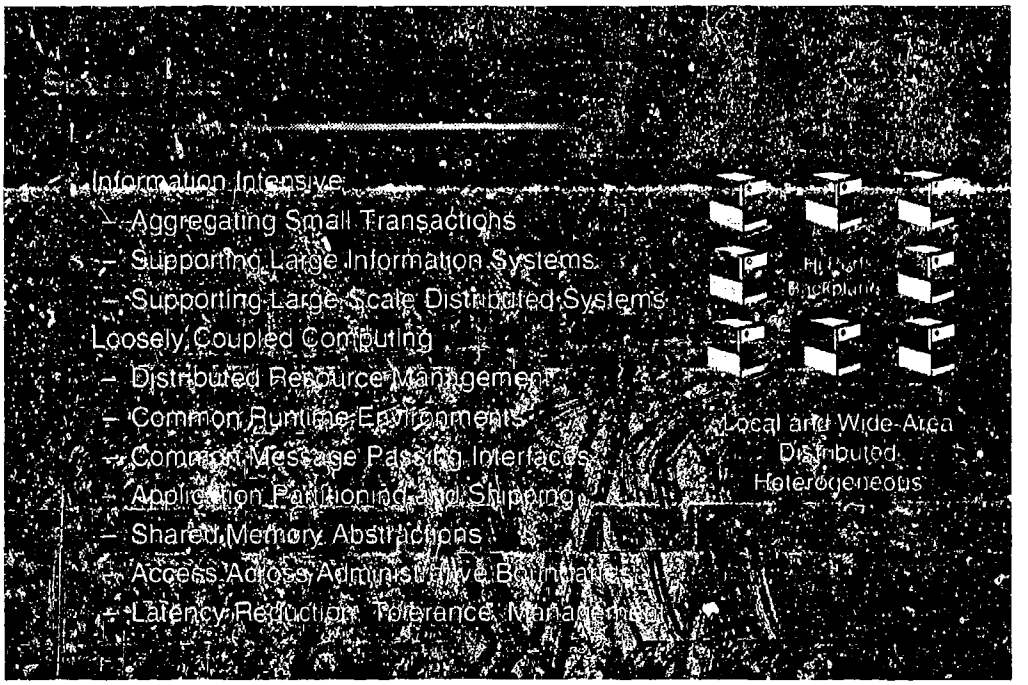


The funding for the areas that I have discussed are shown in this slide. There is approximately $36 million of uncommitted funds for FY96.



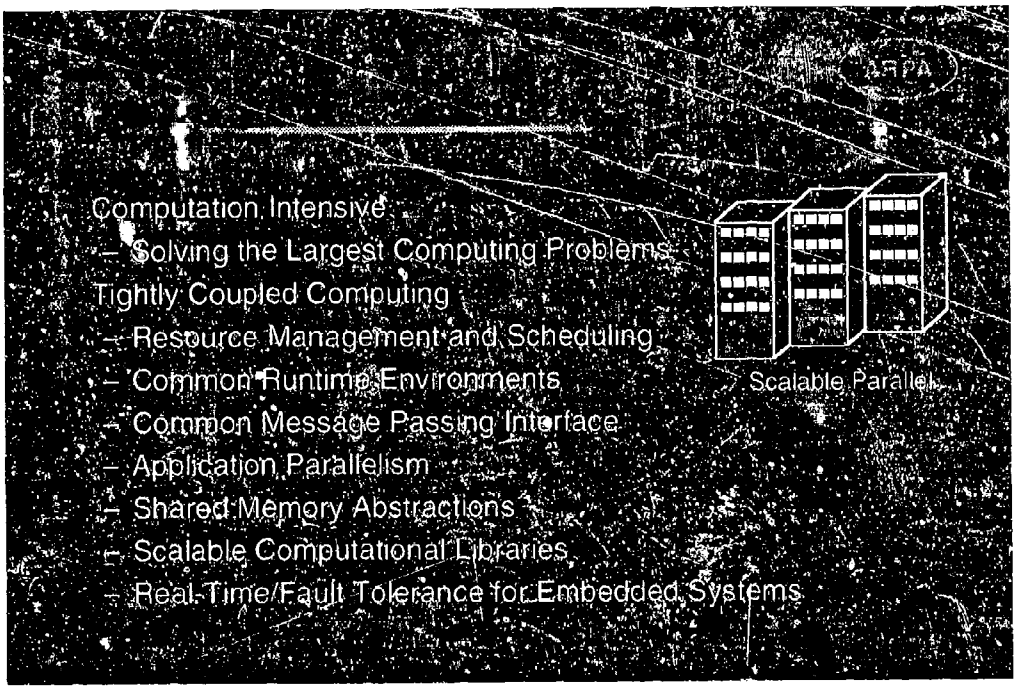
While we have been very successful in creating large parallel machines, networks of workstations, and even personal information appliances, we have not been as successful in creating software that is adaptable or scalable to these distinct environments.

Is there a commonality in these environments that could be exploited if we knew how to do so? Let's examine the challenges facing each of these types of computing.



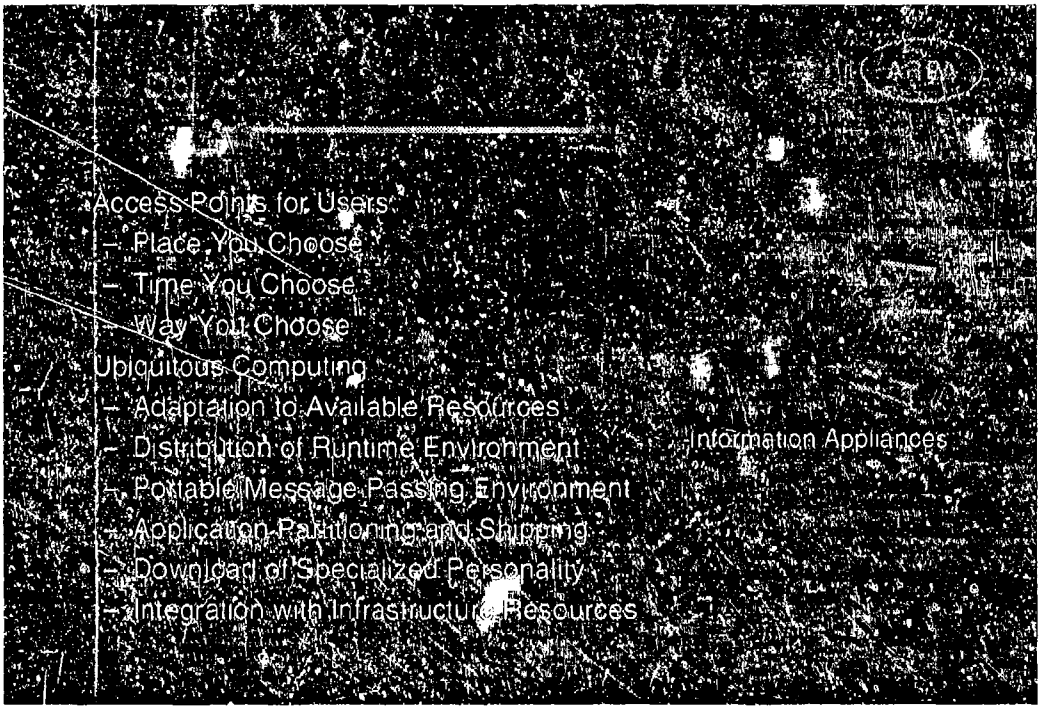
Networks of workstations or loosely-coupled computing environments suggest issues of:

- distributed resource management
- common runtime environments
- common message passing interfaces
- application partitioning and shipping
- appropriate shared memory abstractions
- access across administrative boundaries
- latency reduction, toleration, and management



Now, let's look at highly parallel architectures and their challenges:

- resource management and scheduling
- common runtime environments
- application parallelism
- shared memory abstractions
- scalable computational libraries
- realtime and fault-tolerance for embedded systems

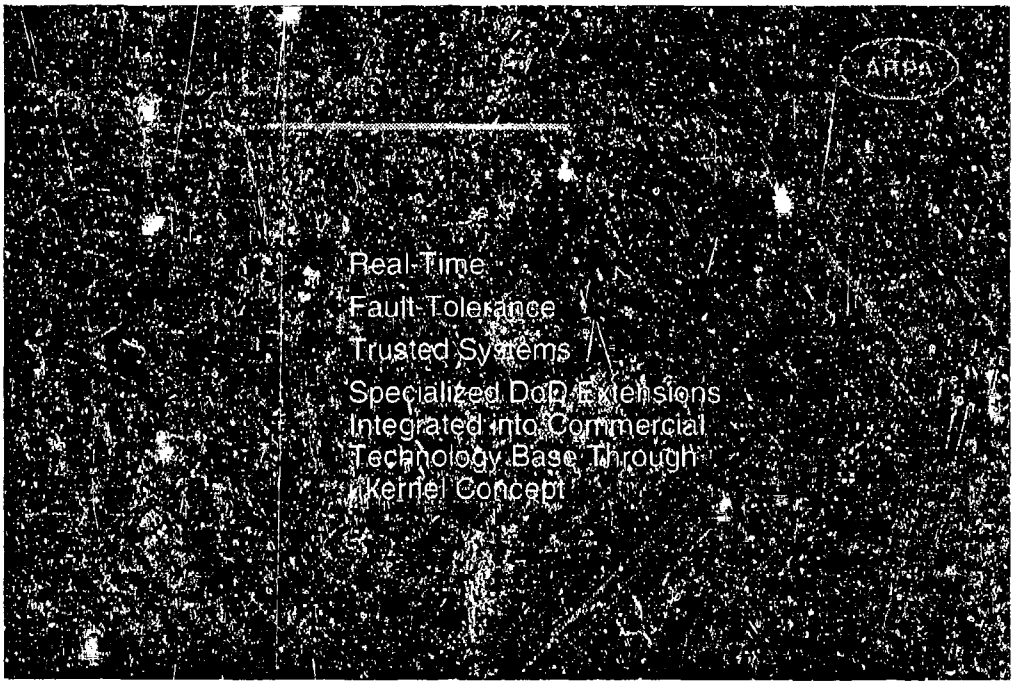


Information appliances, when we scale down, are part of the new move toward ubiquitous computing. The salient issues here are:

- adaptation to available resources
- distribution of runtime environment
- portable message passing environment
- application partitioning and size
- downloading specialized personalities
- integration with infrastructure resources

Note that many of these issues developed independently of one another actually have a common framework based upon

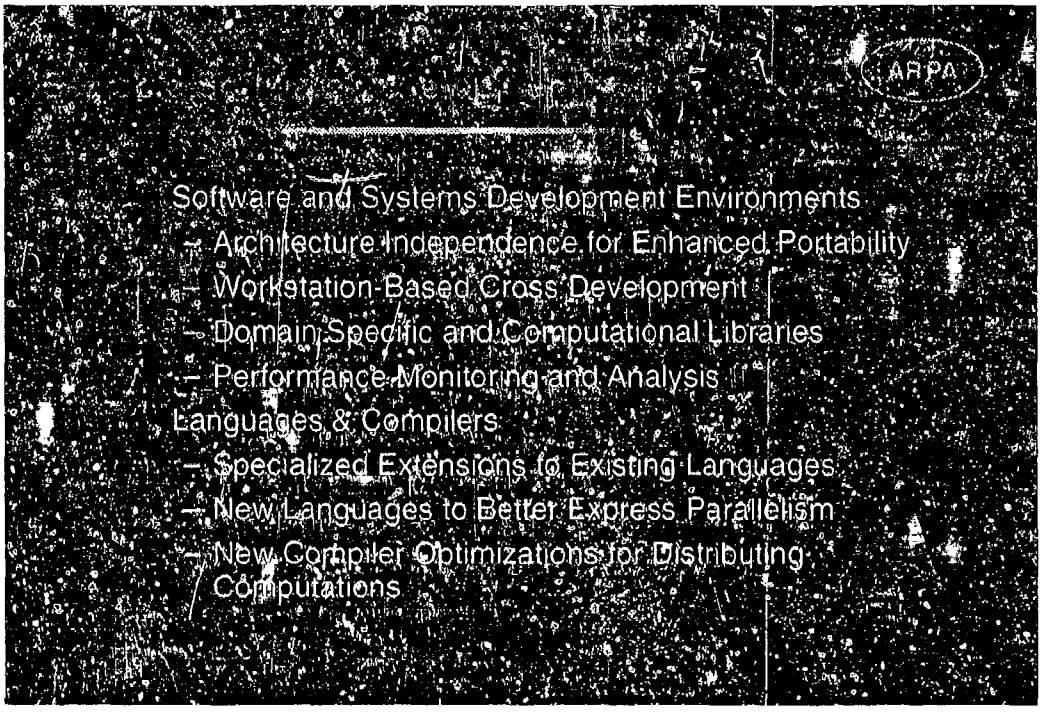
- resource management and adaptation
- runtime environments and distribution
- message passing interfaces and portability
- application partitioning, parallelism, and shipping
- latency reduction, fault-tolerance, and distributed management



The Department of Defense requirements in scalable computing fall in these major areas:

- real-time
- fault-tolerance
- trusted systems (secure systems)
- specialized DoD extensions

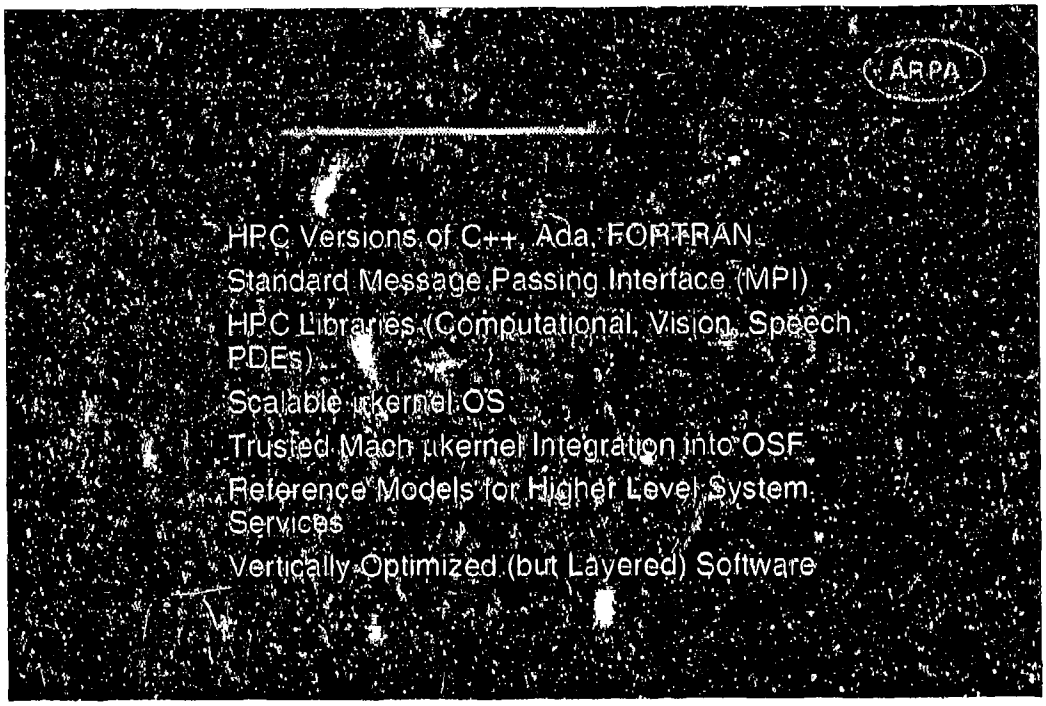
Only the last area is of interest only to the DoD, but commercial design and development in the first three areas is insufficient for DoD requirements. We want to reduce the amount of unique DoD code being generated, and believe that ARPA and other DoD organizations need to stimulate appropriate extensions to commercial operating systems to fulfill these requirements. In some cases, code for these requirements will be integrated with commercial operating systems at our instigation. In other cases, we will ask for hooks with which extensions to handle these areas may be attached.



Our work in software and systems development environments stresses:

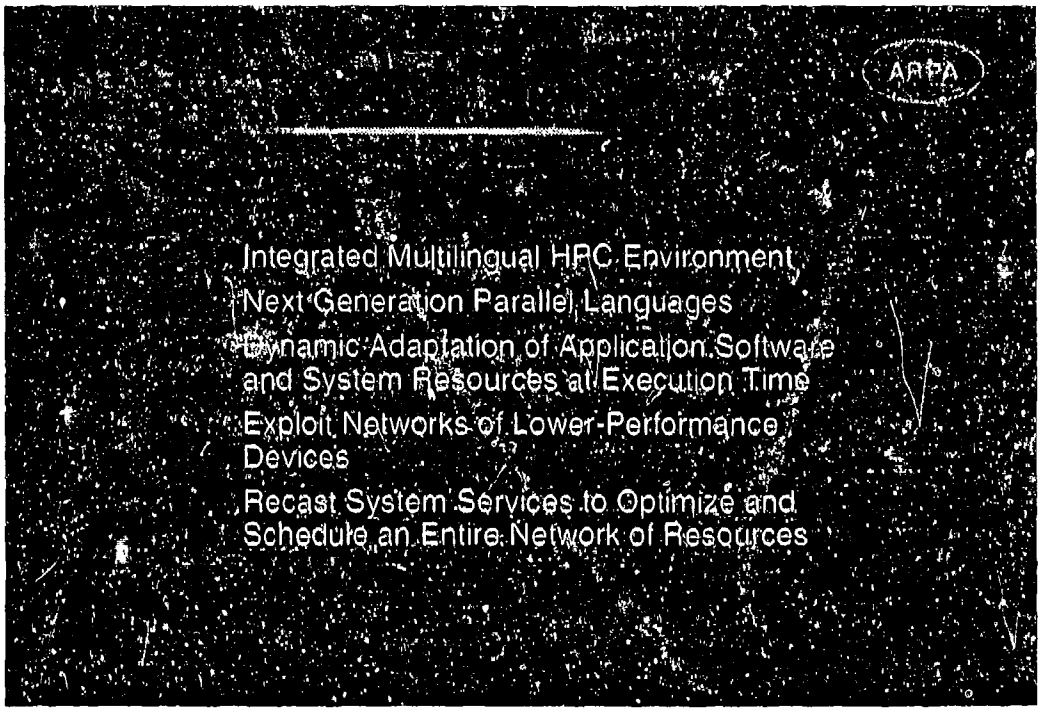
- architecture independence for portability
- workstation-based development and debugging
- environment-specific computational libraries
- performance monitoring and analysis

The languages and compilers are intended to extend existing languages as well as developing new languages that better express parallelism. Compilers for these languages must be able to generate different types of codes to help adapt the code to the domain or environment in which it is running.



Recent ARPA accomplishments in HPC Software include:

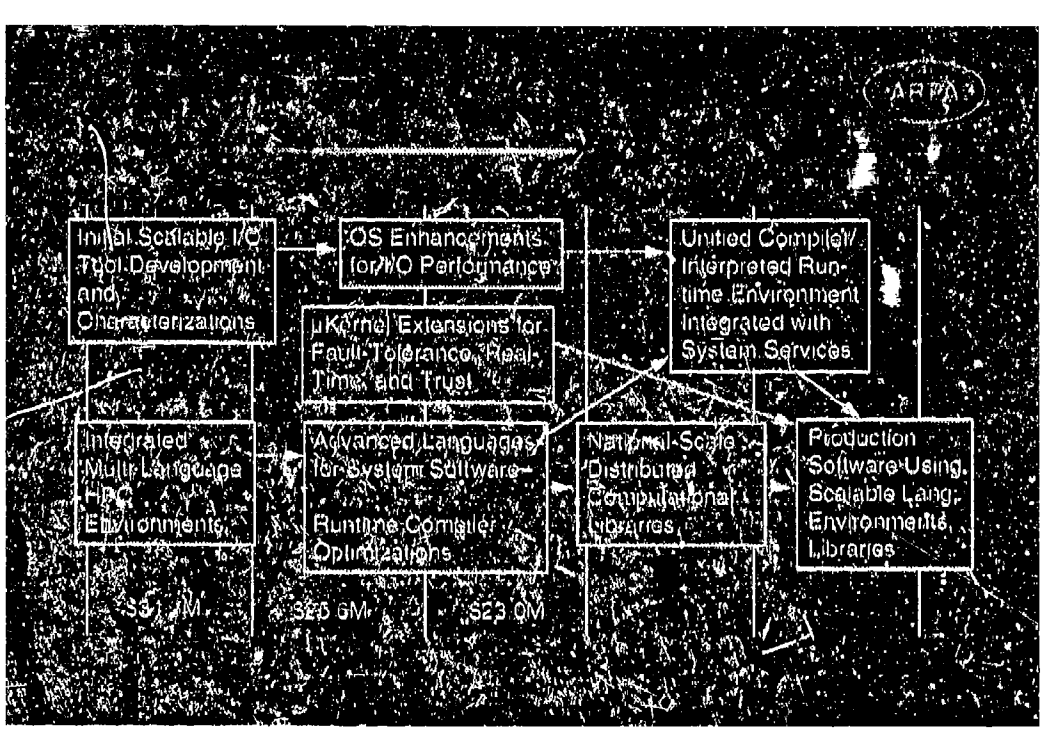
- HPC versions of C++, Ada, and FORTRAN
- A standard message passing library (MPI)
- HPC libraries for computation, vision, speech, and partial differential equations)
- The landmark development of a scalable microkernel OS
- Integration of Trusted Mach into the Open Software Foundation research base
- Reference models for higher level system services
- Vertically optimized but layered software



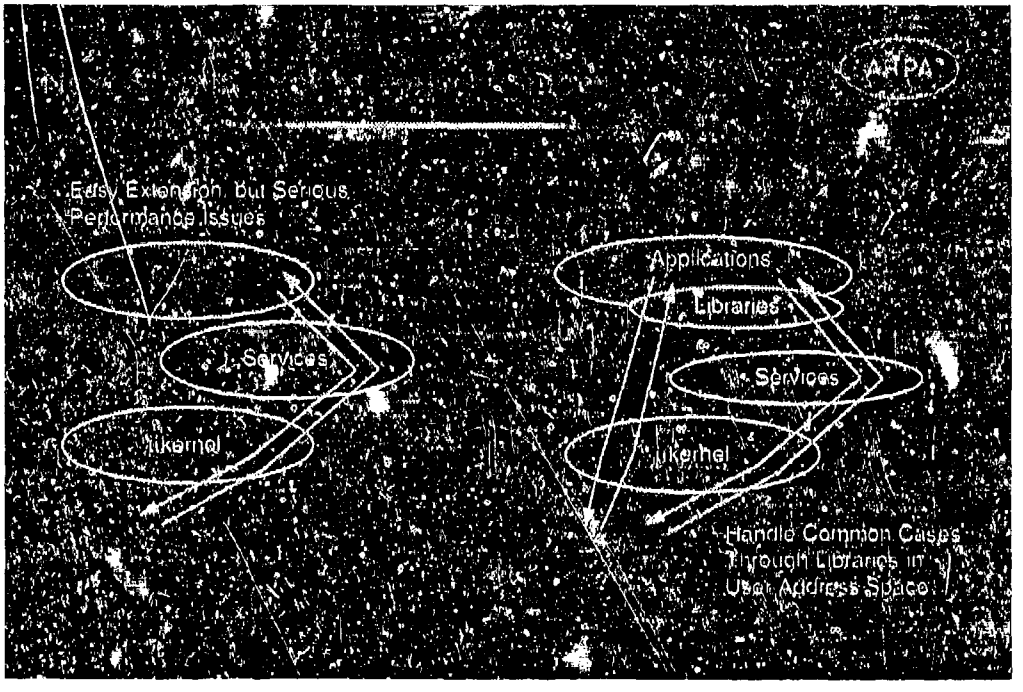
In the future, we expect to create a multi-lingual HPC environment which uses next generation parallel languages. Applications software and system software will both adapt at execution time to run well on the hardware platform available and will exploit highly parallel sets of processors as well as networks of lower-performance devices. System services will be recast to optimize and schedule entire networks of resources.



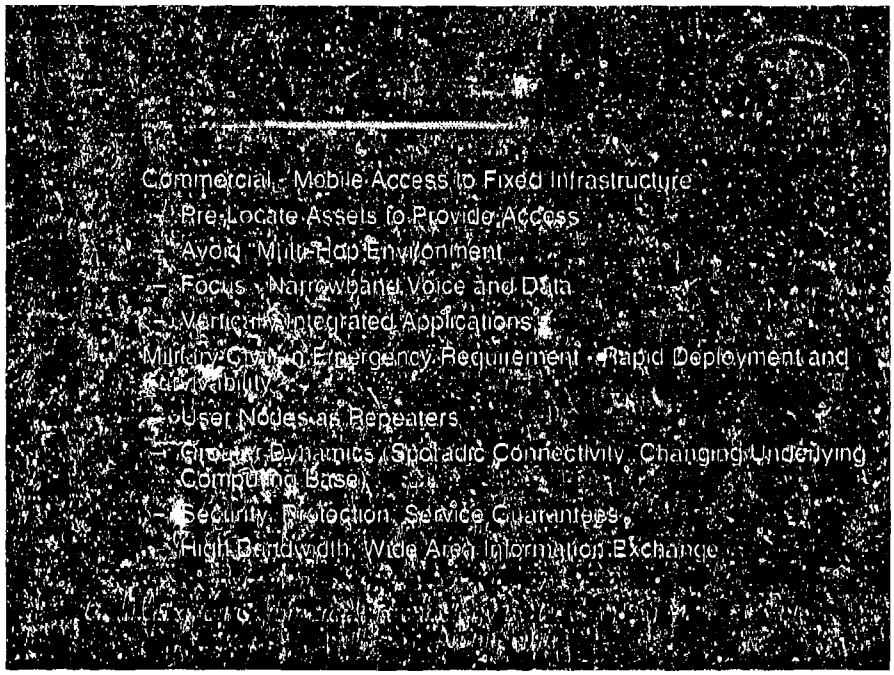
I will be discussing some of the ARPA efforts in mobile information systems and wireless technology. As you will see, there are several offices involved, and we are coordinating our various programs across the offices to sustain a coordinated thrust in this area.



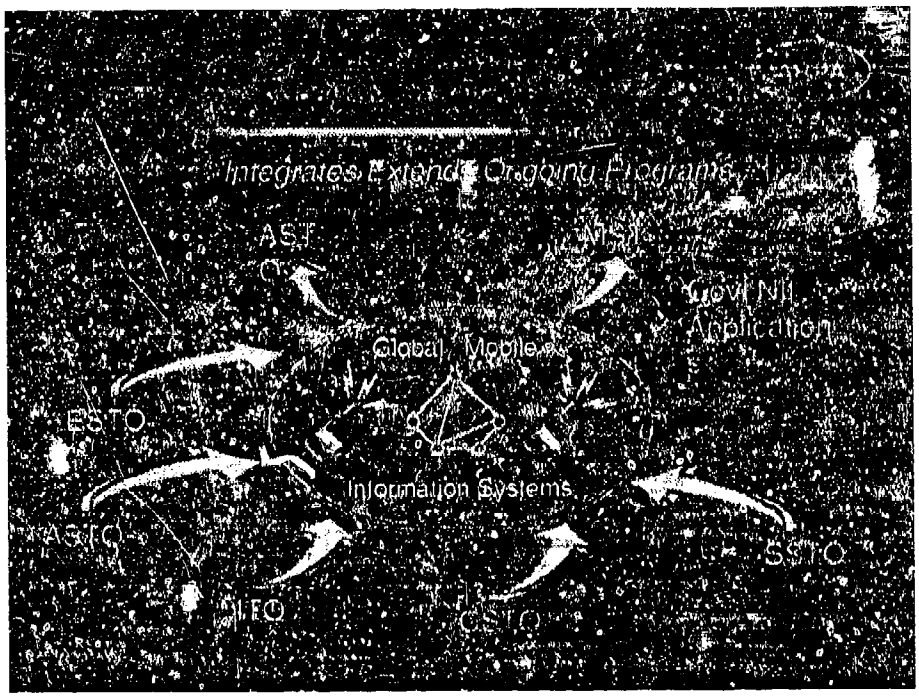
This last slide shows the approximate timeline and funding levels for this program. The top line shows the development of scalable software tools, extensions, enhancements, and runtime environments. The bottom line looks at the languages and their runtime environments. We expect to see an integration of these two lines in the FY98-99 time period.



ARPA has pioneered the now widely-used microkernal approach. One of its limitations, however, is the overhead involved in passing between domain and protection layers as shown in the diagram at left (I-4.9). We are reducing the effect of that overhead by finding various vertical optimizations that preserve layering, such as executing common cases in libraries in the user's address space. With this technique, the number of expensive boundary crossings is dramatically reduced while the layering remains intact.



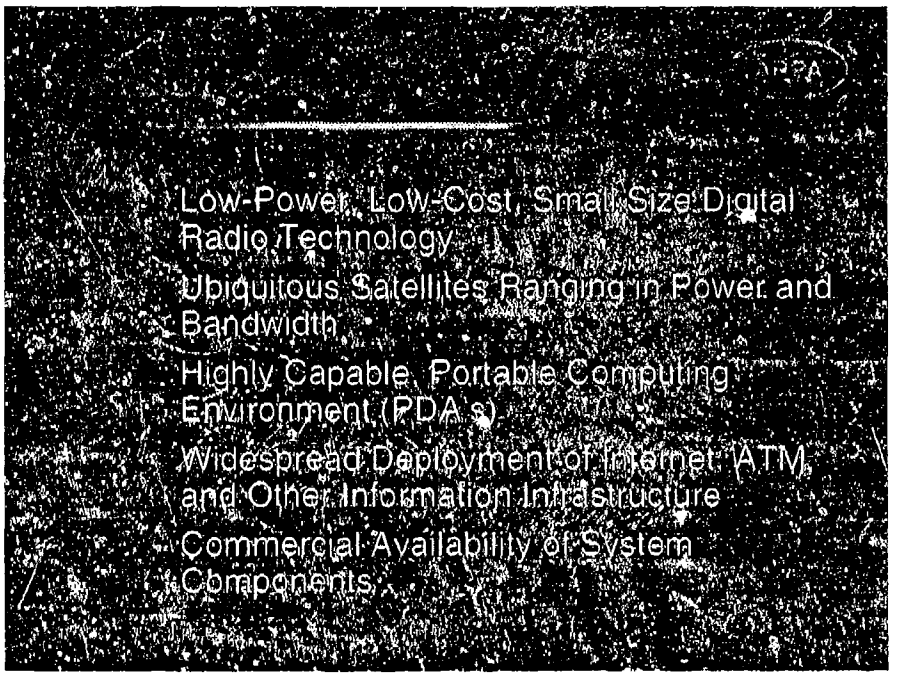
There are underlying differences in the commercial environment compared to military and civilian emergencies that result in some of the differences. Because the commercial world is much more benign and there is time to establish a supporting infrastructure, the resulting architecture will not naturally support the rapid deployment and survivability requirements of the military. For example, a commercial system can establish a network of fixed base stations tied into the wire-based network, while the kinds of force projection expected in a military environment requires the use of multi-hop networks. Furthermore, due to survivability requirements, nodes must be used opportunistically as repeaters. Finally, military requirements for information and computing while in the field demand higher levels of performance than those expected in a commercial world.



As I indicated, the thrust in mobile and wireless technologies at ARPA involves several of the offices.

ESTO is developing some of the underlying low power wireless technology that will make possible these new capabilities. CSTO is developing design methodologies that will allow the development of modular, low-power untethered nodes. ASTO and MTO are investigating systems techniques for militarily capable radios.

CSTO is developing both wireless and end-to-end networking technologies that will exploit these advances to provide a communications infrastructure that supports a high degree of mobility, robustness, and rapid deployment. CSTO is also developing a computing infrastructure that will permit access to information and computing resources in a location-transparent manner. SSTO is developing intelligent information systems that can exploit these capabilities. Finally, ASTO and MSTO are exploring potential military applications of these capabilities. Because these capabilities are also of interest in civilian environments, there is good potential here for spin-out of the technology.



This is not to say, though, that the military should not take advantage of the tremendous advances in underlying technology becoming available in the commercial sector.

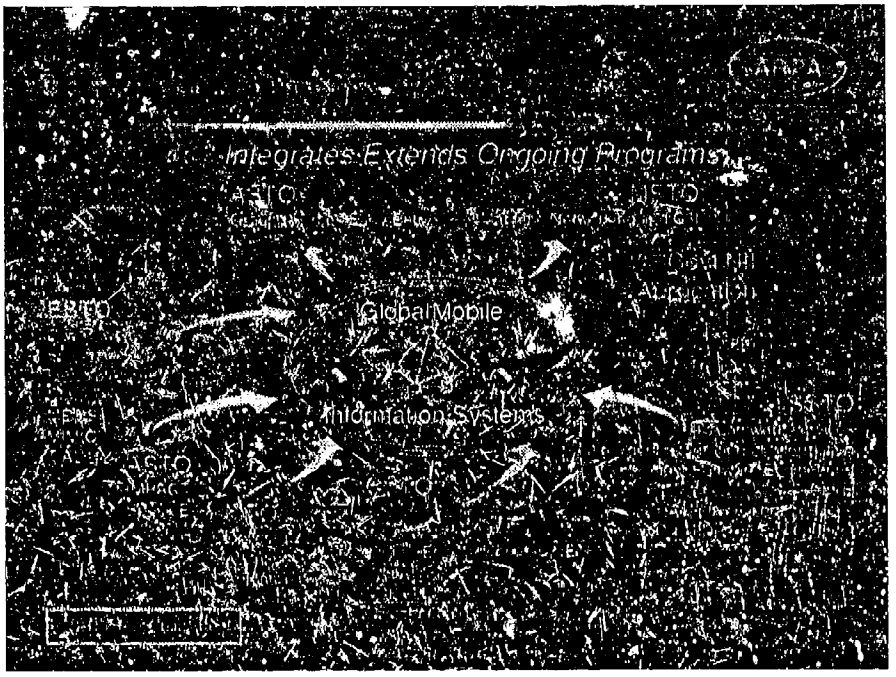
digital signal processing and other components are starting to appear in commercial world, and ARPA initiatives are producing relevant next-generation technologies

satellites from geosync through leo (like iridium) need to be integrated into overall communication network

PDAs and similar technologies can support end user computing and access

there is a global information infrastructure that must be built on and extended into the wireless mobile environment

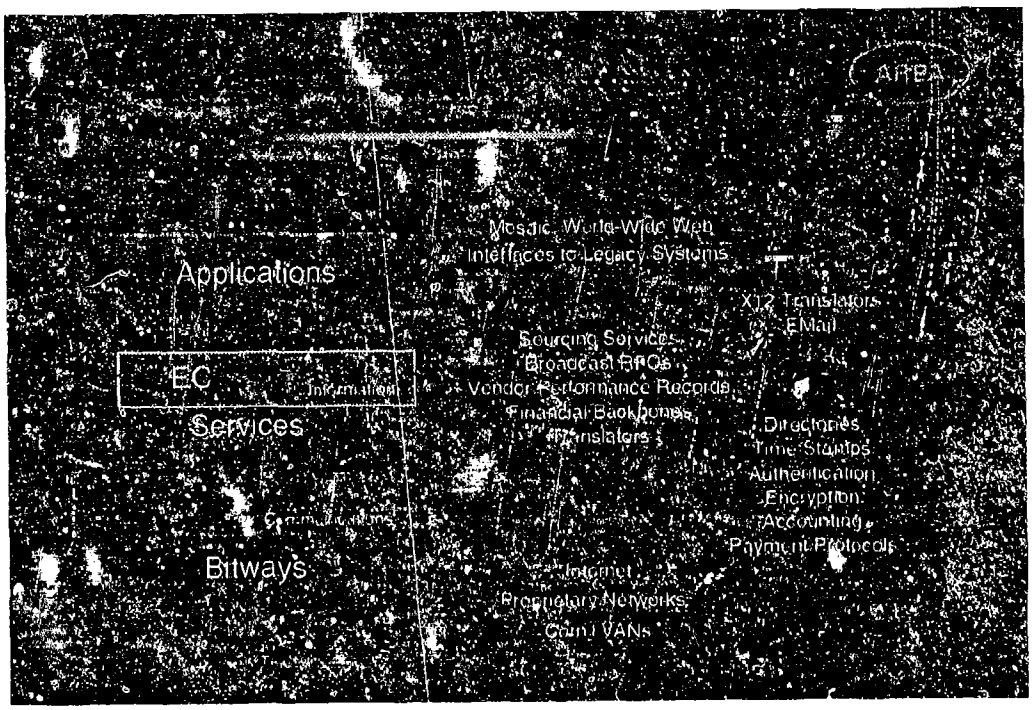
The goal is that ARPA results be integrated into commercial products which then can be integrated into next generation systems



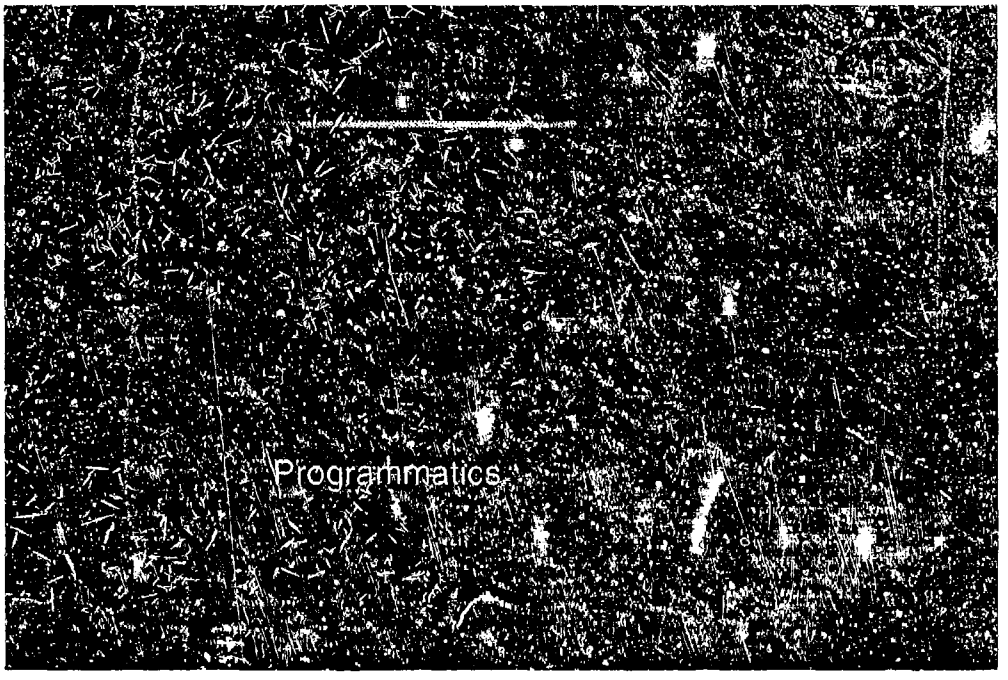
This slide indicates some of the programs involved in the coordinated thrust. Some of these were already being coordinated under a prior thrust in Wireless and Mobile Information Systems (WAMIS). I won't go through the details here, but those who are interested should contact the appropriate office.

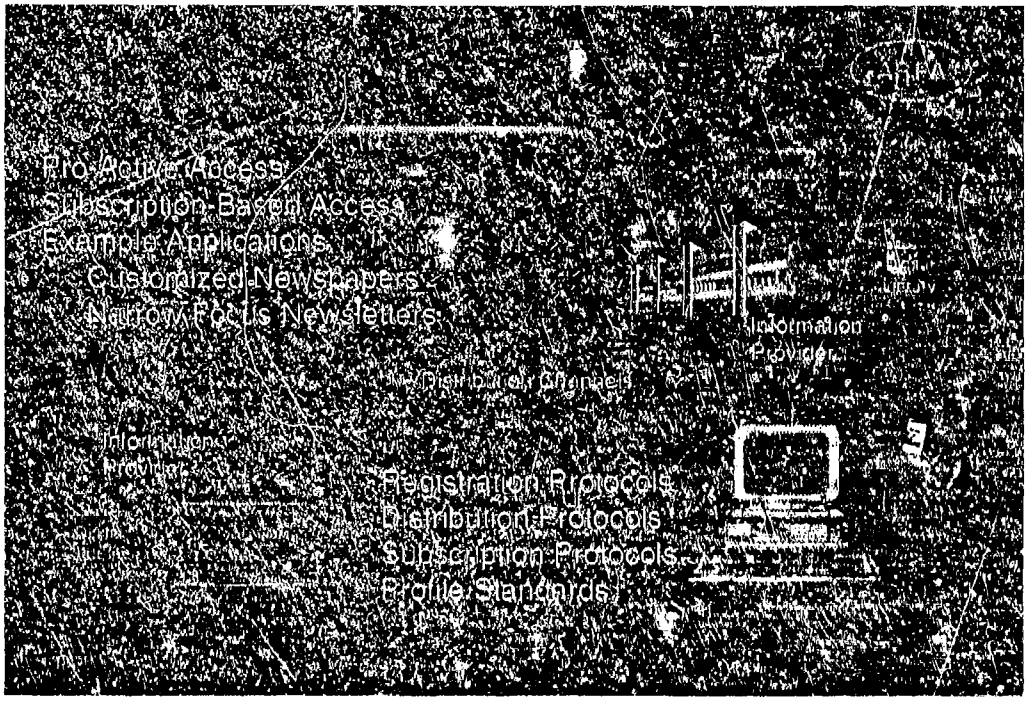


Building upon the untethered node technology, wireless networking technology is being developed that will support mobile operation. The networking technology must be easy to deploy and require little network management through self-organizion. A starting point for this work is the packet radio networking technology explored by ARPA in the early 1980's.

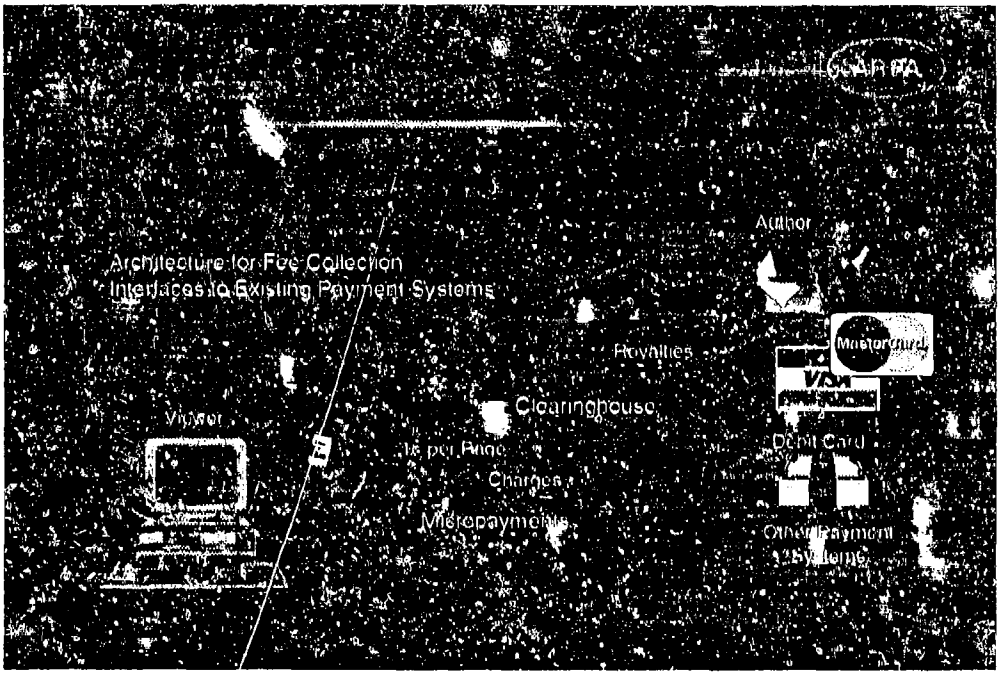


An elaboration of the three layer architecture, illustrating the kinds of access interfaces, commerce oriented applications, high leverage services, and communication/bitway technologies that support electronic commerce.

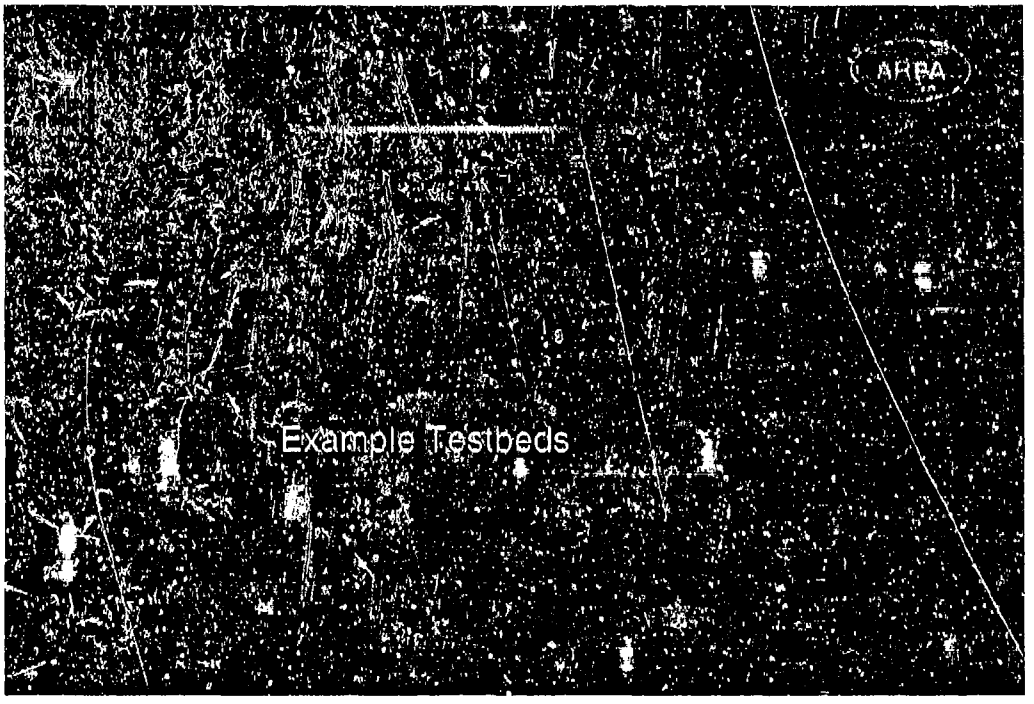

Programmatics

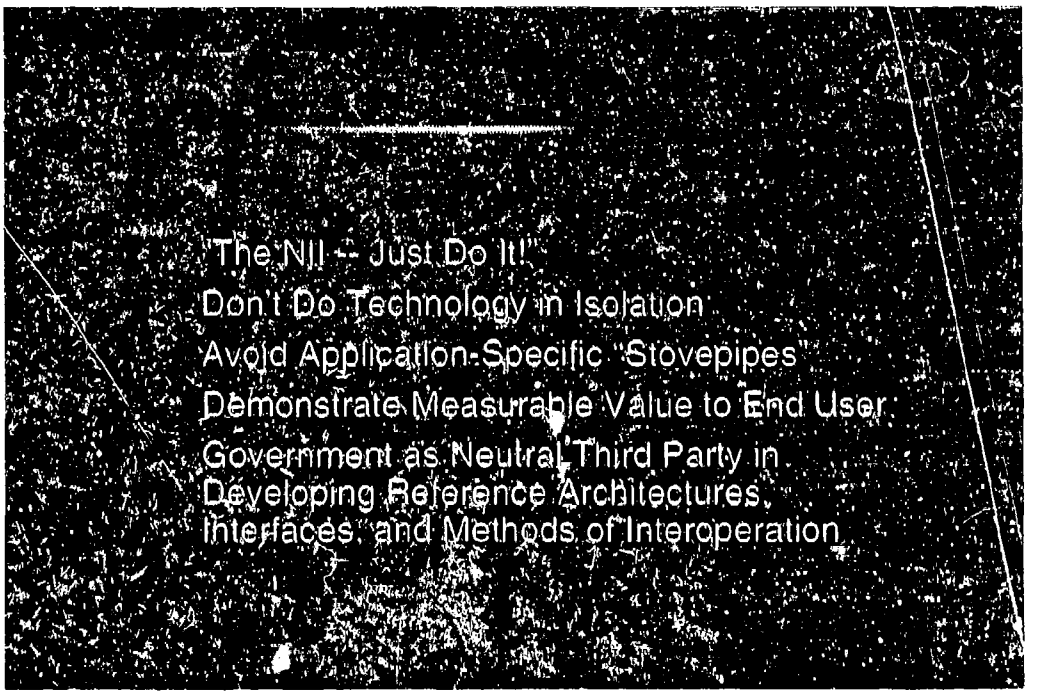


Services for information dissemination, showing the kinds of protocols that need to be developed in a complex, interconnected environment. Documents can be actively "pulled" to the viewer, or passively "pushed" based on subscriptions and interest profiles.



Fee for access are a key to entice business to provide high quality information on the NII. Interfaces to a variety of payment systems will be needed, as will new "clearinghouse" functions that aggregate access charges between users and information providers.

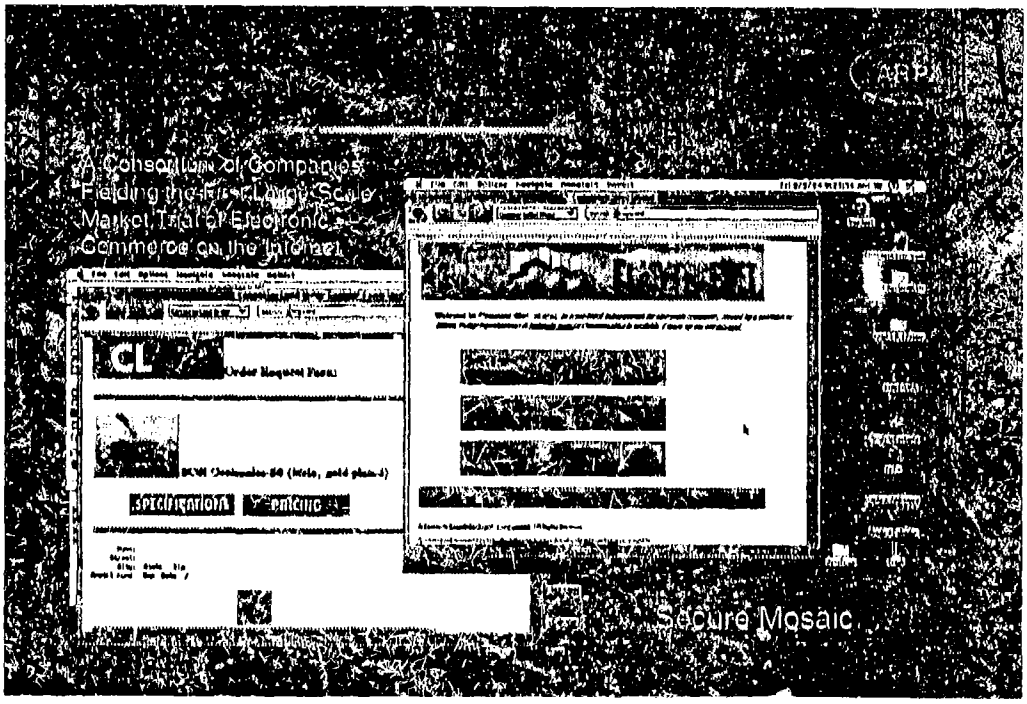

ARPA
Example Testbeds



The need for applications testbeds to drive the development of the service architecture.

The quote is from John Young, former CEO of Hewlett-Packard Corp.

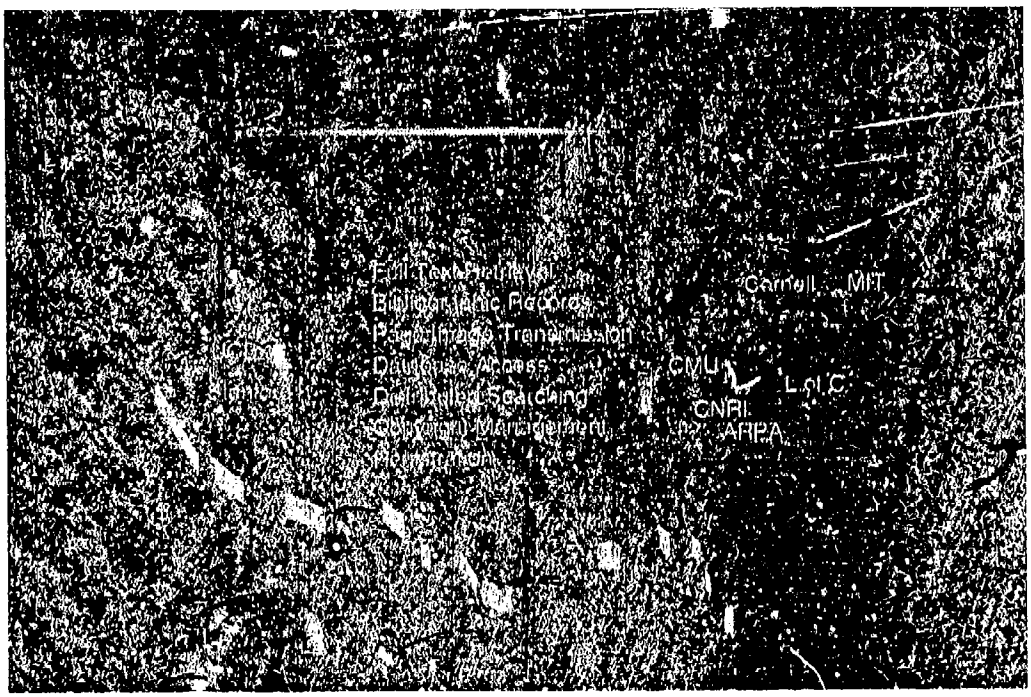
The key thing is getting a high leverage service architecture that can support a diverse set of applications on the NII. Government's role is to work with industry to help define the service architecture.



First ARPA testbed: CommerceNet TRP Project

A deployment opportunity for the manufacturing infrastructure technology developed under the ARPA MADE Program.

A high visibility testbed for ecommerce services over open networks.



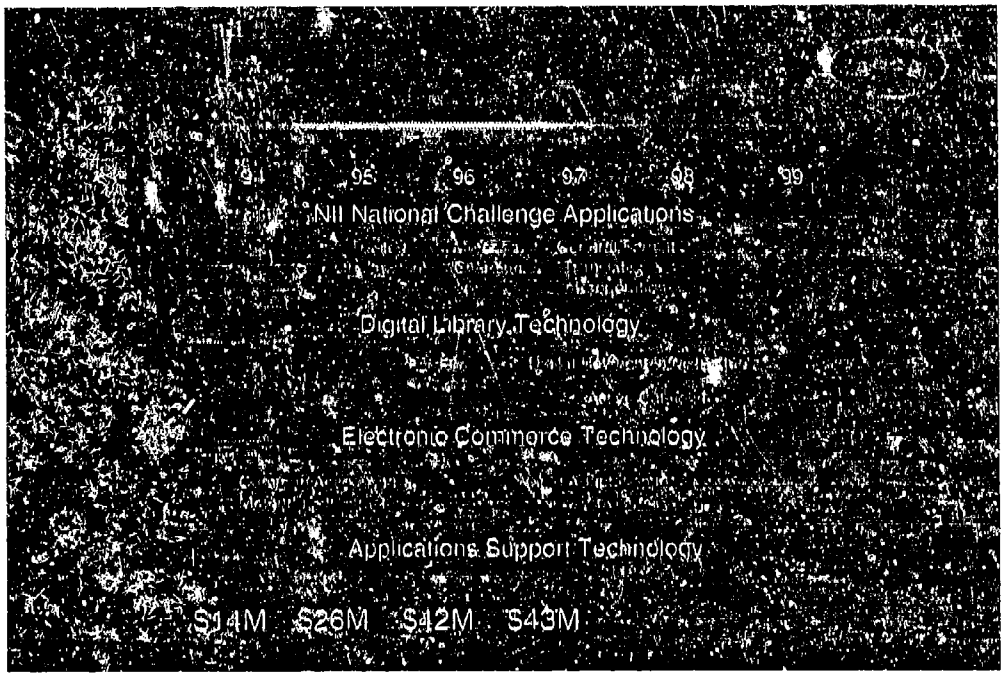
Second ARPA Testbed: Computer Science Technical Report Digital Library

Distributed search, indexing, retrieval

Format interoperability across multi-site library

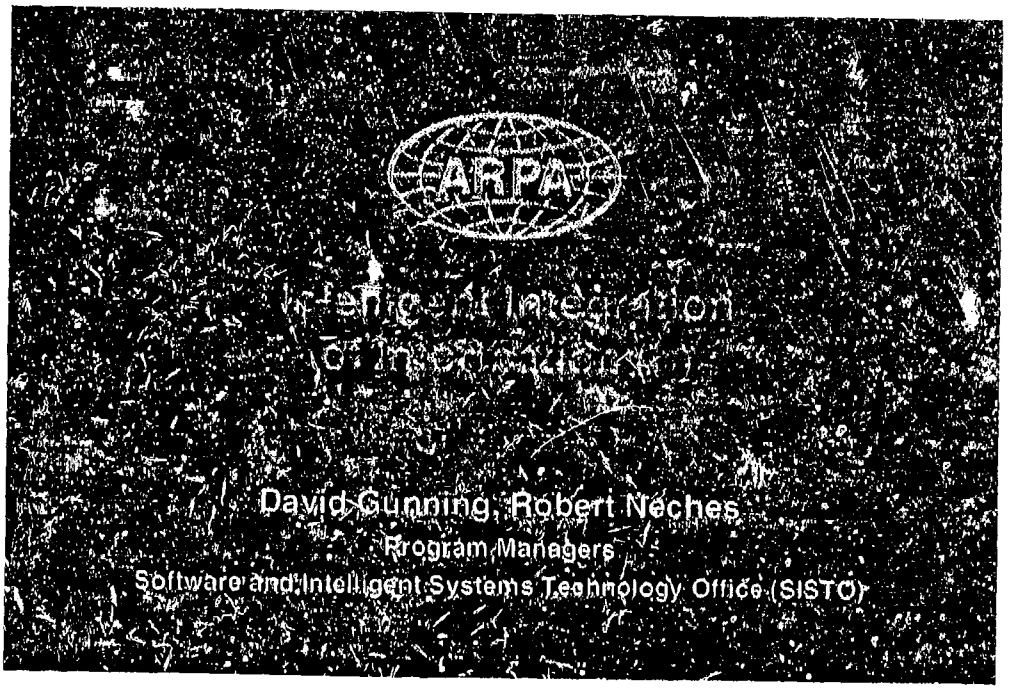
New technology for recording copyright information being prototyped with the Library of Congress (L of C).

This project has spawned a major interagency program in digital libraries including ARPA, NSF, and NASA.

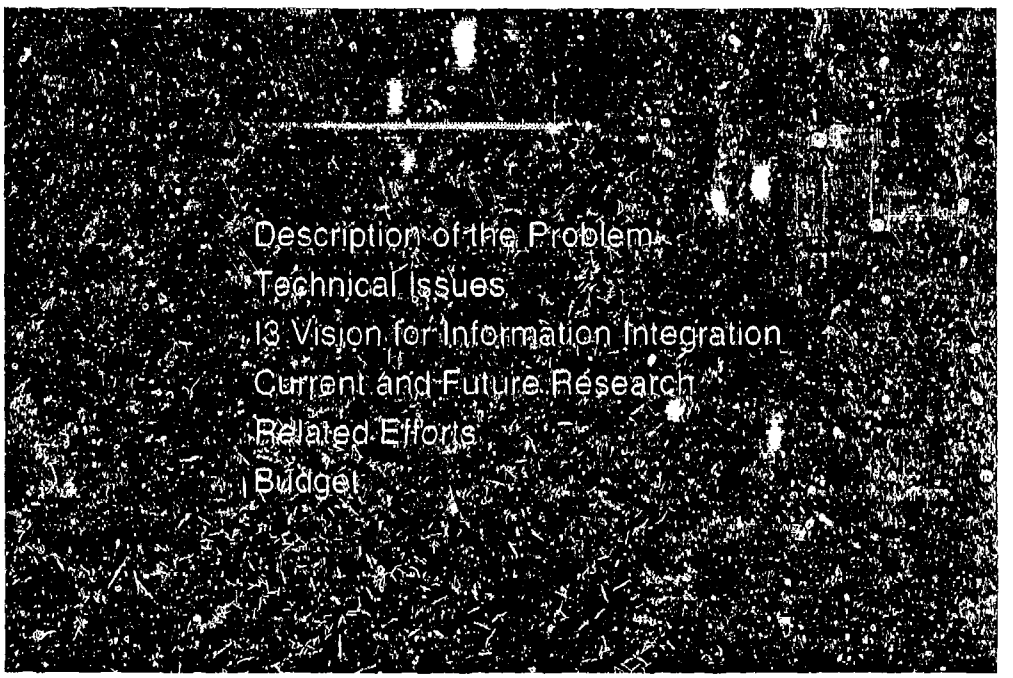


Multitrack effort in digital libraries and electronic commerce technologies. The time line shows the kinds of prototype technologies and when they will be developed. Note how over time the infrastructure capabilities grow to support ecommerce and digital library applications first, and then general "national challenge" applications later.

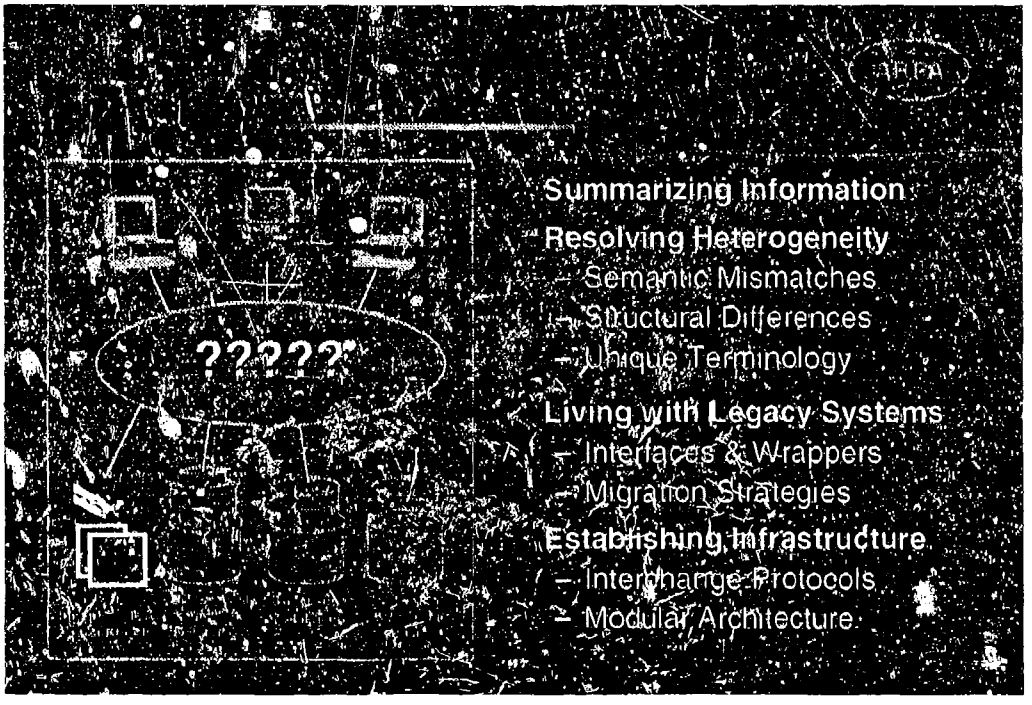
Funding levels are for approved program by year, and are consistent with the recently submitted descriptive summaries.



This briefing describes ARPA's program to investigate the *Intelligent Integration of Information (I³)*, or *I-cubed*, as it is called. The I³ program is co-managed by David Gunning and Robert Neches of the Software and Intelligent Systems Technology Office.



This briefing begins with a description of the information integration problem and a summary the technical issues entailed by that problem. It goes on to describe the basic I3 vision for handling information integration and lists a few examples of the current and future I3 research efforts. Next, the briefing describes a few closely related ARPA efforts, the NIIIP TRP and the Intelligent Information Services programs, followed by a summary of the current budget for those programs.

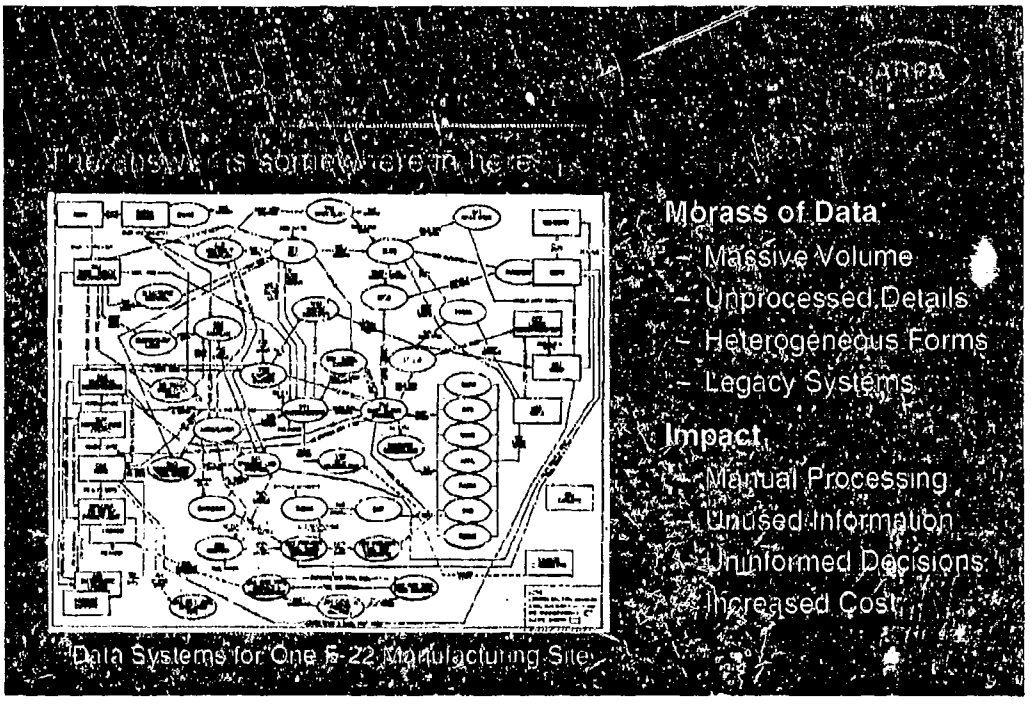


This F-22 example is indicative of a more general information integration problem. We could easily find similar examples in the command and control, intelligence analysis, electronic commerce, health care, etc.

Over the last ten years, American industry has spent $10B developing information systems to automate many of their current processes. Now that the basic digital data is in place, the next level of productivity improvement depends on our ability to integrate and use that mass of raw data. It depends on being able to integrate heterogeneous data systems, finding a way to leverage the $10B of existing legacy data systems, and establishing an open, flexible infrastructure which will enable future growth.

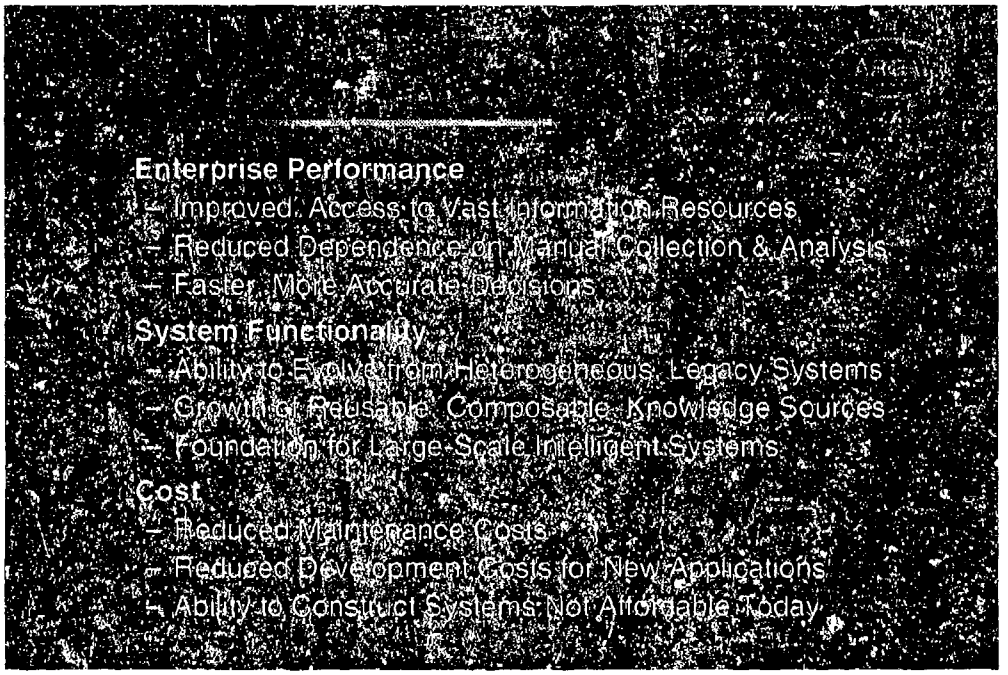
Important data integration capabilities are emerging in a variety of forms (e.g., Internet, MOSAIC, CORBA, database middleware products). As important as these developments are to laying the foundation for higher level integration, they are not addressing the issues required to integrate information at the semantic level.

Theses issues are above the level of networking, data access, or interroperability. They deal with the semantic level of the information -- combining and abstracting the contents of disparate data objects after they have been retrieved from different data systems.



When the problem analysis team searches for that data, this is what they will find – a morass of disparate, heterogeneous, legacy data systems containing massive volumes of unprocessed details. This diagram shows 58 data systems, representing the most significant manufacturing systems at one F-22 manufacturing facility in Marietta, GA. There are additional data systems for management, engineering, and logistics data; and yet another complete set of information systems in Ft. Worth, Seattle, West Palm Beach, and other F-22 development cites. With the NII, all these systems could be happily networked together, waiting for the problem analysis team to find an information "needle" in the haystack of data.

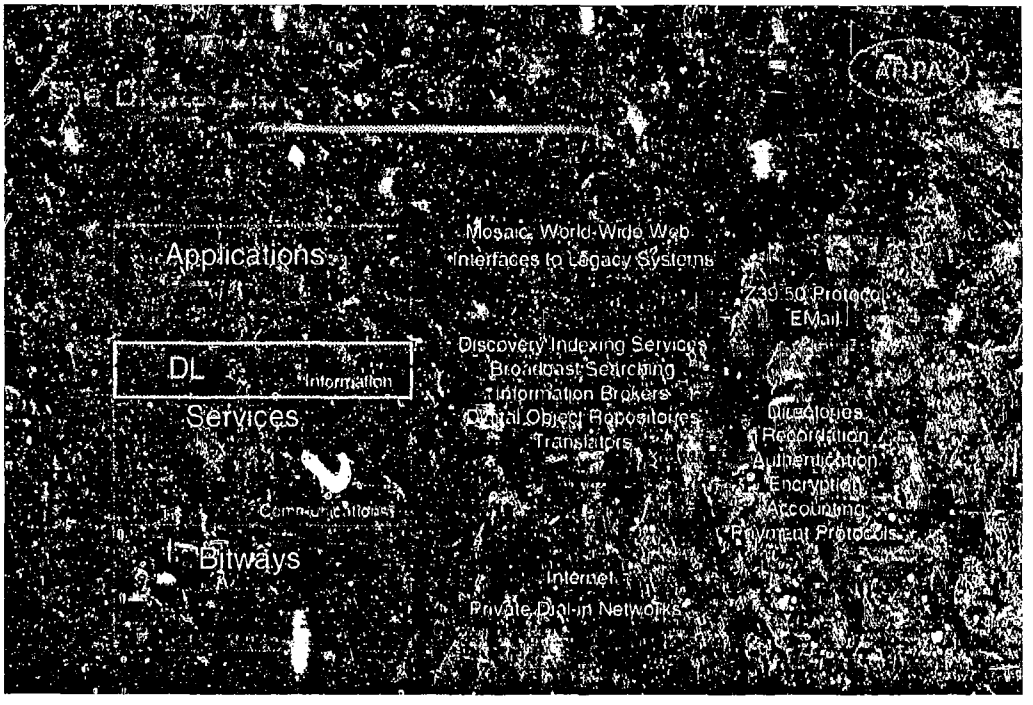
The team will probably solve this problem the same way most large scale information integration problems are solved today – with lots of people. The team will partition the questions about hypothetical causes into major disciplines: engineering, manufacturing, logistics, software, maintenance, etc. A team member from each discipline will consider the data needed to answer the questions and pass on more detailed data requests to technical/database experts who understand each data system. A man-power intensive information gathering and analysis process will occur. A hierarchy of people will spend weeks or months gathering, comparing, collating information from overlapping, non-integrated, data sources to finally put together the information package needed by the problem analysis team. That is -- if they don't miss anything -- and fail to find a valuable piece of information, just because it is too well hidden in the data haystack.



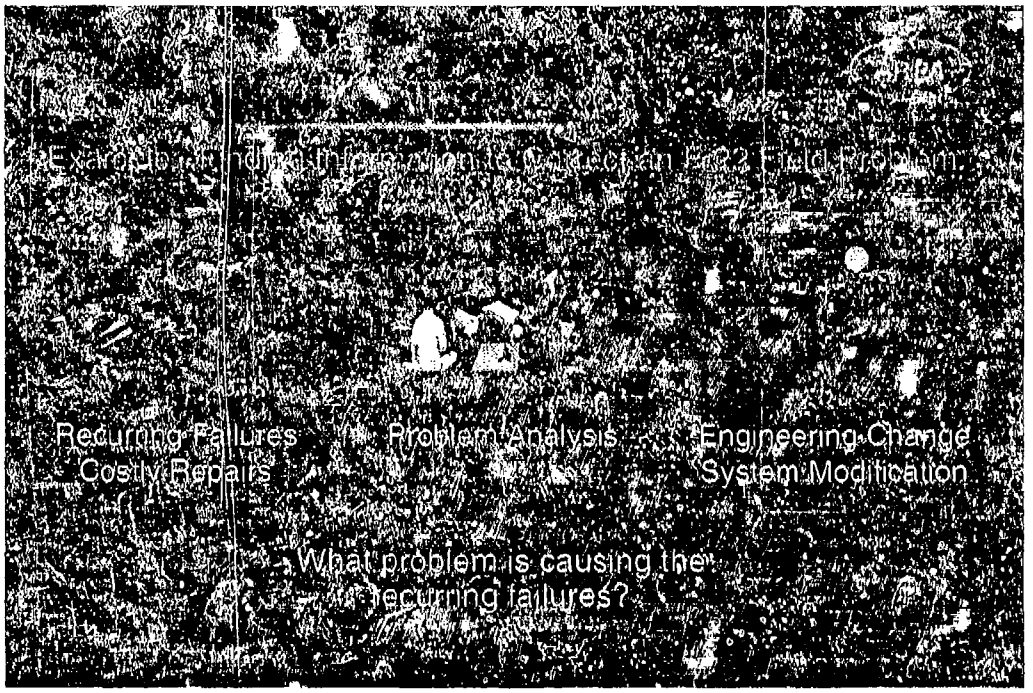
The mediation approach offers several significant payoffs over current approaches. First, it will provide improved information access (quicker and more accurate retrieval of the relevant information) from a broader range of data. This will enable a new level of automation of previously manual data collection and analysis processes.

Second, by allowing integration to occur using wrapped legacy systems and by enabling information integration services to be modularized into reusable, composable components, mediation enables existing system to evolve into large-scale intelligent systems.

Third, the mediation approach will provide improved information at lower development and maintenance cost. Initial development can leverage existing legacy systems, maximizing the reuse of previous investments. The modularity of the mediation architecture allows more efficient response to data and application changes, and allows for gradual evolution through the addition of new components. More importantly, mediation enables growth into a new class of large-scaele, intelligent information systems not possible previously.

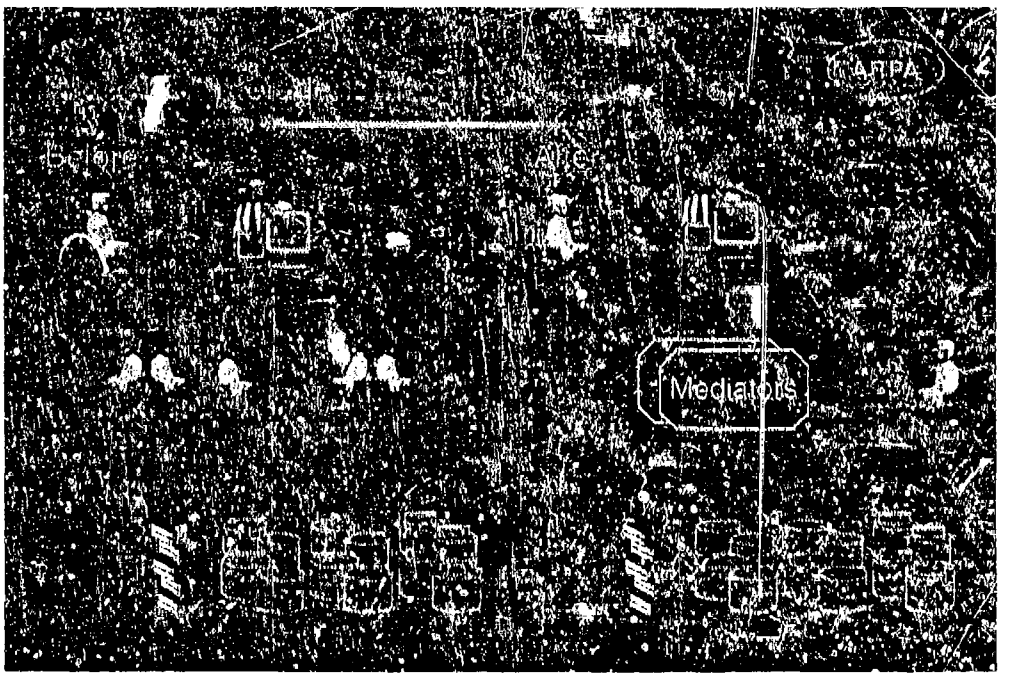


An elaboration of the three layer architecture for digital libraries. Many of the capabilities are the same for DLs and ECs, which is to be hoped for!



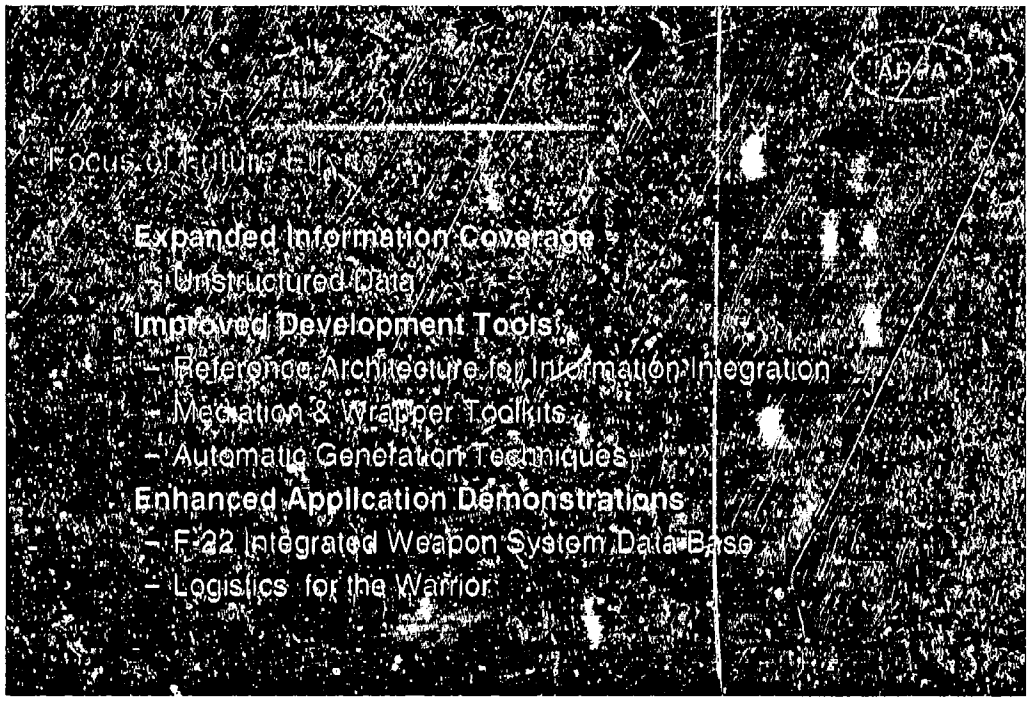
Let's begin with an example of a typical information integration problem. In a few years, the Air Force will be begin flying a new fleet of F-22 aircraft. As the new aircraft begin flying in the operational environment, failures will occur unanticipated by the original designers. Problem analysis teams will need to access the original design, manufacturing, and logistics data to unravel and correct the unanticipated, and costly, design problems.

The success of the problem analysis team – how effectively they can pinpoint the precise design flaw – will depend on how easily they can locate, access, filter, integrate, and analyze the mass of potentially relevant data. This data might include requirements documents, design specs, design rational, CAD drawings, parts lists, computer models, design analyses, test results, software documentation & development records, manufacturing specs, manufacturing "pedigrees", quality assurance records, reliability & maintainability analyses, maintenance procedures, operator & maintainer training records. Success will depend on not just finding, but on abstracting useful information out of this mass of data.

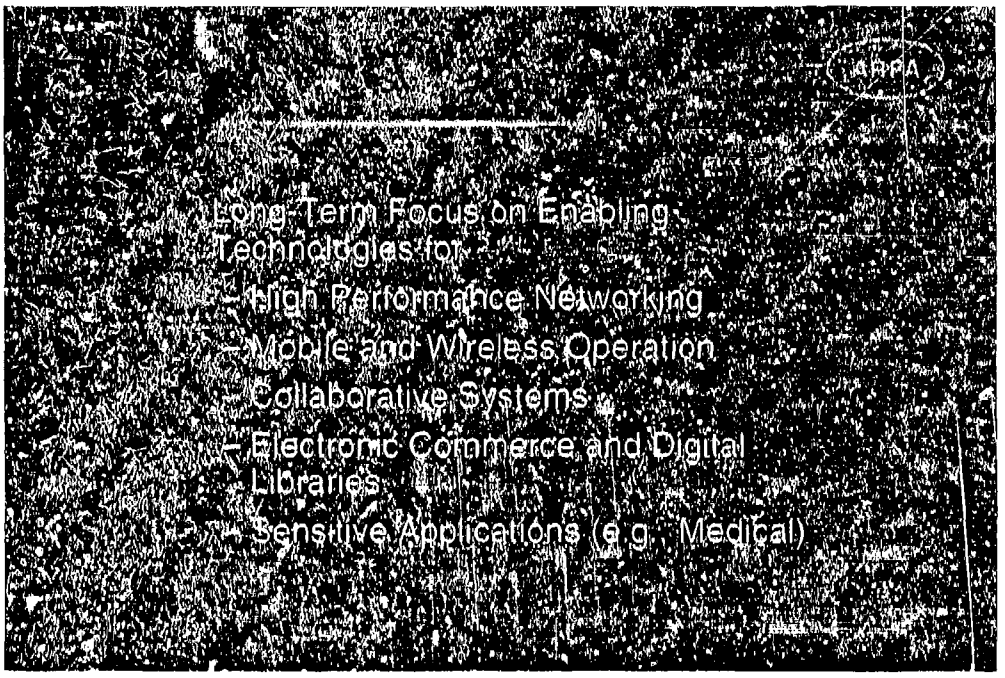


Now let's look at the effect of mediation on our earlier example. Mediators enable fewer people to get more out of more more information. A few of the domain experts who were formerly needed to extract and process data can now embed that knowledge in a domain-specific mediator which can perform that work over and over again, for many people, at no additional cost. This work saving arrangement is the basic advantage of mediation.

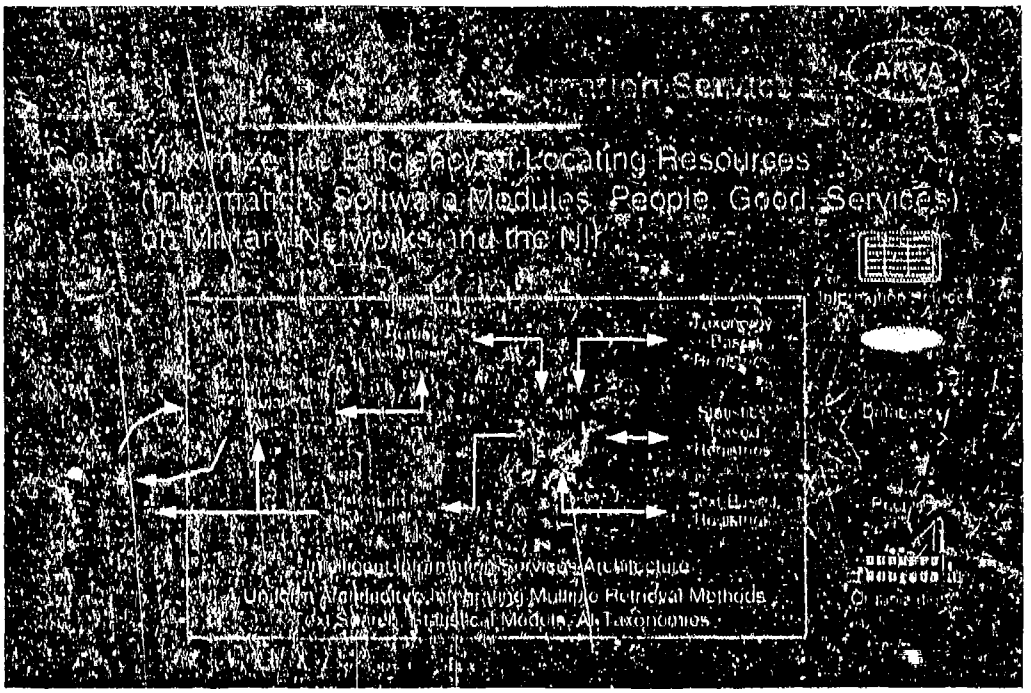
Mediation provides a practical alternative to other methods of integration. One alternative is to connect, point-to-point every application to every data source. This requires n x m connections and quickly becomes a maintenance nightmare. The other extreme is to fully integrate the information systems through a global data schema which relates all data elements, in every data source, to a common data dictionary. This method is extremely costly and time consuming to develop, and very rigid when changes are required in the individual data sources. Mediation provides a practical compromise to these two approaches.



In the future, the I3 program will expand the current work along three major dimensions. First, it will expand the information coverage to enable the integration of unstructured data (text, graphics, etc) as well as structured data sources. Second, it will focus on the production of mediation development tools. Third, it will expand the current demonstrations, especially ones supporting weapon system development on the F-22, logistics planning for theater-level logistics.



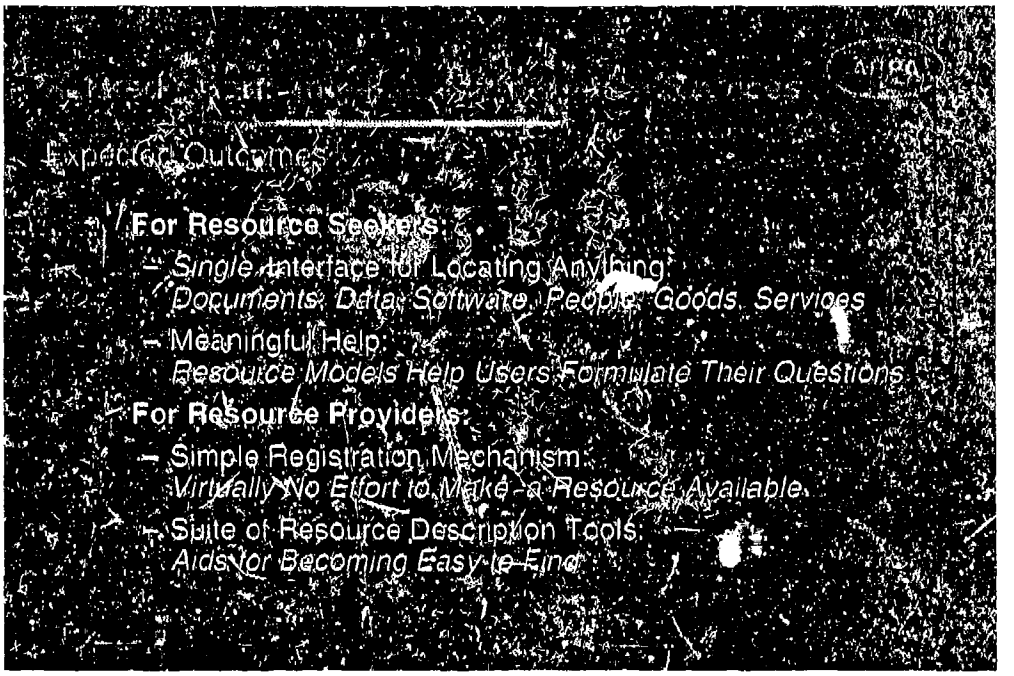
Longer-term research projects will involve experimental development and application of scalable security solutions, a flexible security infrastructure, and secure interoperability among service types (computing, cable, telephone). Hardware support for security services and development of software that can be trusted are also key problems.



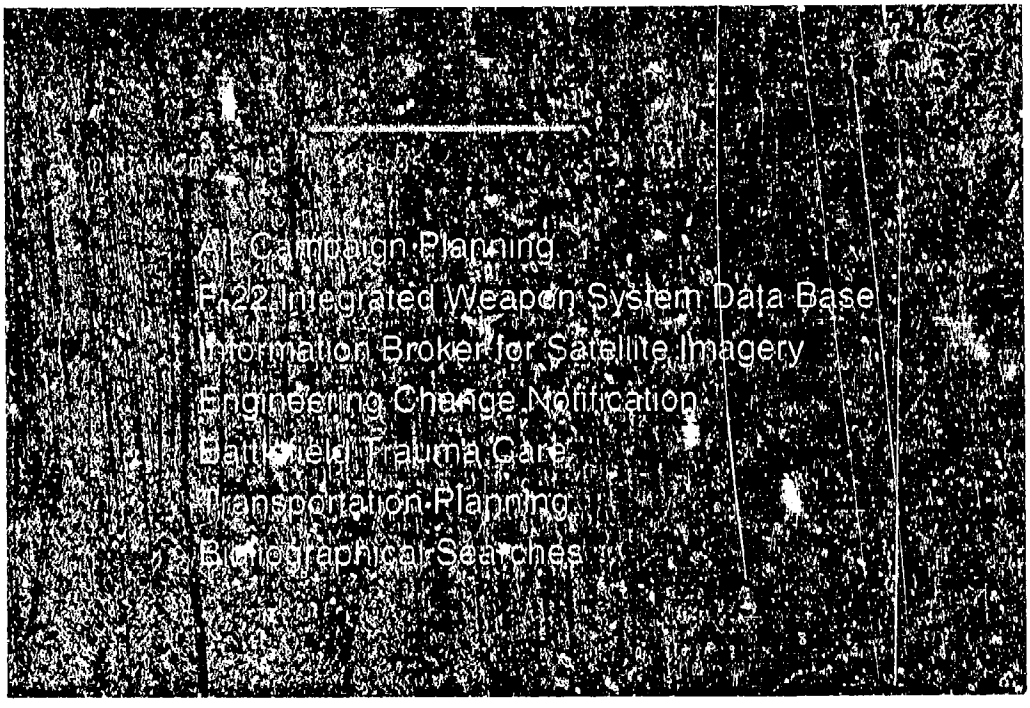
ARPA has plans to also begin a new program, called Intelligent Information Services (IIS), managed by Robert Neches.

The goal of this program is to maximize the ability of users to locate and utilize resources of all types (e.g., information, software, people, goods, services, etc.) over the NII and similar networks. An IIS system will aid the user in formulating a resource searching query, execute a search for matching resources using taxonomy-based and statistical-based representations, and integrate the results for presentation to the user.

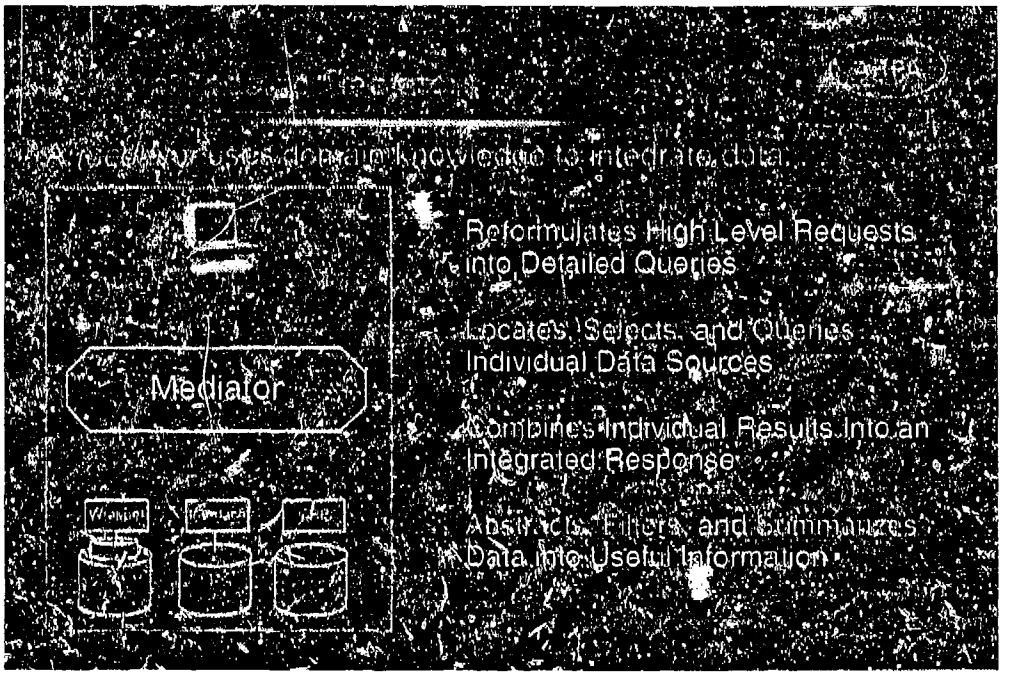
Research in this area is needed because of numerous unresolved technical issues: the lack of a universal technique to represent resource capabilities, the interdependent nature of resource requests, and the lack of conventions for describing and validation resource information.



The IIS program will produce several outcomes for resource seekers and resource providers. For resource seekers, IIS will provide a single interface for locating all resource types. For resource providers it will develop simple mechanisms for describing and registering resources.



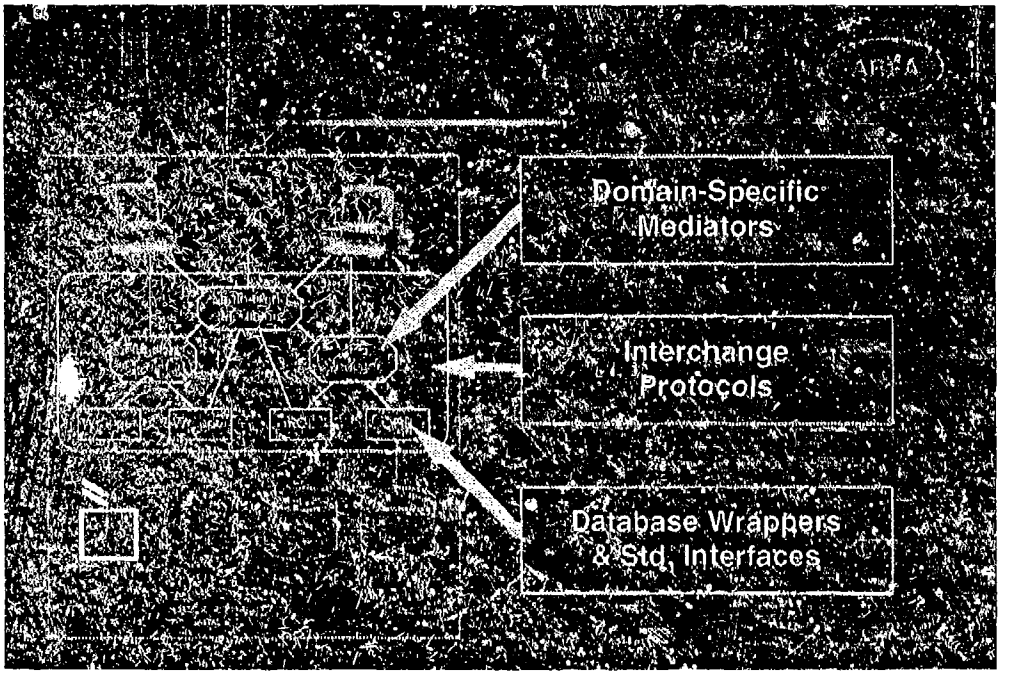
The I3 program has produced several testbed demonstrations, and in some cases operational systems, which demonstrate the feasibility and utility of mediation technology. The Air Campaign Planning Tool, currently in operation by the Air Force, employs a mediator to access target data from multiple intelligence databases. ARPA and the F-22 program are using a mediation prototype to become the kernel of the F-22 Integrated Weapon System Data Base. Lockheed is using a mediator to act as an information broker for locating and accessing satellite imagery from multiple data sources. Lockheed has also demonstrated the use of mediation technology to notify engineers of design changes. The TCIMS TRP is using mediation to integrate data for battlefield trauma care. ISI has demonstrated the use of a very sophisticated mediation system to integrate data from several transportation planning data sources. The TSIMMIS project at Stanford has built a demonstrated which will retrieve data from multiple bibliographical data sources.



Mediators combine, abstract, and process data for a specific application domain. By using domain knowledge, mediators can resolve semantic mismatches among heterogeneous data sources, abstract data to the appropriate level of detail, and transform data as necessary to create useful information.

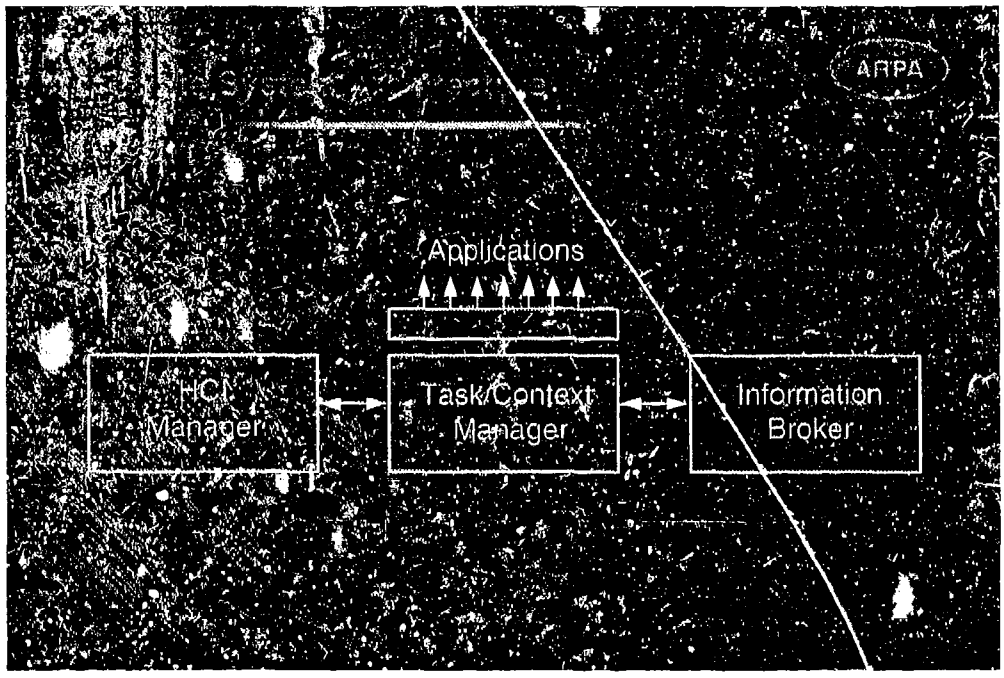
This diagram shows the flow of information through a typical mediator. There are different varieties of mediation, with several alternative approaches currently being explored by the research community, but this illustrates the most common mediation approach.

An initial data request is sent to the mediator from a user -- a person or an application program. The request, which is usually expressed in high-level domain terminology, is evaluated by the mediator. The mediator will analyze the content being requested, locate and select the data sources and generate the appropriate sequence of queries for each data source. This entails translating the request from high-level domain terminology into the unique data terminology and access language required by each source. Once the results of these queries are returned, the mediator will combine the individual results into an integrated response, resolving inconsistencies and translating the unique data terminology back into common domain terminology. As required by each request, the mediator will also abstract filter, and summarize the data retrieved to create useful information to suit the purposes of the requesting agent.

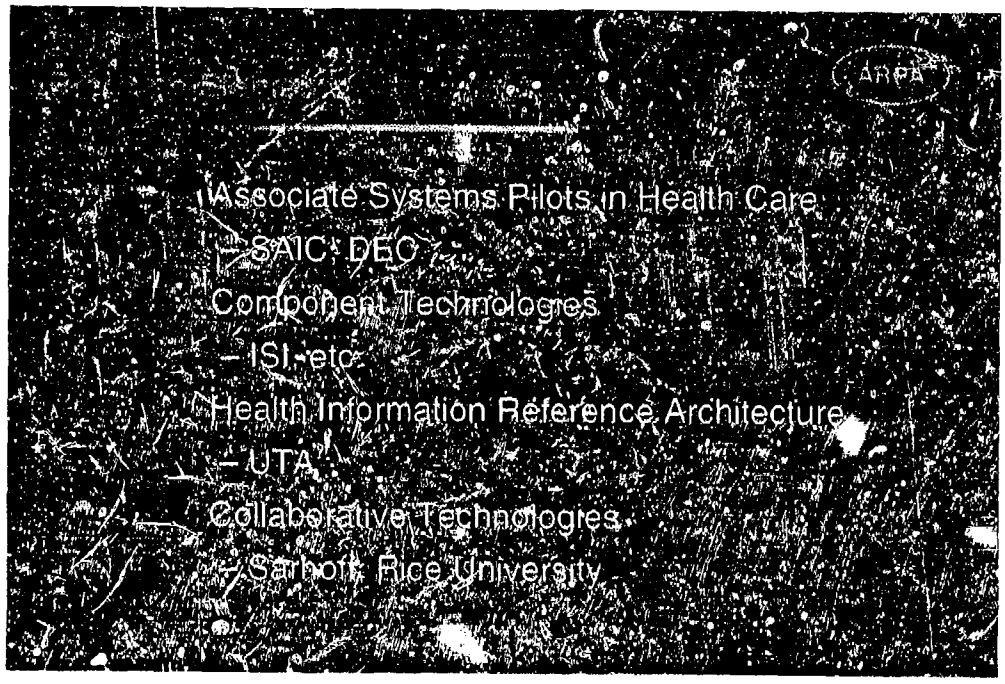


The I3 program has developed a conceptual approach for dealing with these issues. There are three major components to this approach: (1) domain-specific *mediators* which integrate the semantic content of disparate data sources, (2) interchange protocols which provide a common method for components to communicate semantic information, and (3) database *wrappers* which provide a standard interface for legacy and other heterogeneous components.

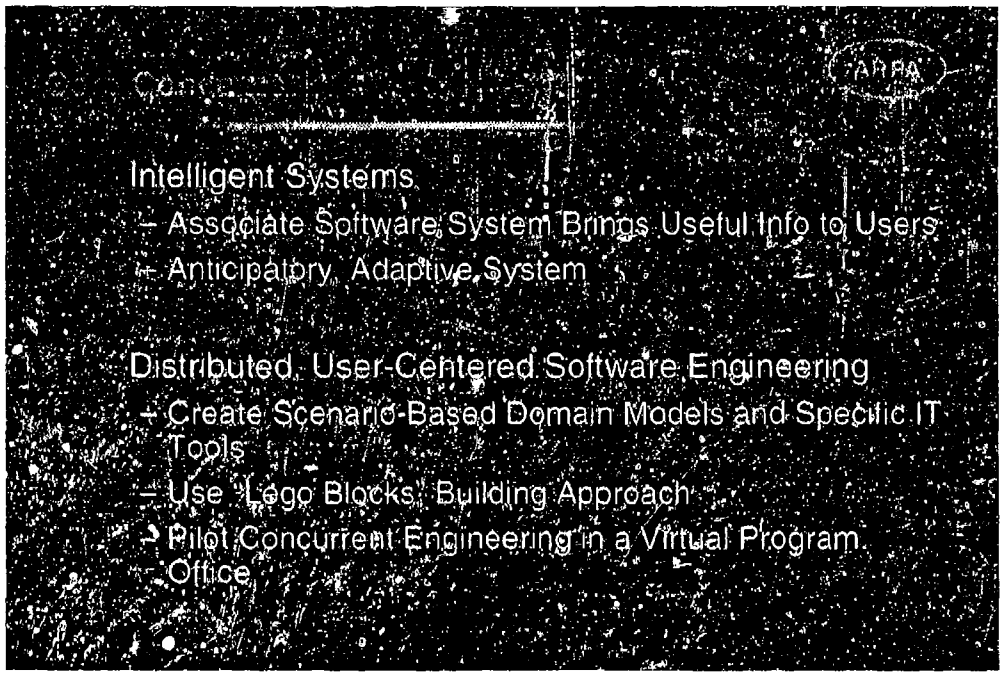
At the heart of this vision are domain-specific *mediators* which accomplish semantic integration for a particular domain. By focusing on one topic area, these software modules partition the work so that a domain expert can develop and maintain a model of the information in one domain and map that model to the unique terms, structures, semantics in different data sources. These modules then become the basic unit of code for maintenance and evolution, enabling lower maintenance costs over time.



There are three components to the architecture. The first is a human-computer interface. A task/context manager interacts with the applications. Finally, an information broker assists the user in identifying the appropriate information for the application in order to support the user with minimum effort.

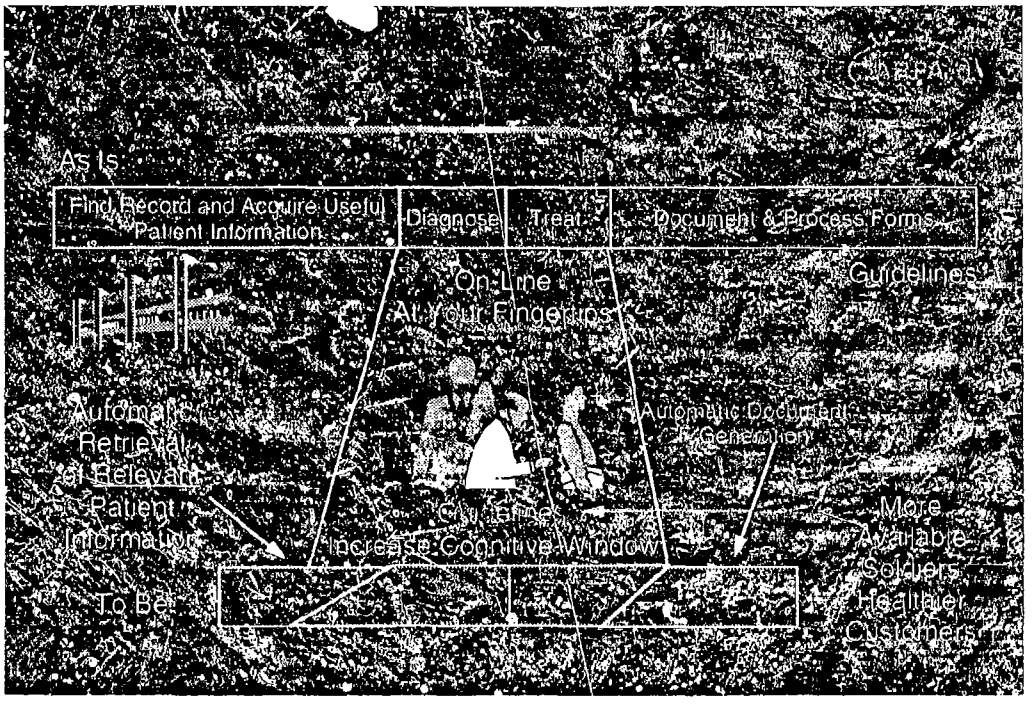


Program elements are focused on goals and include associate systems architectures, leggo block-like components used within the associate systems, a reference architecture and technologies to support distributed collaboration.


Intelligent Systems
– Associate Software System Brings Useful Info to Users
– Anticipatory, Adaptive System
Distributed, User-Centered Software Engineering
– Create Scenario-Based Domain Models and Specific IT Tools
– Use "Lego Blocks" Building Approach
– Pilot Concurrent Engineering in a Virtual Program Office

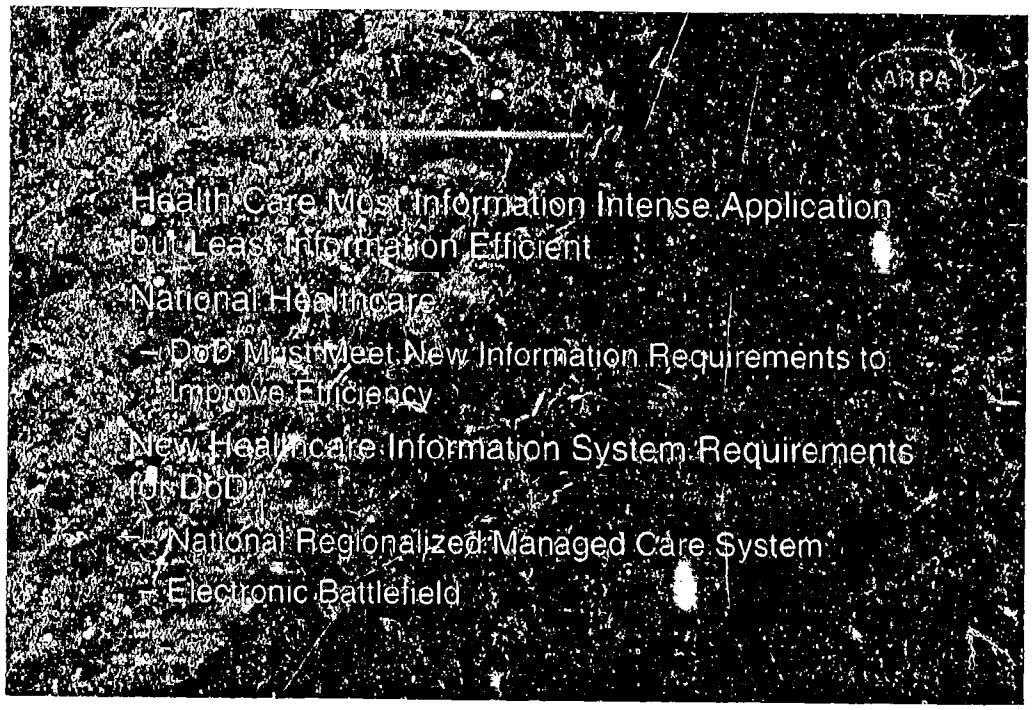


The goals of the Health Information Infrastructure Program are to help design a scalable, evolvable architecture for health information and to produce a set of tools that make it easier, faster to build health information systems. The user-center design paradigm results in an "information dial tone" for users. This system "leggo block" approach also results in a new method to acquire information systems.



The current state of affairs is illustrated in the figure's top line. Most patient records are hand-written and stored within the professional's office. The record may not be available for review by another professional; or, if the record is present, it may lack essential information. Professionals do not have ready access to medical knowledge or outcomes information during patient encounters. Their cognitive activities - diagnosing and treating - are based on individual practice experiences, informal communications among their peers or medical knowledge gleaned from sources outside the practice environment. Documentation of a patient visit is usually hand-written and not often shared among other care professionals. Requests for diagnostic tests, patient medications and treatments are also hand-written and require additional processing at the laboratory or pharmacy. Since the requests and their results are not shared, duplicate tests and treatments are frequently administered.

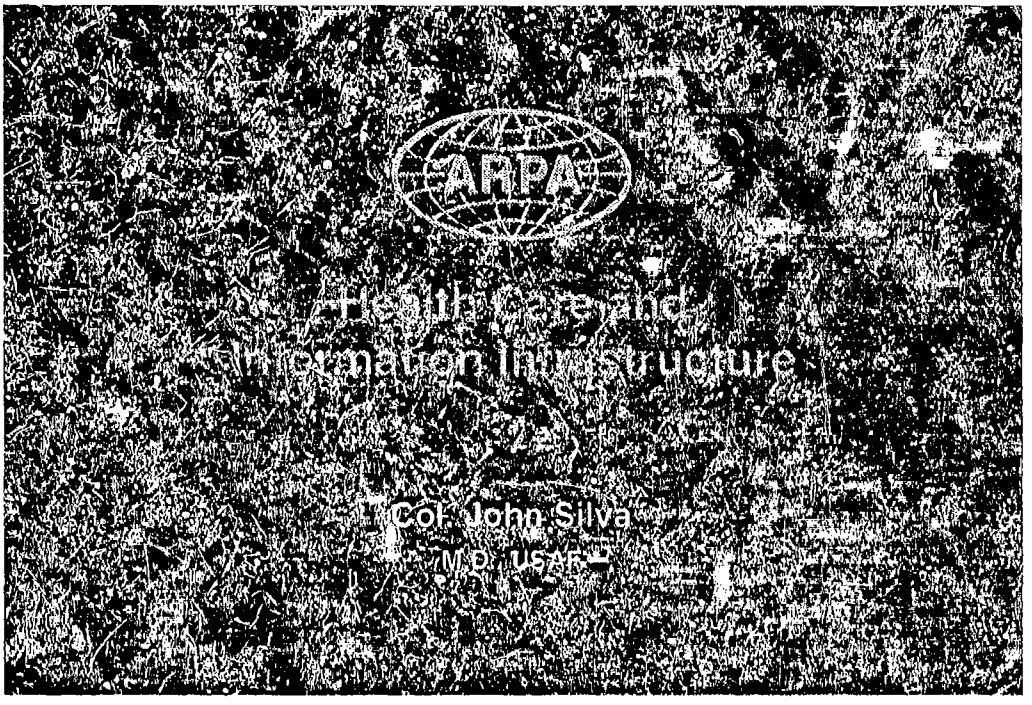
Contrast the current state of health information with the vision depicted in the lower portion of the Figure. The Health Information Infrastructure automatically provides relevant patient information directly to the professional. Medical knowledge, national outcomes data and provider-specific results are brought to the professional during their encounter with the patient. Computerized patient records are captured as a by-product of the delivery of care. Actions, such as prescriptions, laboratory requests, are generated automatically and forwarded electronically to the servicing entity in the community. Health outcomes data are collected within the professional's office, forwarded to data centers and aggregated for community and national-level results. As a result of insertion of intelligent information systems technologies, the professional has more time to interact with the patient and to think about diagnoses and treatments - increasing the 'cognitive window'.

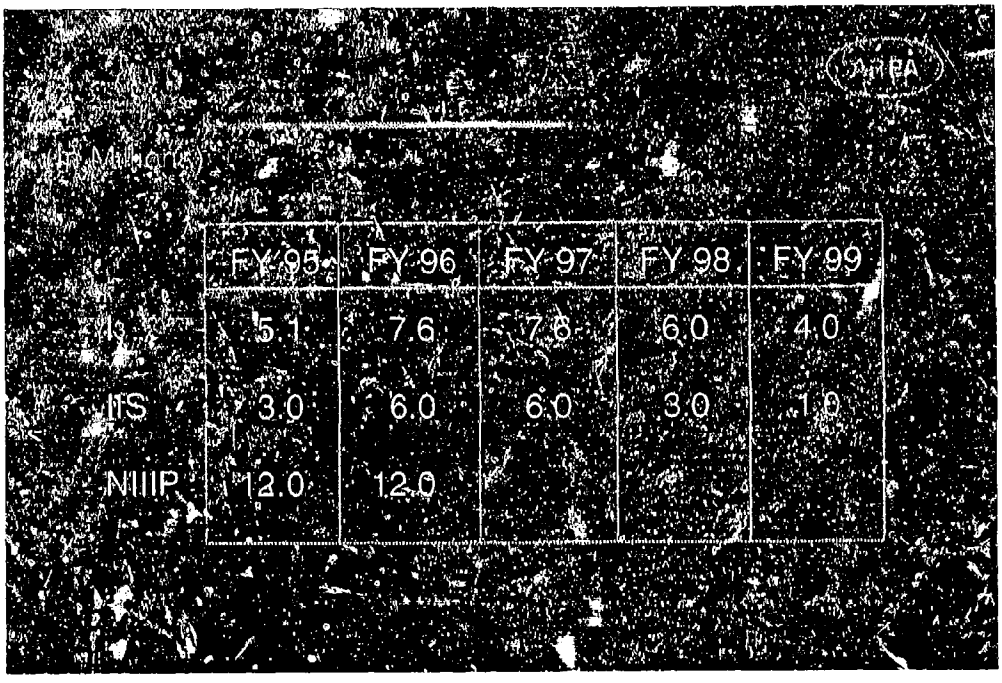


Health care consumes over 14% of the GDP and is accelerating. While most information intense industries spend up to 10% of their opperating budgets on IT, health care spends less than 3%. But the 'cottage industry' approach to building information systems for health care results in stove-piping of department systems and numerous islands of automation. The resultant lack of interoperability of health data further increases the administrative overhead.

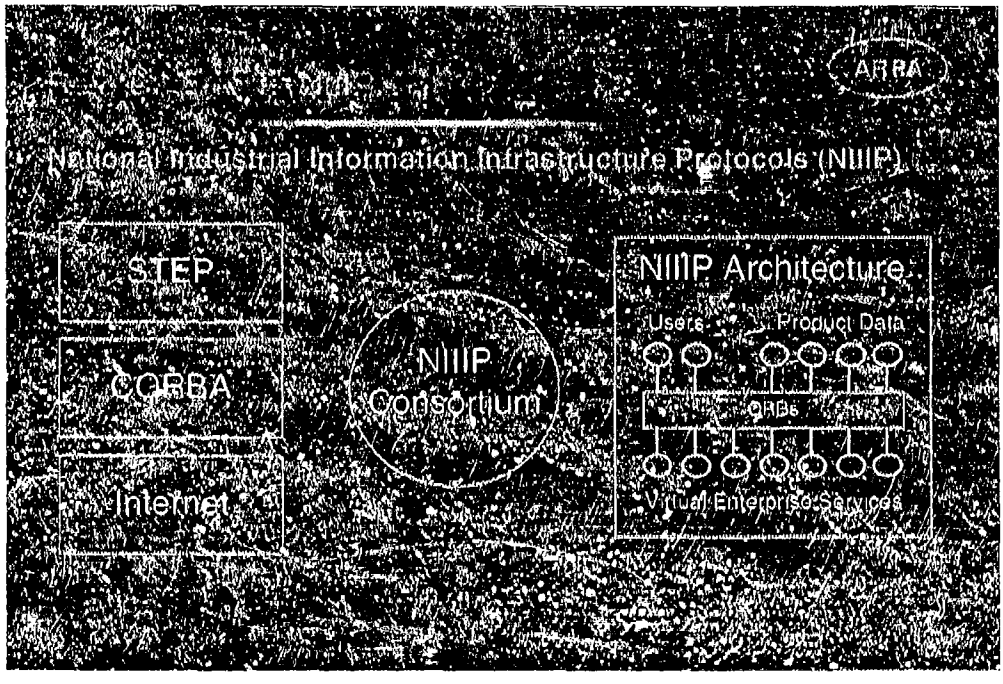
DoD has similar problems and must dramatically increase the efficiency of health care delivery as it undergoes major downsizing.

DoD is also moving to TRICARE - regionalized managed care that will impose further demands for information to manage clinical practices, hospitals and regions.


ARPA
Health Care and
Information Infrastructure
Col John Silva
M.D. USAF

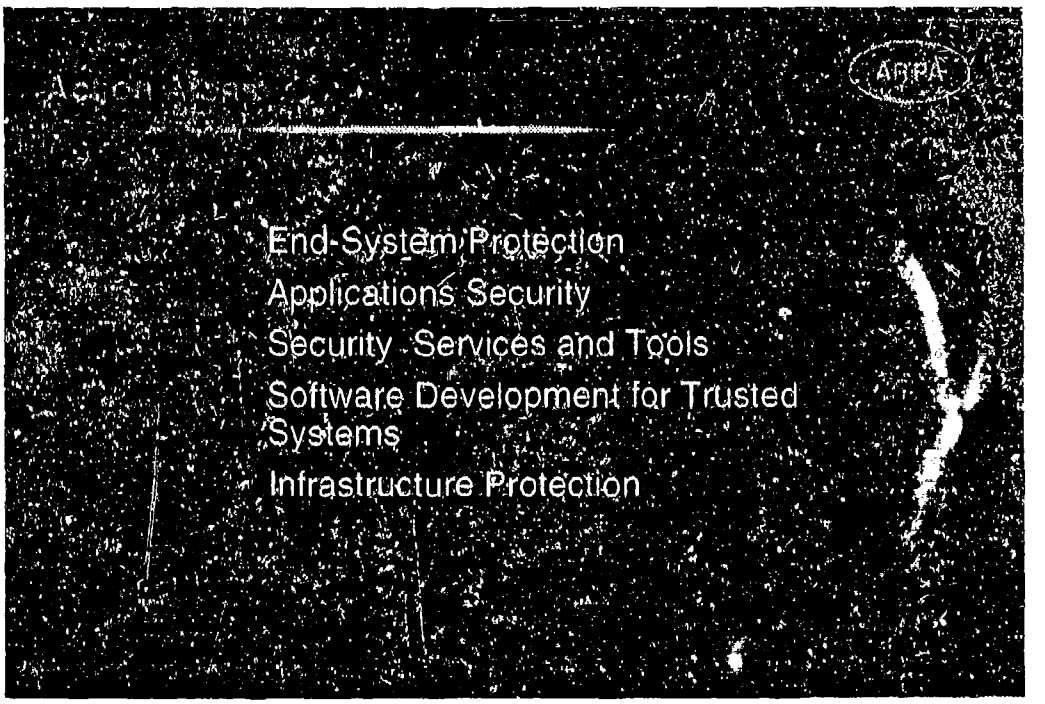


This is the current budget for I3 and its related projects.



A related effort in this area is the newly awarded NIIIP TRP. This consortium, led by IBM and made up of several computer developers and industrial users, will being developing and demonstrating information infrastructure protocols over the next 2 years. These CORBA-based protocols will be designed and implemented to enable engineering and manufacturing teams to quickly establish and utilize virtual enterprises.

The members of the NIIIP Consortium are: IBM, DEC, Texas Instruments, Taligent, Enterprise Integration Technology, Univeral Energy Systems, University of Florida, STEP Tools, Renselar Polytechnic Institute, NIST, Lockheed Aeronautical Systems Company, Magnovox, GD Electric Boat, Wright Labs, and ARPA.



The agenda for action focuses on the following four areas: end-system protection, applications security, security services and tools, and infrastructure protection. End-system protection includes applying authentication technologies to users and systems, developing next-generation firewalls for portal protection for secure enclaves, and developing policy-based confinement technologies for new operating systems development.

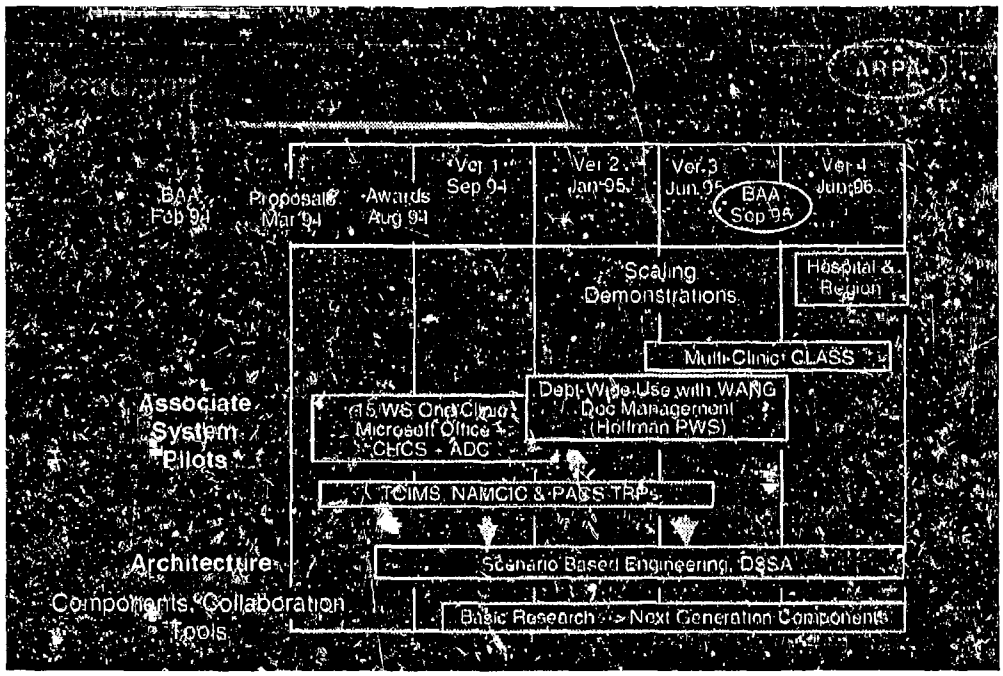
Applications security includes remote database access with authentication and dynamic system configuration to support user security policies, as well as support for secure interoperation of secure applications.

Security servies and tools includes reference standards for secure service distribution, tools for an "underwriters lab"-like security evaluation service, and tools to support incident response. Innovative secuirty module aproaches include keyed interfaces, cryptographic application programming nterfaces, generic key escrow approaches with software options, and modular scalable encryptors.

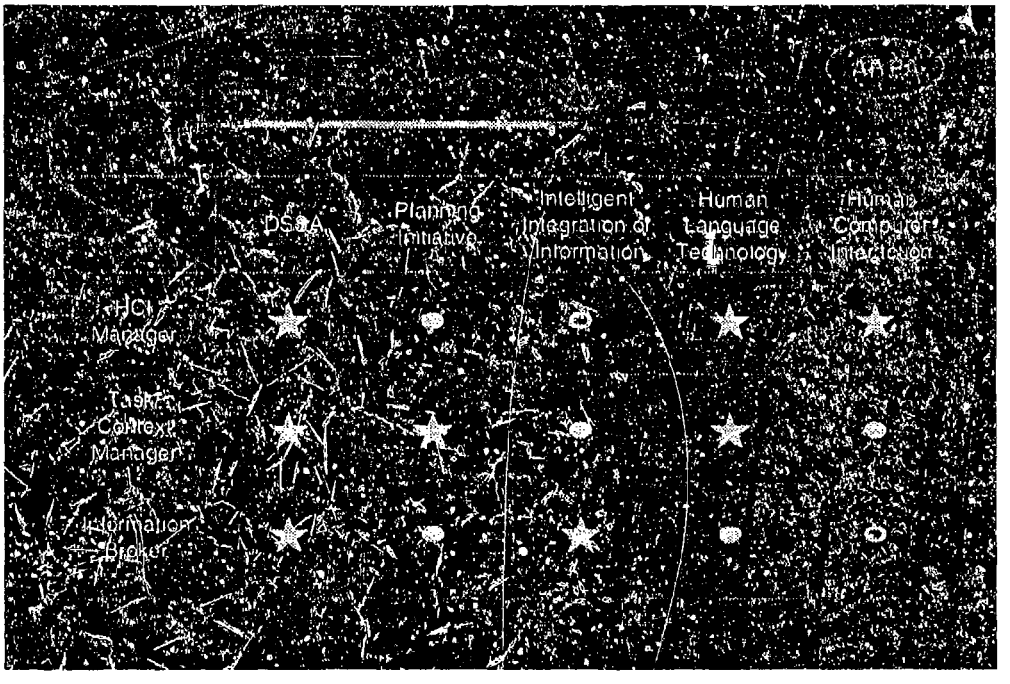
Infrastructure protection includes accelerating the redesign of existing protocols and network services, applying authentication technolgoies to network protocols, and reducing vulnerability to denial of service. This area will also expand the emergency response team system and use intrusion detection technology geared to the increasing scale of the NII.



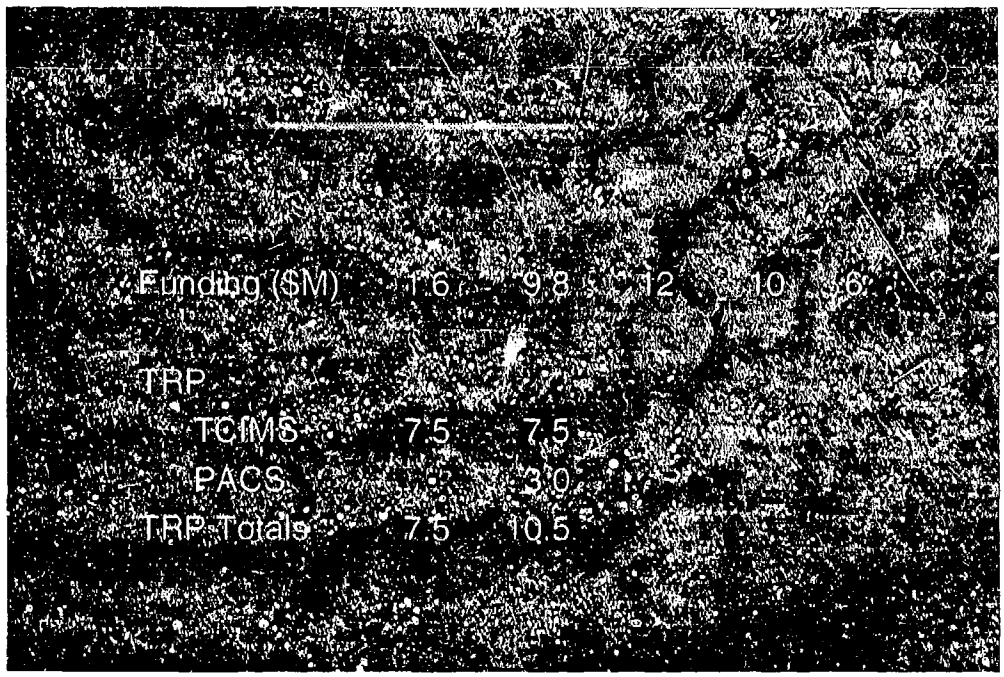
The strategy for the information security program will combine immediate leverage through near-term results with a long-term focus on enabling technologies for the National Challenge problems such as high performance networking, mobile and wireless operation, collaborative systems, electronic commerce and digital libraries, and sensitive applications (e.g., medical). In the near term the program will produce toolkits for security administration, security integration, and emergency response.



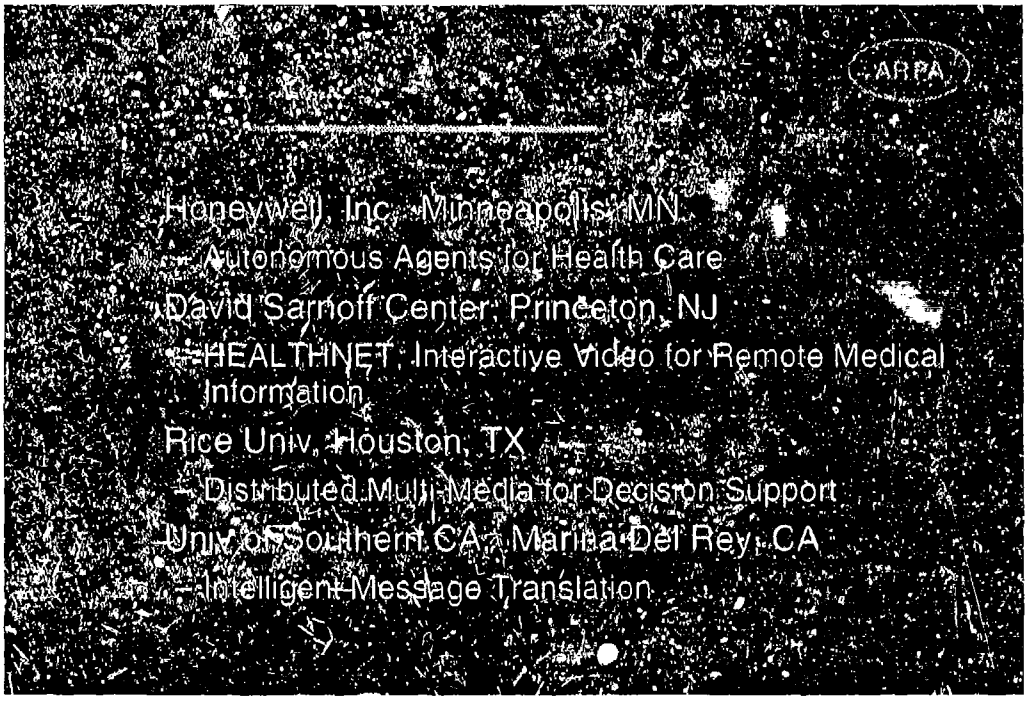
BAA was released in Feb 94 with awards in August. No additional BAAs are programed as the current awards consume current funding. The proposed scaling experiments in FY97 will require additional funding and may result in a second program BAA.



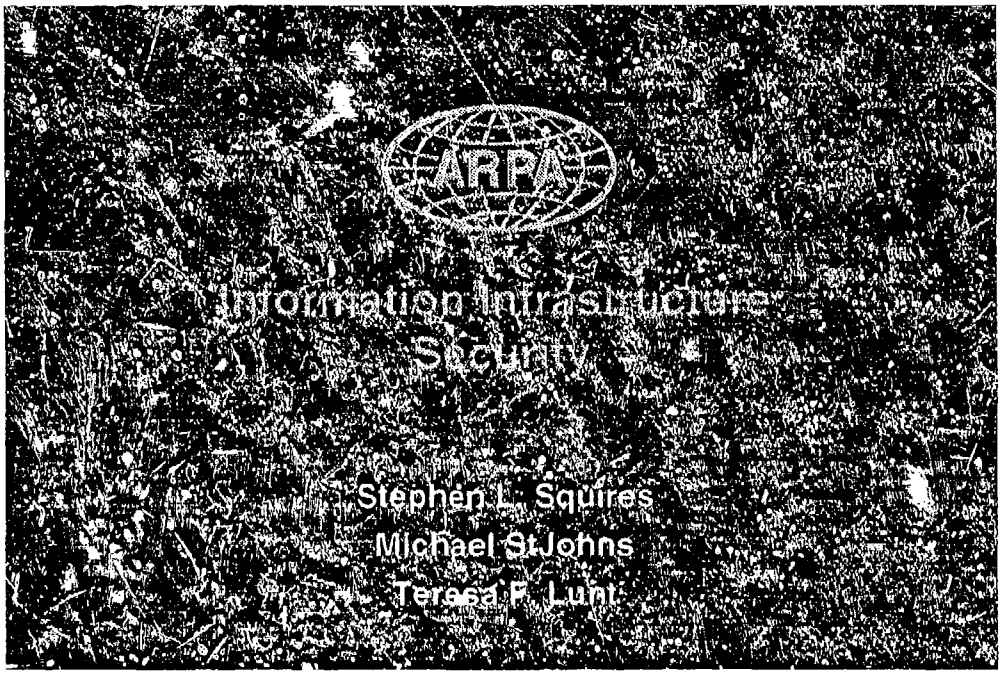
The leggo block approach leverages components from other ARPA programs and offices. Each symbol show how elements from other ARPA programs will contribute to the three functional components discussed in the last slide.

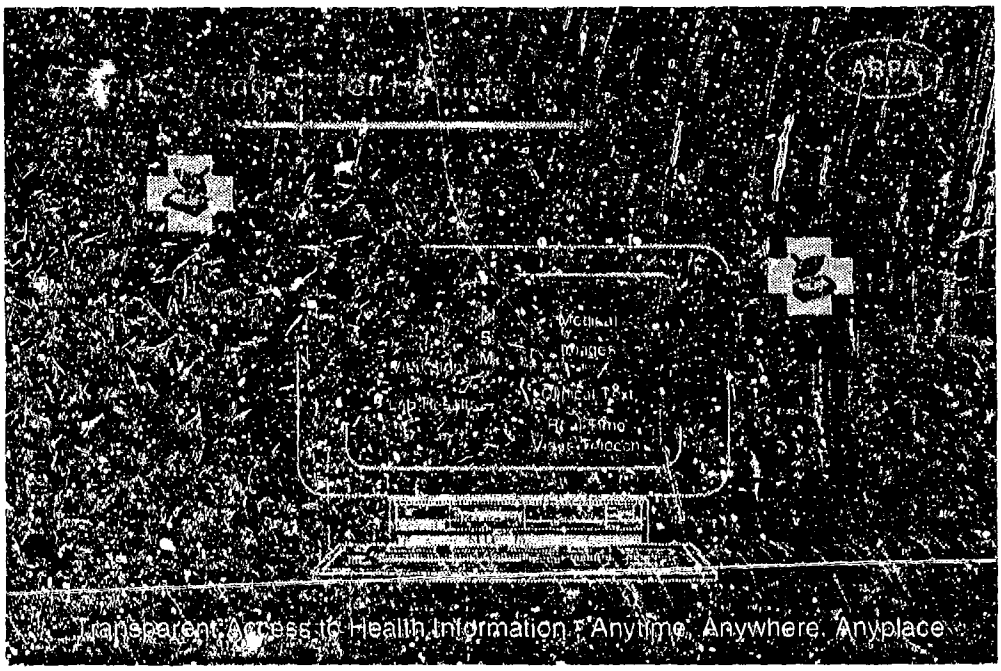


Here is the funding profile for 1994 through 1998 as currently configured.

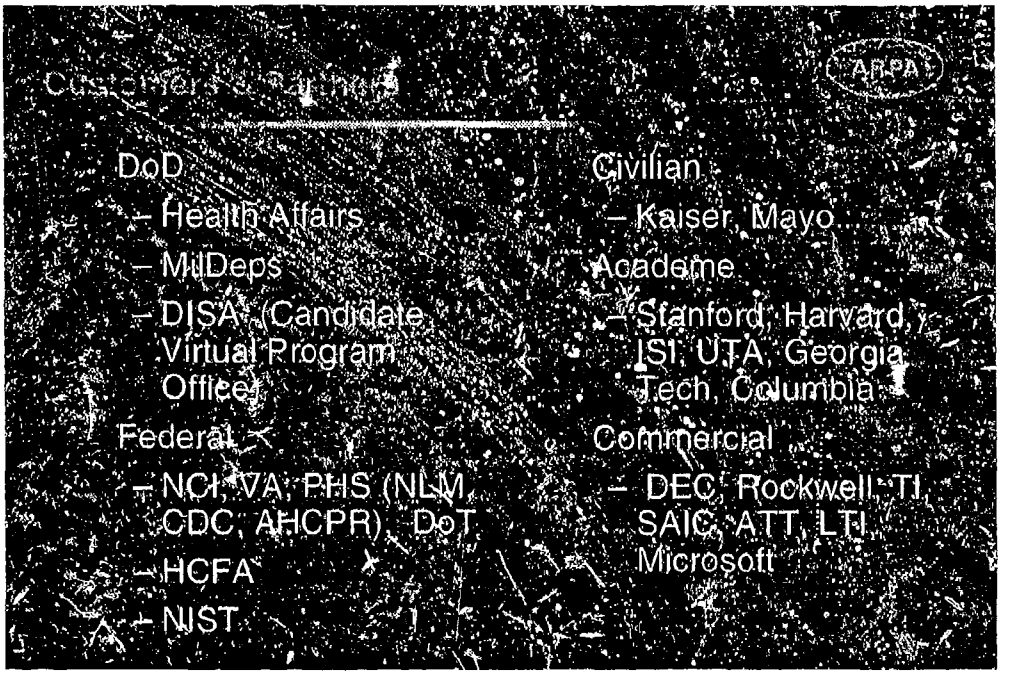


Here are the principal contractors.

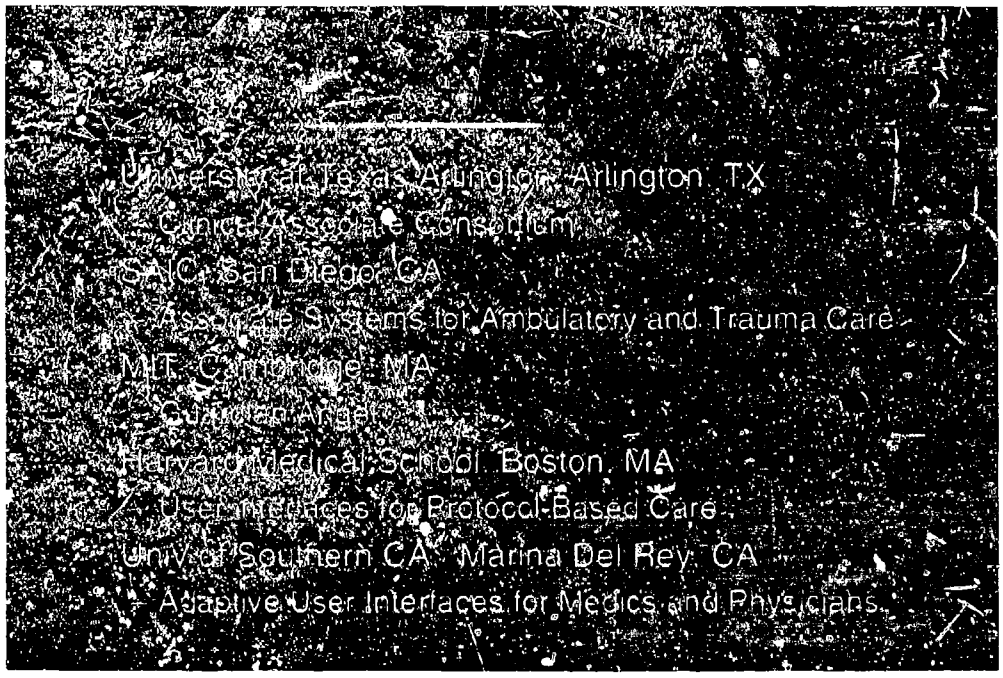

ARPA
Information Infrastructure
Security
Stephen L. Squires
Michael StJohns
Teresa F. Lunt



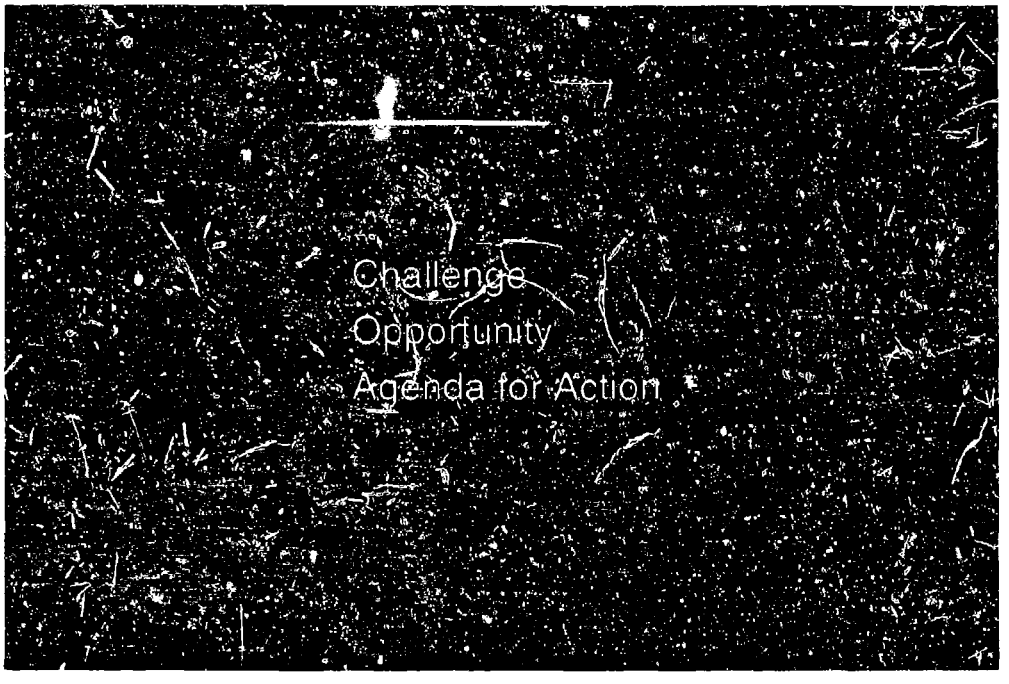
Wrap-up: As the National Information Infrastructure m atures and extends beyond national boundaries, health information must extend transparently to users across the globe. We expect that this program will contribute to this goal.



There are many participants in the program. Some are customers, others are participants. All are key to the program.



The principal contractors continued.



Information infrastructure security:

This talk will cover the

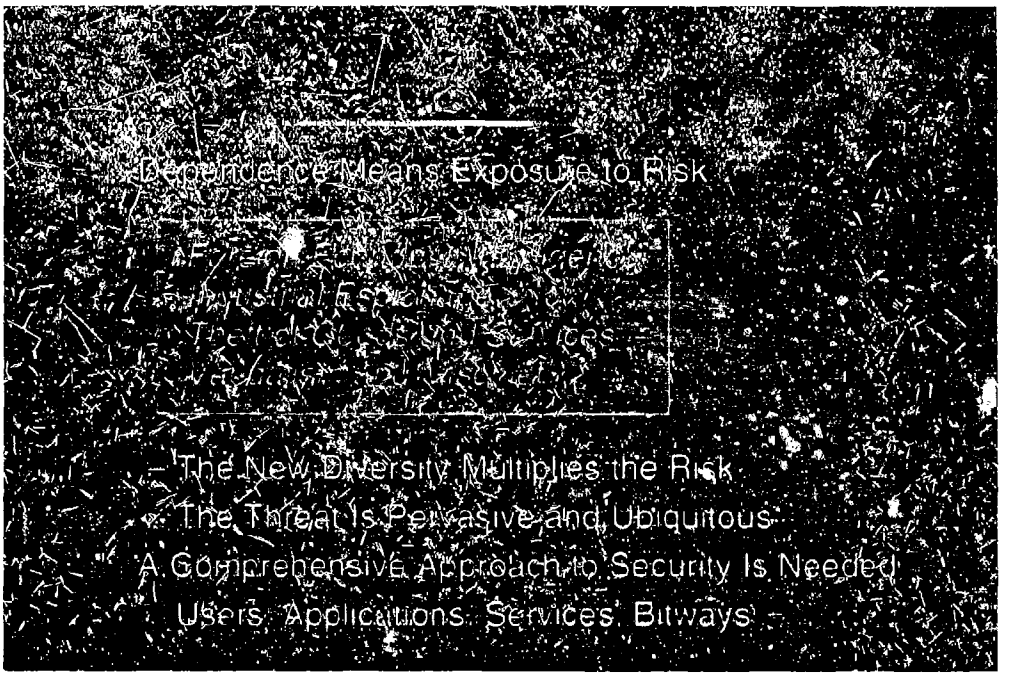
Challenge

Opportunity

for information infrastructure security.

We will also outline an

Agenda for action



This increased dependence on the NII will mean increased exposure to attack, for example:

Foreign economic intelligence

Industrial espionage

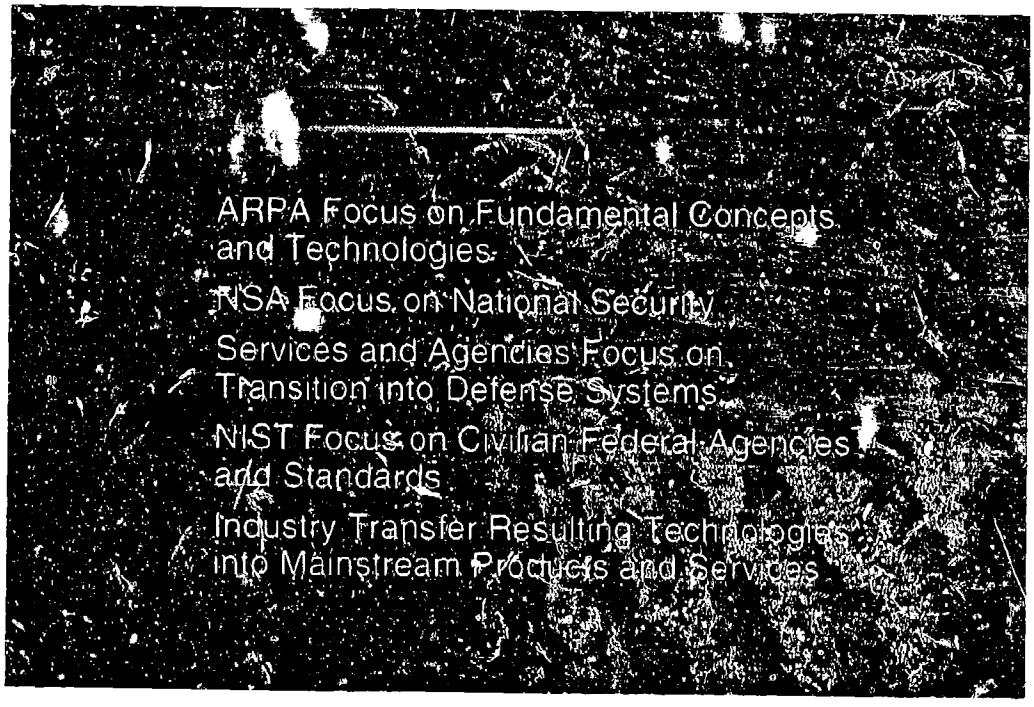
Theft of goods and services (including theft of money)

Vandalism and mischief

These attacks can be carried out anonymously by any of the millions of connected users.

The increased diversity multiplies the risk, as cable TV and telephone networks and network components become accessible from computing networks, and vice versa.

A comprehensive approach to security is needed, from protecting end users and their applications, protecting end systems and their information assets, protecting the network infrastructure, and providing embedded security services.



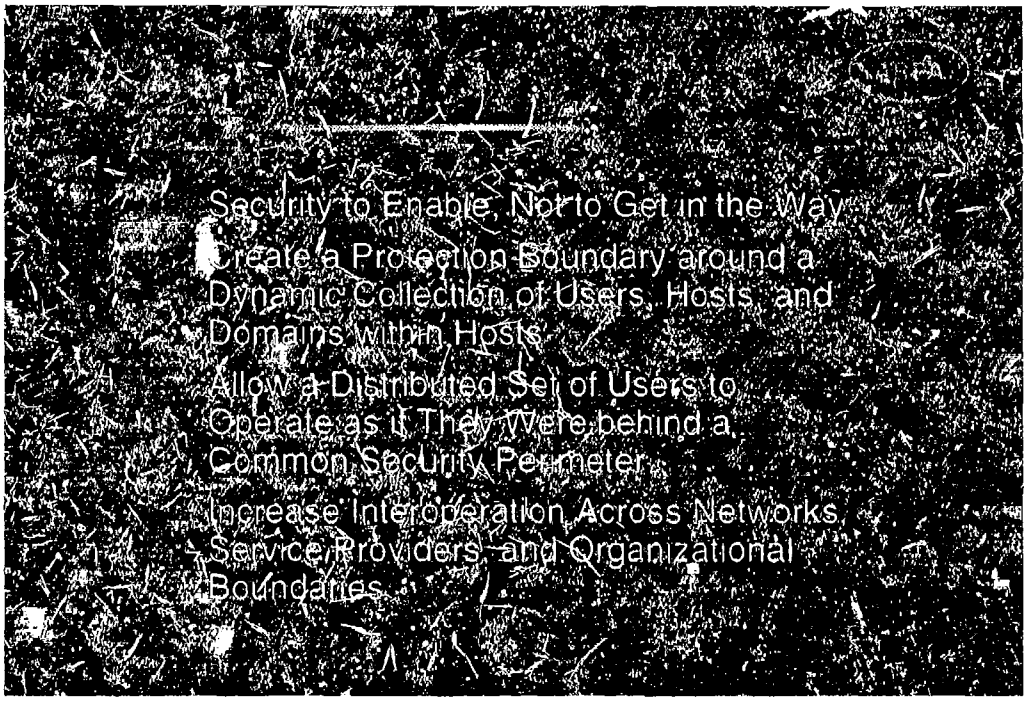
Government and private sector coordination is essential to the development and deployment of a secure information infrastructure.

ARPA, NSA, NIST, and the services and agencies have complementary roles within the Federal government.

ARPA is working with these other government groups to coordinate our efforts and to maximize technology transition to government use.

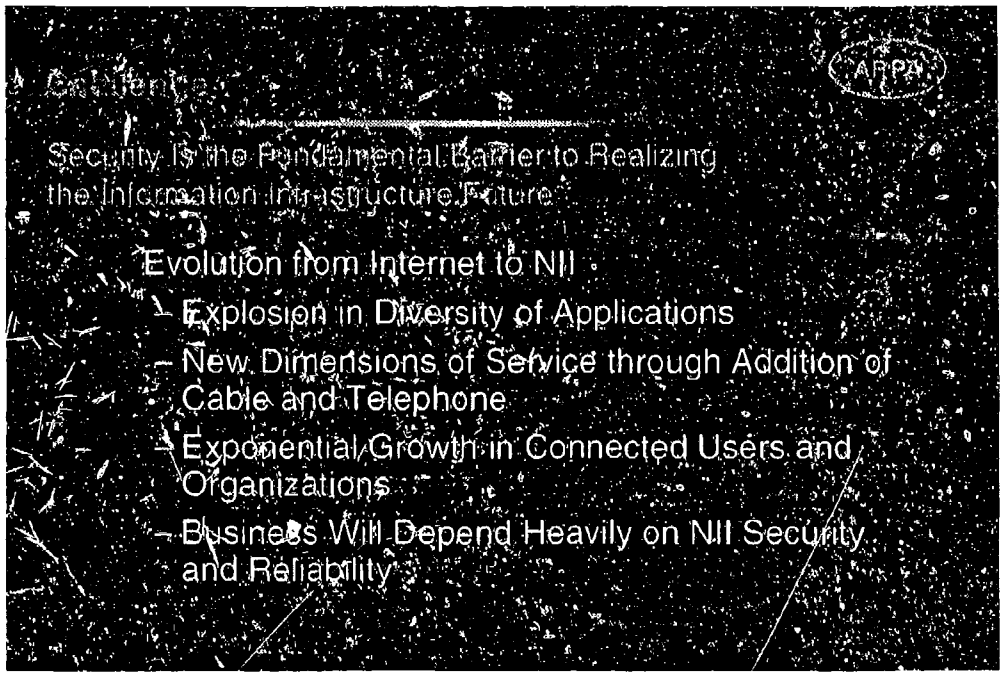
ARPA must work closely with industry to maximize the changes for technology transfer into commercial products and services.

Pilot projects will be used to explore alternative transfer approaches.



Security should enable desired uses of the network and connected systems; it shouldn't get in the way (as is the case with today's firewalls). What is needed is technology that would allow the creation of a protection boundary around a dynamic collection of users, hosts, and processing domains within hosts. Within this protection boundary, a distributed set of users can operate as if they were behind a common security perimeter at a single local site. Even within a single machine, execution domains can be designated as within or without the security perimeter. In this way, portions of a system can be walled off to allow guest or unchecked software to safely execute in confined isolation without posing a threat to the rest of the system.

Secure enclaves will increase interoperation across networks, service providers, and organizational boundaries. Such interoperation is not possible today with any degree of security.



Security is the fundamental barrier to realizing the information infrastructure future as people, their organizations, and their systems get increasingly interconnected and dependent on information technology.

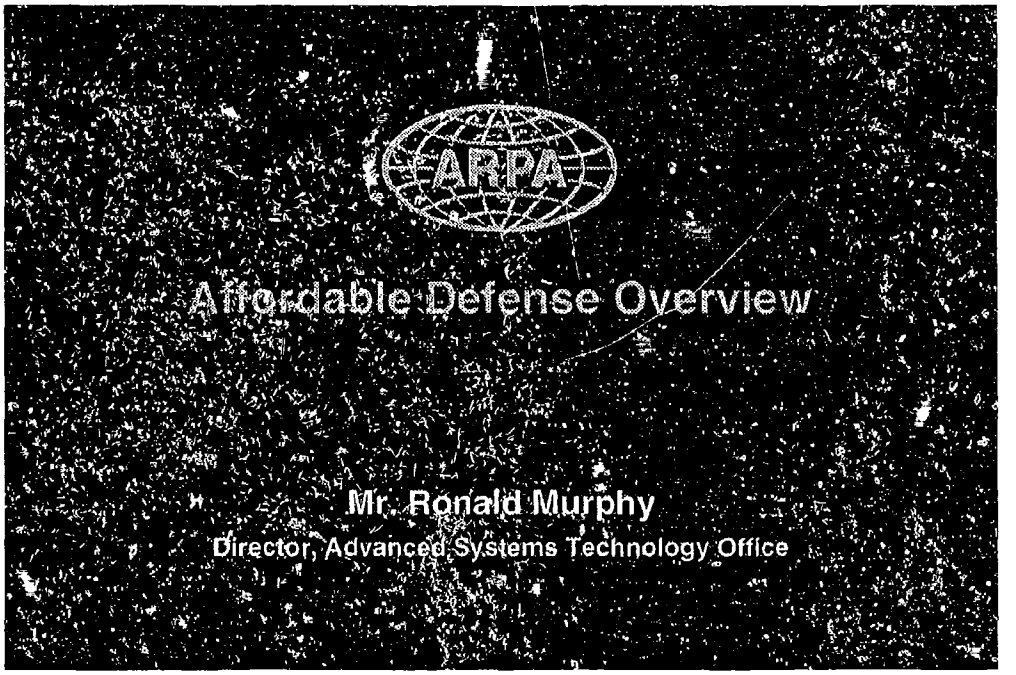
The challenges of the future will be many.

Diversity: Many new applications are coming online, and many many more types are envisioned.

New dimensions: The addition of cable TV, telephone, smart paging networks, and the like will open the way for many new types of uses.

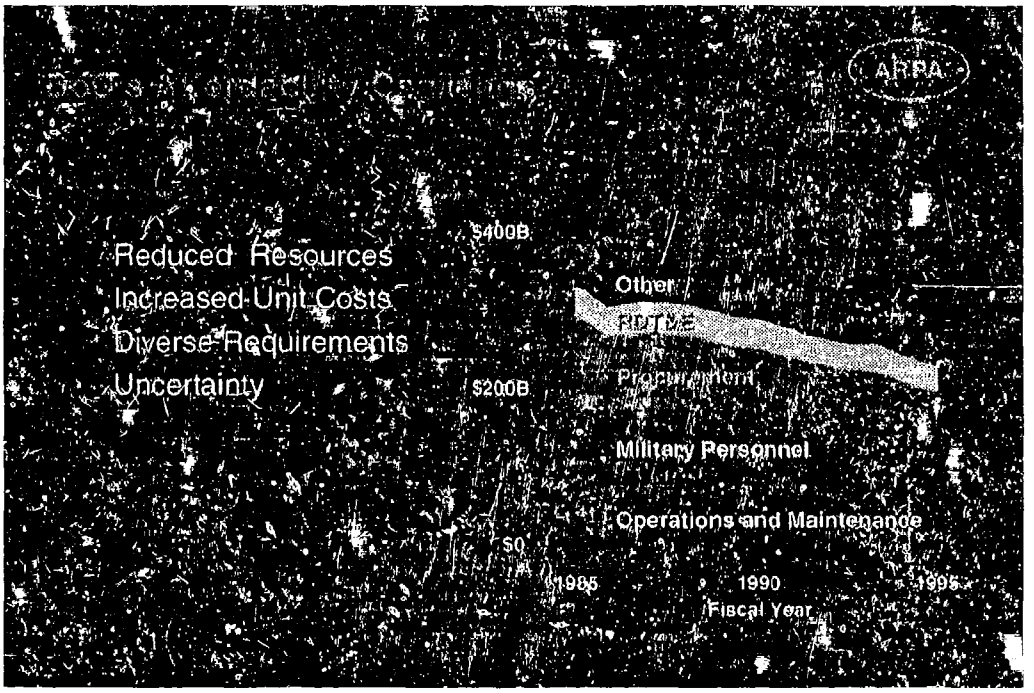
Scale: From hundreds of milions of national users in the US to bilions of users throughout the global system. Explosive growth in the number of organizations using the network.

Businesses will come to depend heavily on the network for everyday business transactions, just as they now do on the telephone network. The network will have to be secure and reliable, and highly available.



Theme:

Affordability has emerged as one of our most significant challenges. The peace dividend and Cold War victory have made common the need for more technologically advanced weapons at less cost. Reduced force structures and inventories with an increased potential for rapid responses any where in the world add to the problems of affordability. Affordability can be achieved if addressed early in the requirements and development phases when production and operational cost drivers are integrated into the design and development process. advanced computational, information, and manufacturing sciences can make a significant contribution toward achieving an affordable defense.



DoD's challenge to assure the Nation's defense at an affordable cost is formidable. The data graphically depicts the seriousness of the defense budget decline and the urgency of wise investments.

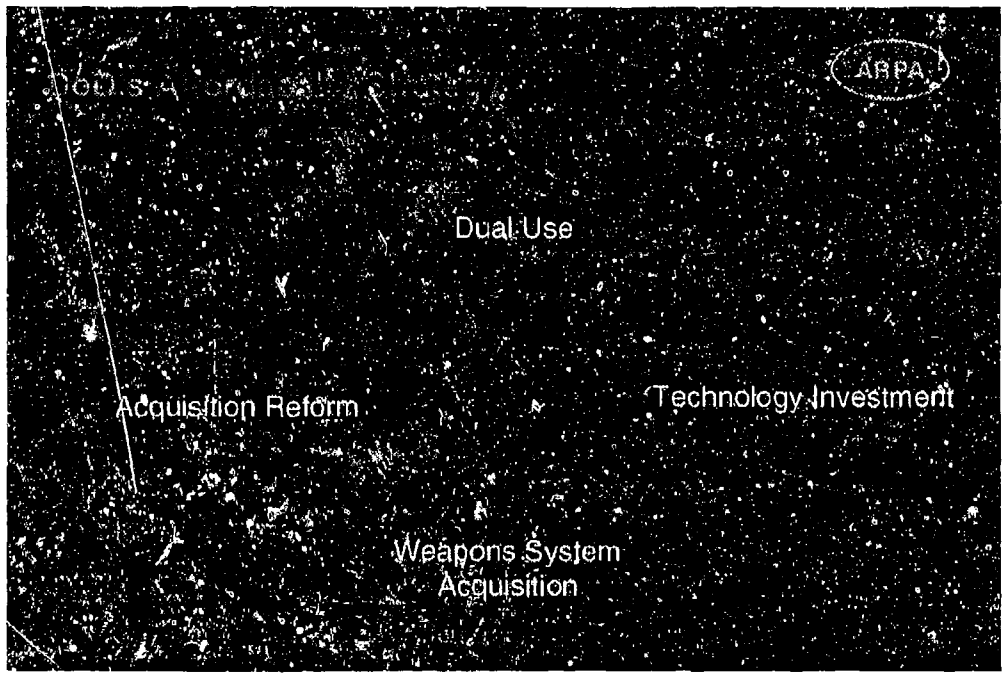
Recent dominant US military successes coupled with the Cold War Victory make it difficult for DoD to justify the need to maintain current investment levels.

The total effect of the declining budget is much more subtle. The reduction in force structures and fewer facilities in which to train and rehearse lead to smaller inventory buys. Smaller quantities in traditional economic terms bring increased unit costs. This can make production or development economically unattractive to industry.

Unfortunately, the threat has not gone away; it has simply changed. The proliferation of weapons and technologies throughout the third world is creating many regional threats that, although individually small, are very sophisticated and require technologically advanced responses within very short and critical timelines. We must now plan for engagements that will be fought with coalitions and allies. This organizational diversity itself brings many new technological demands.

The new world order, declining budget, and changing threat is manifested in uncertainty within our major development programs for our next generation systems.

DoD must do more for less and find a new way of doing business to accomplish that goal.

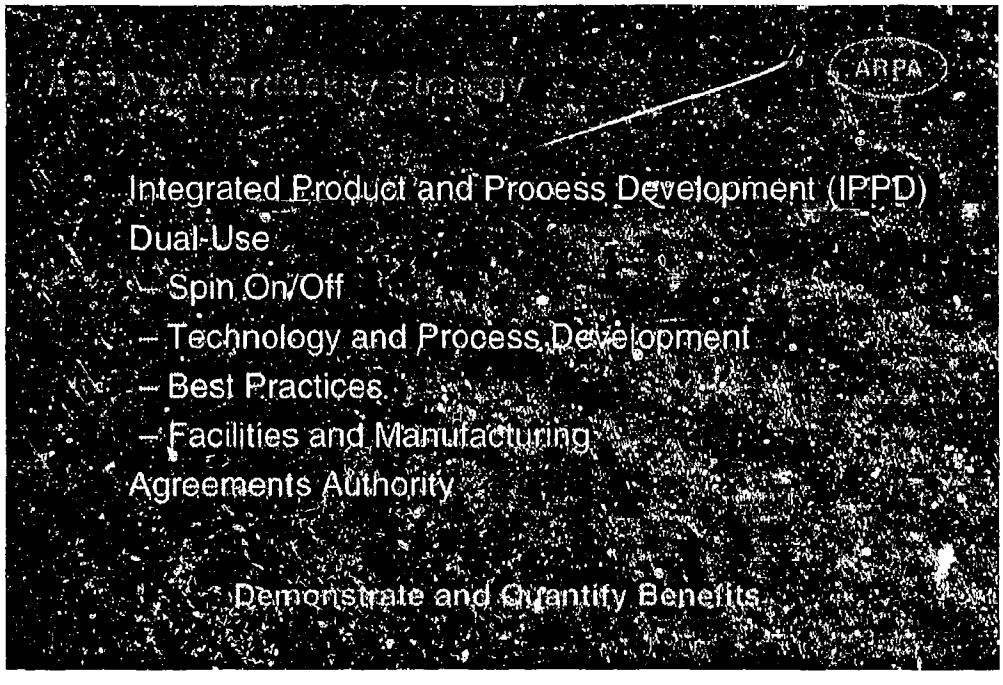


DoD's affordability strategy is lead by PDUS (Acquisition & Technology) Hon. R. Noel Longuemare, and centers around four key elements, Acquisition Reform, Dual-Use, Weapons System Acquisition, and Technology Investment. All of these together are required to address affordability.

Acquisition Reform, headed by DUSD (Acquisition Reform) Mrs. Colleen Preston is attacking the legislative and regulatory barriers to more efficient acquisition.

Dual-Use policies are represented by Mr. Ken Flamm, PDASD (Dual Use Technology Policy in International Programs) where DoD is now focused on economic policy initiatives enabling best practices and engineering approaches to eliminate non-value added components and activities from procurement and development. More than just using non-developmental items (NDI) and commercial products, dual-use promotes sharing the very facilities and means to develop and manufacture military and commercial products.

Technology Investment strategies are represented by DDR&E (Dr. Anita Jones) and DUSD (Mr. Larry Lynn). ARPA, reporting through DDR&E, can lead the development and promote the transition of key enabling technologies which will help ensure timely implementation of affordability in the development process. Current programs have been initiated which address some of the affordability issues; additionally , major acquisition programs are recognizing the importance of emerging affordability technologies. For long term affordability success technology investments, acquisition reform, and dual-use policies must all be implemented into the acquisition and support of weapon systems. Here the DoD must put into practice demonstrated affordability technologies, policies, and practices.



ARPA has always been the right place to undertake high risk programs and to experiment with new ideas that have potential for high payoffs.

ARPA is responding to DoD's needs by aligning investments across critical affordability enabling technologies. Key to this response are investments in developing and demonstrating an integrated product and process development (IPPD) capability. The goal is to design an IPPD architecture that encompasses all dimensions of the affordability spectrum. ARPA is implementing initiatives to include complex system design, e.g. aircraft, spacecraft, land systems, and ships. These efforts start with advanced simulation and modeling tools to help decision makers and users better understand their needs in technical and cost terms, continue through the fundamental information and analytical framework to bring all cost driving and related interests into the design process for vehicle systems, and use advanced simulation to aid operational training and readiness. They will exploit ARPA's core competencies in analytical and computational tools, information sciences, and manufacturing technologies.

ARPA's Dual-Use strategy includes identifying ways to use technologies in spin-on and spin-off applications. The development and understanding of agile and flexible manufacturing technologies can enable facilities, technologies and processes to be used for both commercial and military products, thus expanding the product base and achieving more affordable products.

ARPA's strategy is to quantify the benefits of IPPD and Dual-Use in the context of affordable military products, subsystems, and components. The IPPD systems engineering tools coupled with ARPA's modeling and simulation investments can significantly help military users and developers quickly understand the requirements and test and evaluation aspects of their developments. These tools will incorporate costs and address affordability as part of the underlying requirements and preliminary design.

Finally ARPA is using its newly sanctioned Agreements Authority to systematically expand, exploit, demonstrate, and quantify innovative business practices in the design and development processes.



Perimeter protection (next-generation firewalls) will provide a barrier behind which organizations can safely perform their sensitive internal business, and behind which they can be protected from intrusion from the network.

Organizations must be able to specify their own security policies, and these organization-specifiable policies must be enforceable in tomorrow's end systems.

Flexible, dynamic security enclaves can be established that effect distributed, virtual protected entities. Users within such protected enclaves can interact with each other with the same protections they would have if they were behind a common firewall.

End systems will be able to execute guest sofware or other potentially suspect software in their own isolated domains of execution, so that any security flaws in that software cannot threaten the rest of the system.

Secure interoperation of applications is necessary to support secure data sharing across the network, for example, remote access and integration of data from medical databases.

Degrees of protection will be available, depending on the need.

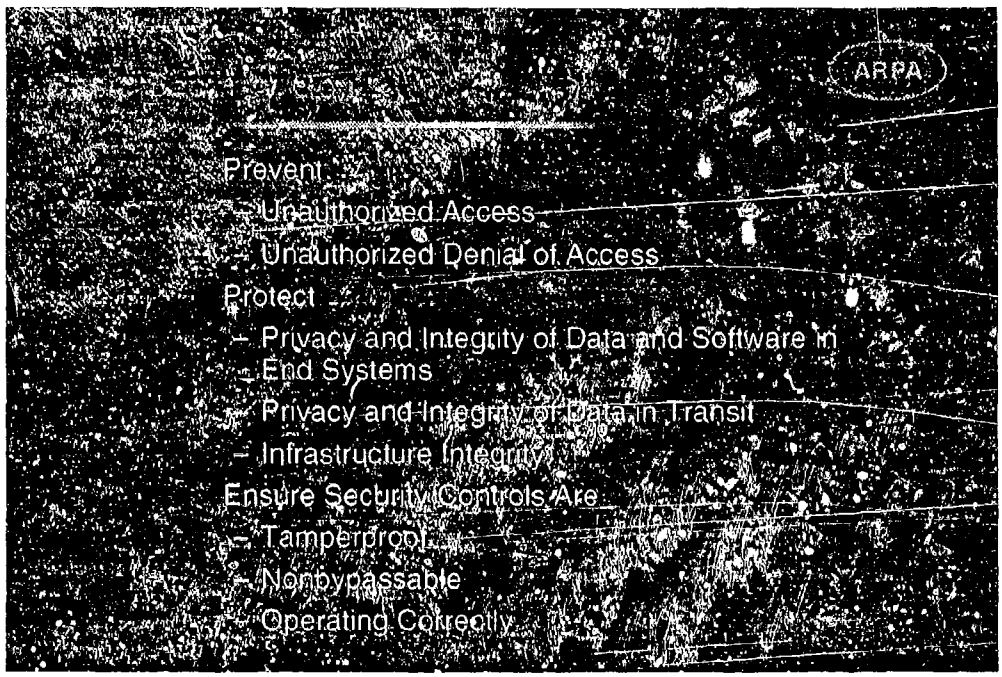


To achieve the vision for the future, commercial carriers (internet providers, telephone, cellular, cable, etc.) will need to provide strengthened infrastructure components (e.g., switches, routers, name servers, directories, etc.)

Basic security services will be offered by commercial carriers and/or third parties (for example, for authentication, access control, privacy, security monitoring, integrity, key-escrow, metering, notorization, etc.)

Security controls, for a basic minimum degree of security, will be required in order for end systems to connect to the network. This is necessary, because a single weak subscriber can provide a point of entry that may threaten other subscribers on the network.

Third-party on-line security validation services will be provided, to provide initial validation of appropriate end-system security before connecting to the network. Periodic security assessments can be performed to ensure that the secure configuration is maintained over time and as end systems evolve.



The basic goals of information infrastructure security require that we address a wide range of issues. The goals are as follows.

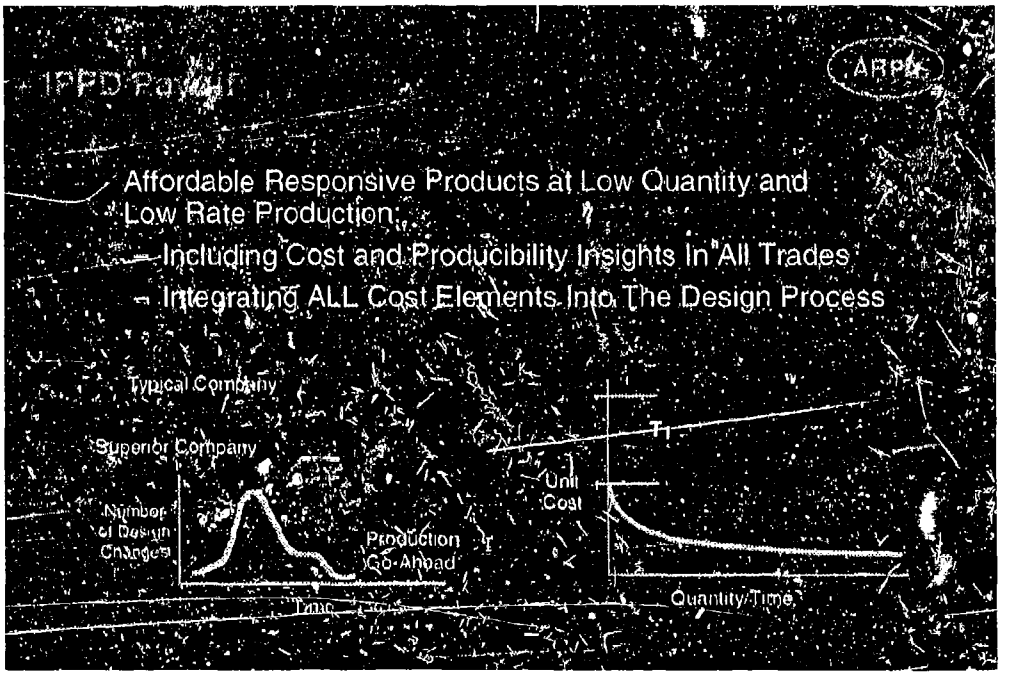
We need to prevent unauthorized access and unauthorized denial of access.

We need to protect the privacy and integrity of data and software in end systems.

We need to protect the privacy and integrity of data in transit from one end system to another.

We need to protect the integrity of the infrastructure and its components.

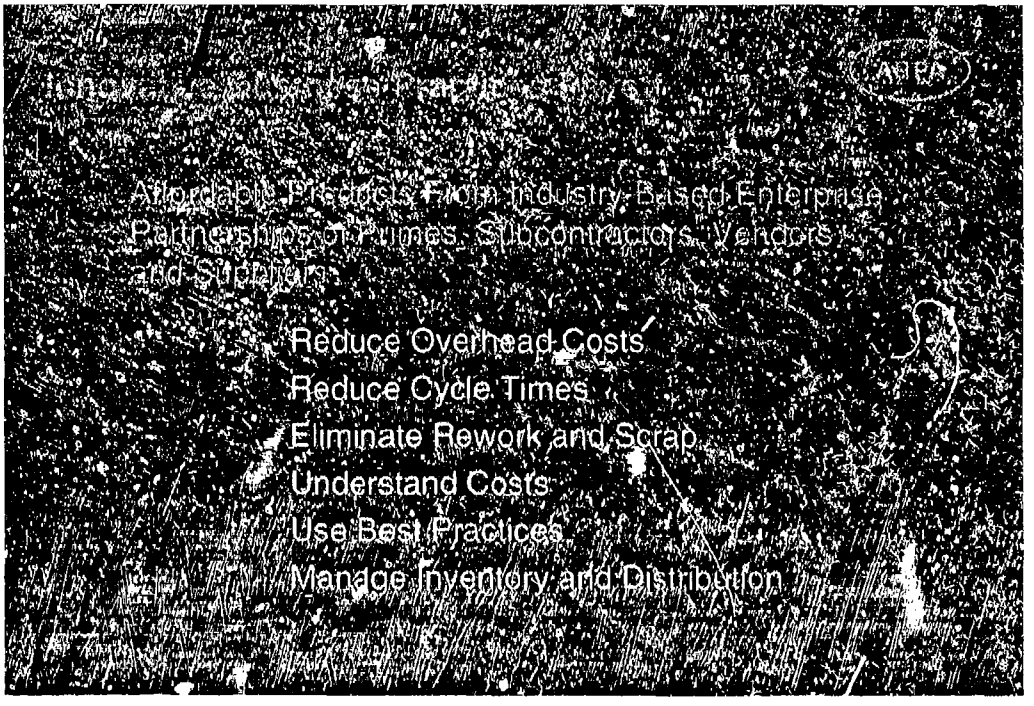
Assurance in the correctness, tamperproof-ness, and nonbypassability of the security controls can be increased in a number of ways, including the use of formal methods for the most critical components or applications of security. Using various assurance techniques, appropriate degrees of assurance can be provided.



Affordability studies throughout industry, DoD, and ARPA for many years have tried to articulate the benefit of parallel or concurrent engineering in the upfront phases of system development. The argument remains that the majority of the costs are determined in the design phase and therefore the greatest leverage for reducing costs and designing affordable products is also found in the upfront effort. Until the MIT study of the automotive industry was published in 1990 there was little data to quantify the payoff. MIT's work provides data in the high-volume commercial automotive context that supports the underlying assertions.

Their studies and findings highlight the technology deficiencies that still exist in providing an efficient way for many of the cost driving engineering disciplines to participate concurrently in the design process. Much of the clear economic advantage that has been demonstrated was done with human interface and was limited by that process. We believe that if sufficient information, analytical and computational design tools can be linked together to share data, requirements and sensitivities many design alternatives could be iterated and evaluated in a relatively short time. Costs of alternatives and performance trades including costs could be responsibly performed. The resultant candidate systems or technologies could be electronically prototyped and evaluated within a high fidelity simulation environment and the military utility of the candidates assessed at a war fighting level. Costs, producibility, and affordability could be critical and meaningful components in the assessment by users and developers.

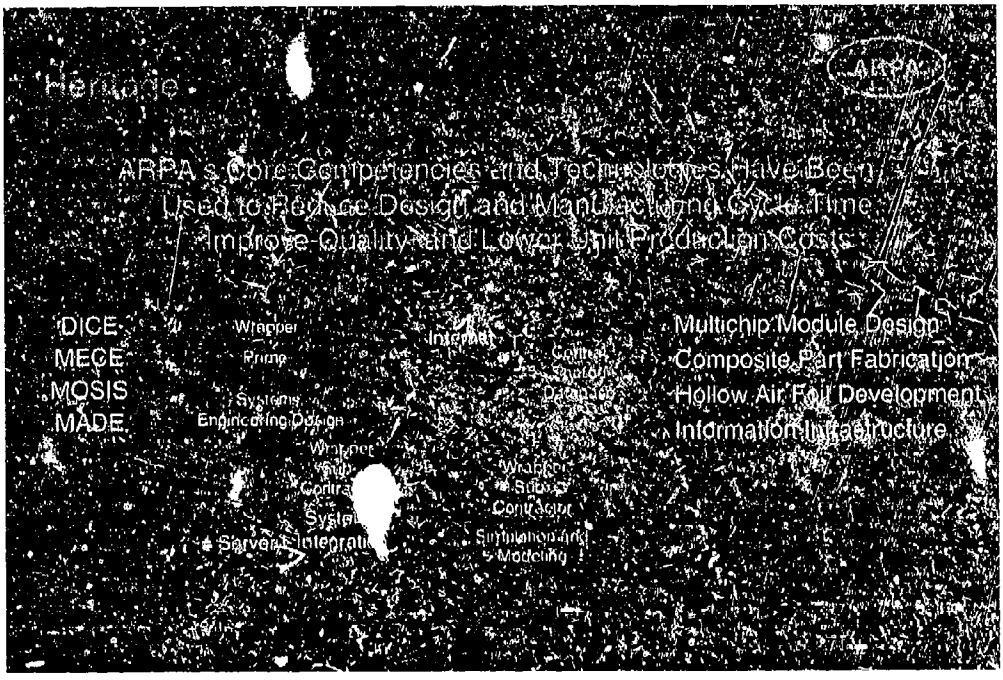
Joint participation by the users, developers, builders and supporters in the design process can lead to doing it right the first time rather than our current way of design-test-fix and then redesign for production. This will significantly reduce the quantity to cost sensitivity which now makes small military production runs unaffordable.



Going as far back as the first Packard Commission report, acquisition and procurement experts have suggested that considerable time and dollar savings can be attained through the use of commercial best business practices. The barriers to implementing these recommendations have always been the institutionalization and codification of the defense procurement and acquisition process not only by the FAR, DFAR and C/SCSC but also by a culture that has been matured by its practitioners. Even when specific authority has been granted to relax or eliminate some onerous documentation or certifying requirements, the full measure of the regulations are often applied because both the industry and defense participants are comfortable with them.

Congress recently passed legislation to expand ARPA's Agreements Authority. Previous legislation allowed ARPA to obtain basic research through Agreements Authority without requiring formal government contracts and related financial reporting. The expanded Agreements Authority now permits ARPA to also purchase hardware and buy products from companies which do not have compliant C/SCSC systems. The new Agreements Authority is for three years and requires ARPA to assess and quantify the benefits that accrue from this elimination of bureaucratic requirements in a hardware development context. Agreements Authority gives ARPA and participating contractors the flexibility to replace existing regulations with more flexible best commercial practices. The opportunity allows for innovative management of the business enterprise to include partnering and sharing of design responsibility among primes, subcontractors, vendors and suppliers. Efficient and effective management of inventory and supplies replaces the old incentives to stock pile and front load contracts.

Agreements Authority provides an opportunity to exploit best practices to include devising management and financial reporting systems that meet the law (IRS) but do not require expensive additional costs to implement government mandated reporting systems. This new approach requires streamlining of oversight by the government and new methods and procedures for gaining insight to fulfill basic fiduciary responsibilities. A new area of interest is in activity or process based accounting, costing and management. We feel that these financial methods and tools will enable us to evaluate value and non-value added activities and to quantify and measure affordability issues and benefits.

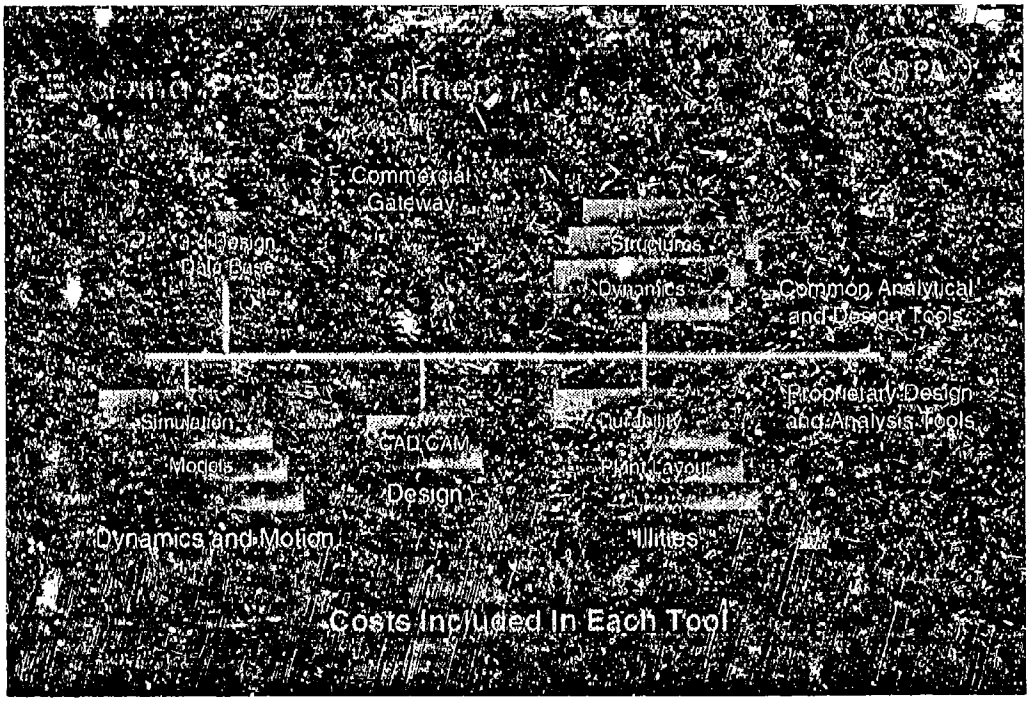


ARPA has a rich heritage of to addressing design and manufacturing efficiencies through advanced technologies. Over the last decade ARPA has invested in identifying, developing and demonstrating through pilot projects the technologies necessary to reduce manufacturing cycle times, improve product quality, and lower unit production cost. These pilot projects included: MOSIS (Metal Oxide Silicone Implementation Service), DICE (DARPA Initiative in Concurrent Engineering), MECE (Multimedia Engineering Collaborative Environment), MADE (Manufacturing and Design Engineering), and several others.

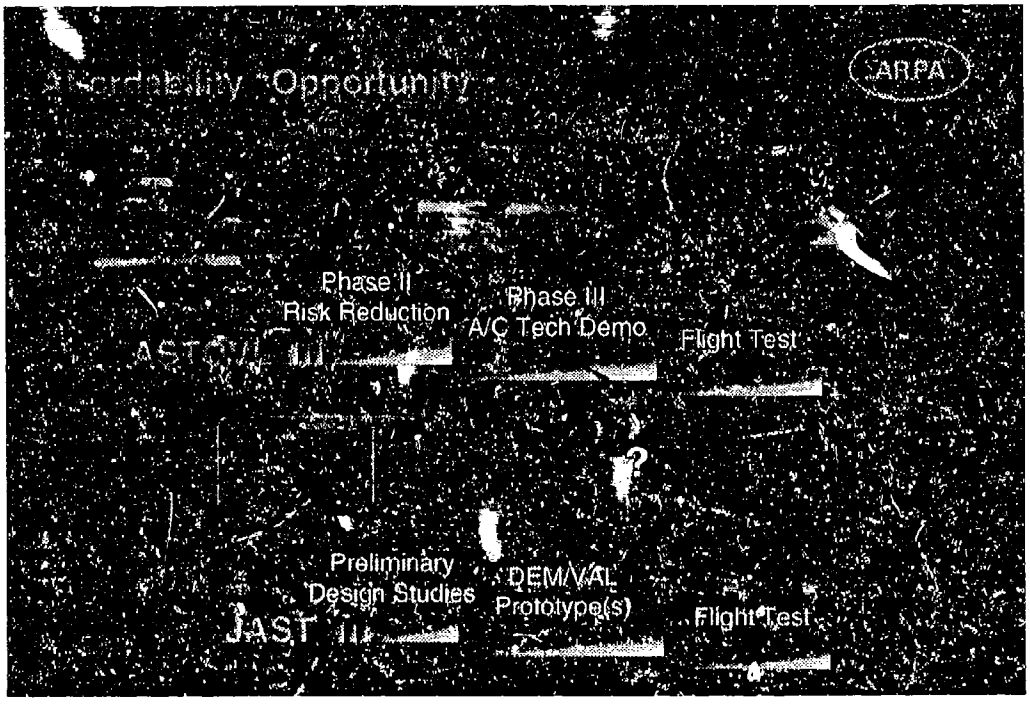
Past efforts focused on collaboration technologies and networking infrastructure to aid in the concurrent interaction of multiple and dispersed engineering disciplines. The technologies developed in the broad areas of information science, network servers, information formats and protocols, as well as analytical design tools, manufacturing and materials processes have produced multimedia conferencing, wrapper technology, and semi-automated designer aids.

Pilot projects were used to demonstrate the benefits of concurrent engineering and electronic commerce within dispersed project teams. The successful demonstrations included: Hollow Airfoil Development, Composite Part Fabrication, and Multi-chip Module Design and Fabrication.

Accomplishments and lessons learned from the pilot projects include controlled configuration management of a shared design database; reduced design and process development cycle times; reduced numbers of engineering change orders; and reduced scrap and rework. These successes are being used as a point of departure to proceed in expanding our efforts. Specifically, ARPA is investing in efforts to increase the number of engineering disciplines, integrate cost and best practices, and include all stakeholders in the design process

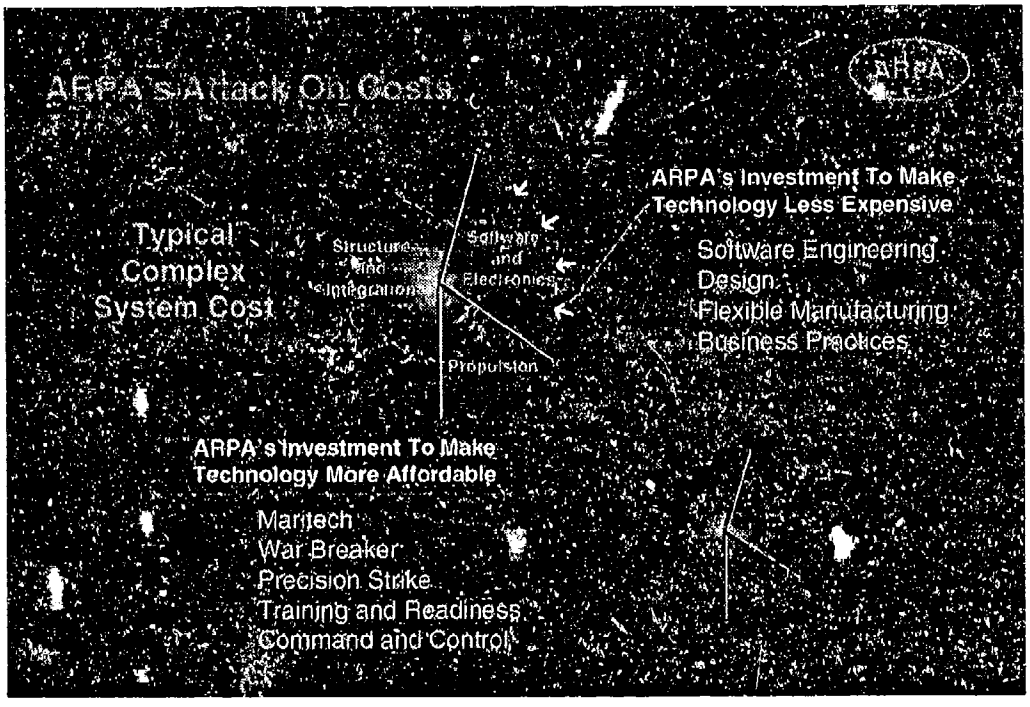


We are making progress and seeing some payoffs from our initial investments in concurrent engineering and IPPD. This is a schematic of the information architecture that ARPA, NIST and the University of Iowa have put together in a program to develop and mature a comprehensive IPPD environment. It depicts the integration of the University of Iowa's motion based simulator into the mechanical, structural and dynamic disciplines of the design process. Important to note is the wrapper technology developed to allow competing commercial customers to simultaneously participate in the design iteration process without compromising their individual proprietary algorithms and processes. The upper portion of the data stream connects the traditional Commercial Off The Shelf (COTS) software design and manufacturing tools while the lower domains bring in individual cost driving engineering constraints or considerations. Human factors and life cycle elements of reliability and durability are also inserted into the design iteration. At present, costs are evaluated separately in the final alternative selection process. An area of opportunity is in integrating process and activity based cost estimating relationships (CERS) and cost knowledge bases into the individual design tools so that the engineers can directly evaluate the impact of cost and performance trades at all levels of detail within the overall process. Using the previously mentioned innovative business practices will allow prime contractors to involve their subcontractors, vendors and suppliers in interactive participation in the design process. Recently there was an opportunity to help a major US auto manufacturer use this ARPA-sponsored IPPD environment to rapidly examine many design alternatives to solve a rather complex problem.

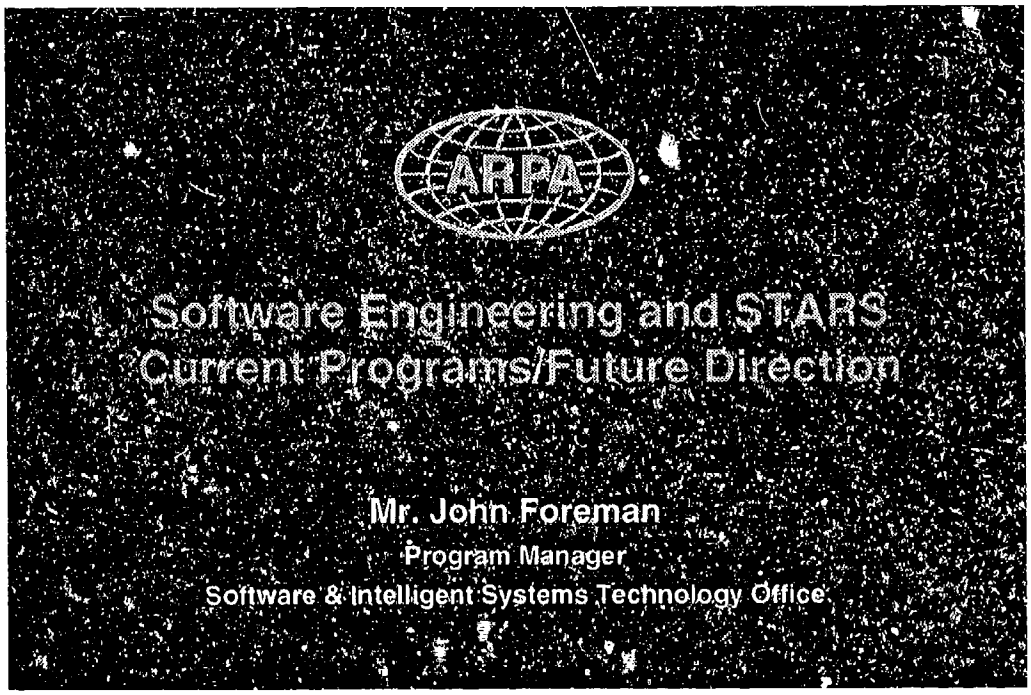


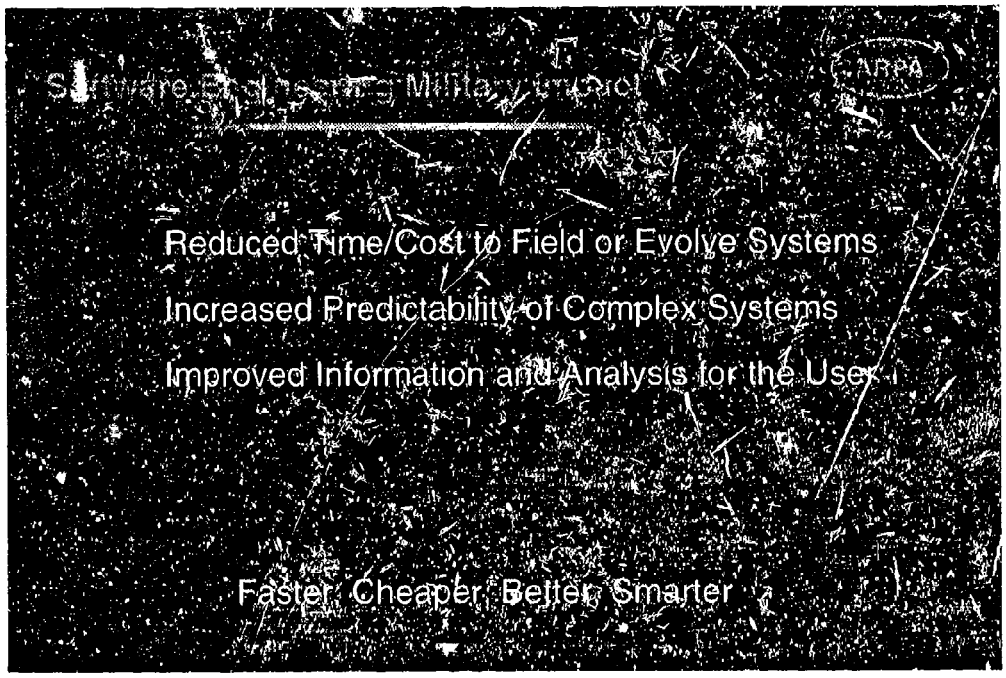
We have a window of opportunity to develop, demonstrate, and transition technologies for affordability in the ARPA X-32 (ASTOVL) program. The X-32 has always had affordability and reduced cost as an essential program goal. The program is centered about three high level requirements: empty weight, deck spotting factor, and the use of an existing propulsion system core. Three X-32 contractor teams: Boeing, Pratt & Whitney and Rolls Royce; Lockheed, Pratt & Whitney and Allison; and McDonnell Douglas and GE; in addition to developing and demonstrating critical ASTOVL technology in Phase II Risk Reduction, are also currently completing "Affordability Jump-start" tasks. The teams are evaluating various design and manufacturing technologies for affordability as well as designing an accounting and management framework to develop a generic activity based cost estimating model. The jump-start effort identifies desired attributes of an IPPD environment supported by an activity based cost and management system. The actual effort will build, use, measure, and quantify the impact of these IPPD tools and innovative business practices (elimination of mil-specs and standards as well as using activity based costing rather than C/SCSC) in subsequent phases of the program.

The X-32 contractor teams have already begun to build, demonstrate and use affordability tools and IPPD environment hosted design processes to gain competitive advantage in their ongoing design of an affordable advanced strike fighter. The measurement of the IPPD affordability impact and the quantification of its benefits will be important not only to X-32 but the lessons learned and technologies and processes developed can be transitioned to the eventual Joint Advanced (Affordable) Strike Technology Fighter (JAST) and other complex vehicle systems. The timing of the X-32 technology and IPPD environment development is ideal for integration into the JAST Program master schedule. Whether ASTOVL becomes a JAST candidate or only provides affordability concepts and tools it will contribute significantly to the affordability goals of our next major aircraft development program.



The agenda for the Affordable Defense session will explore a variety of discipline areas in which ARPA is investing in to make technology and subsequently military systems more affordable. Today's presentations are divided into two sessions, morning and afternoon. Dr. Michael McGrath will chair both sessions. The morning session will emphasize ARPA's efforts to make technology less expensive. The afternoon session will be more global, addressing system level topics such as: tools, technology, costs, simulation, and system development through rehearsal and implementation that are being developed to help build more affordable systems.

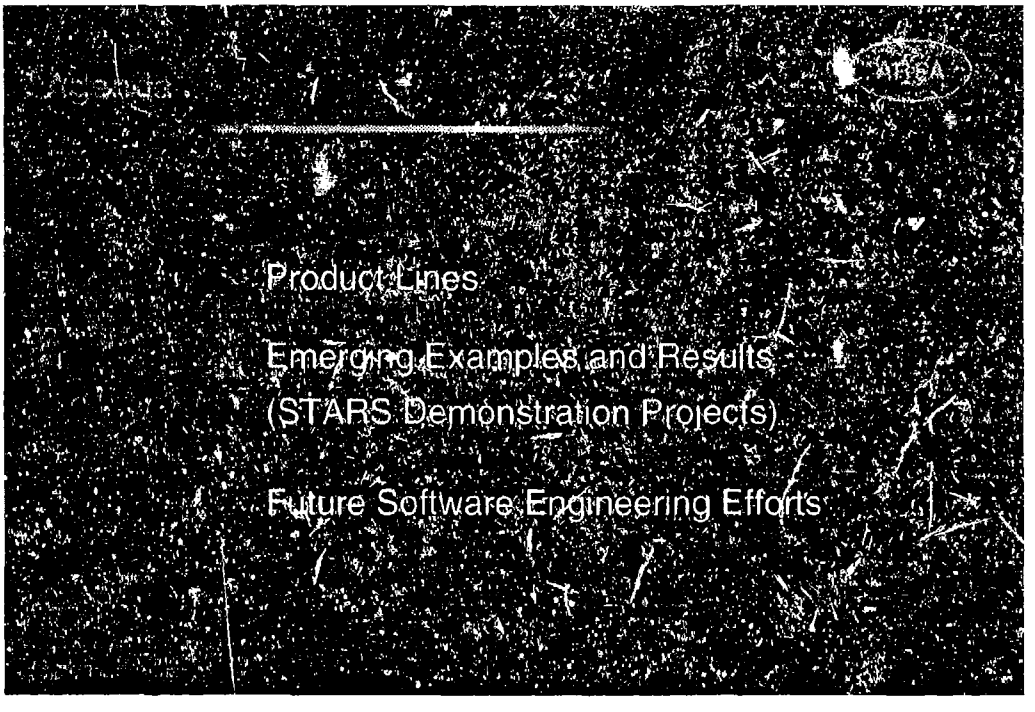

ARPA
Software Engineering and STARS
Current Programs/Future Direction
Mr. John Foreman
Program Manager
Software & Intelligent Systems Technology Office



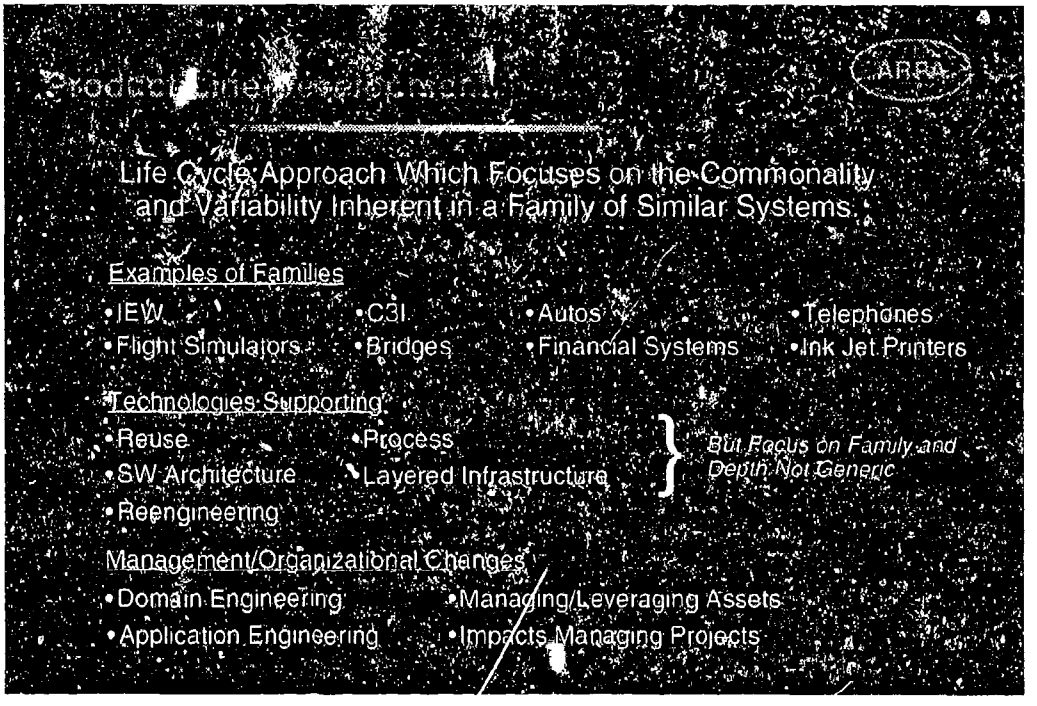
Before I begin talking about current activities, let me state my view regarding the impact of software engineering on the military. My perspective is not a research only perspective, but rather one that emphasizes how software engineering is a vehicle for achieving faster, cheaper, better and perhaps smarter systems. More specifically, we are concerned with:

* reduced time/cost to field or evolve systems
* increased predictability in the development of complex systems
* improved information and analysis for the user

Stated another way, reduced time to develop, reduced cost of ownership, and increased mission capabilities.

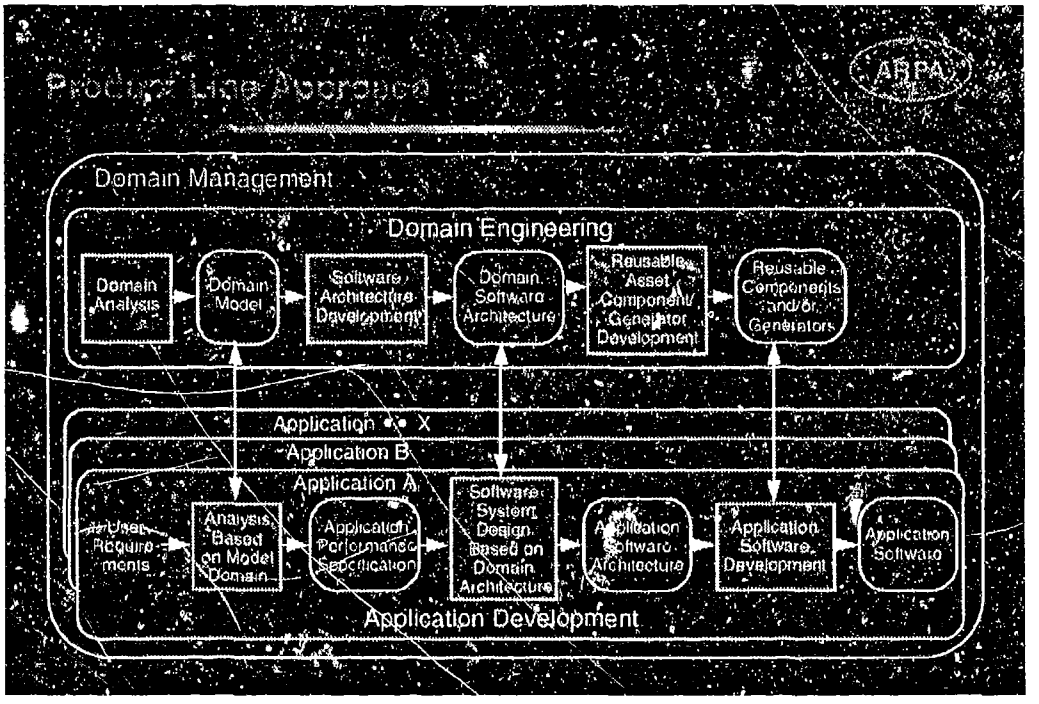


In my talk today, I will address some activities that are addressing the faster, cheaper, better and smarter perspective. It is significant that not all will be technical solutions, but often are an integration of various technologies with some organizational and acquisition type changes. I'll start out discussing product lines, provide some examples of the power of this concept and the technologies, and then talk about future software engineering efforts



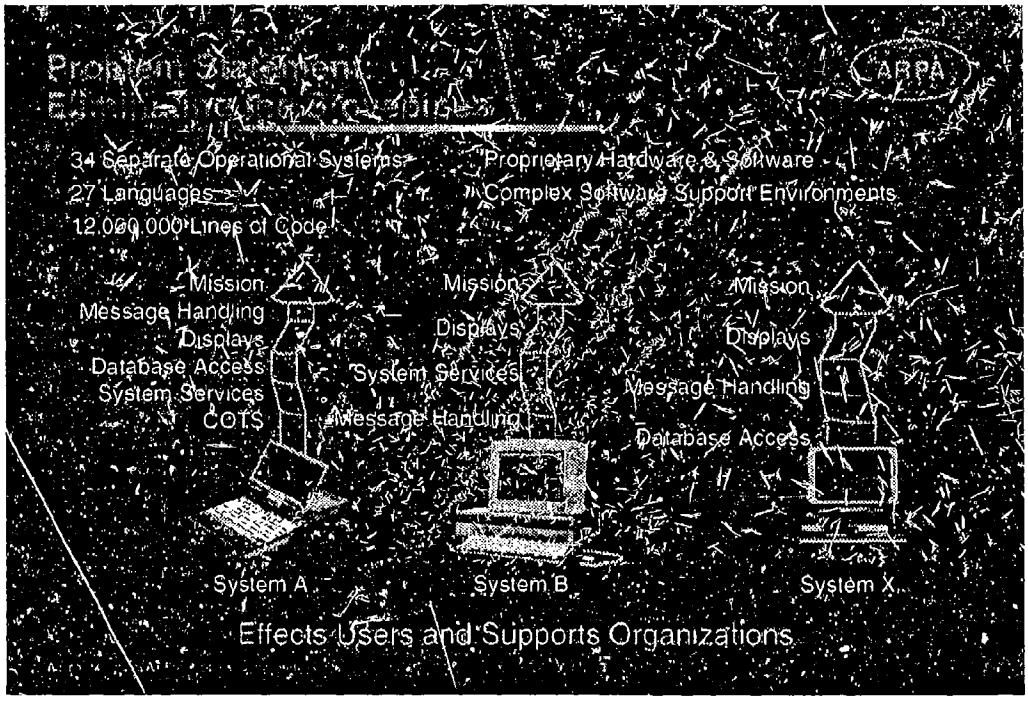
Let me explain what the product line approach is.....

The approach here was to just walk thru the slide, from bullet to bullet



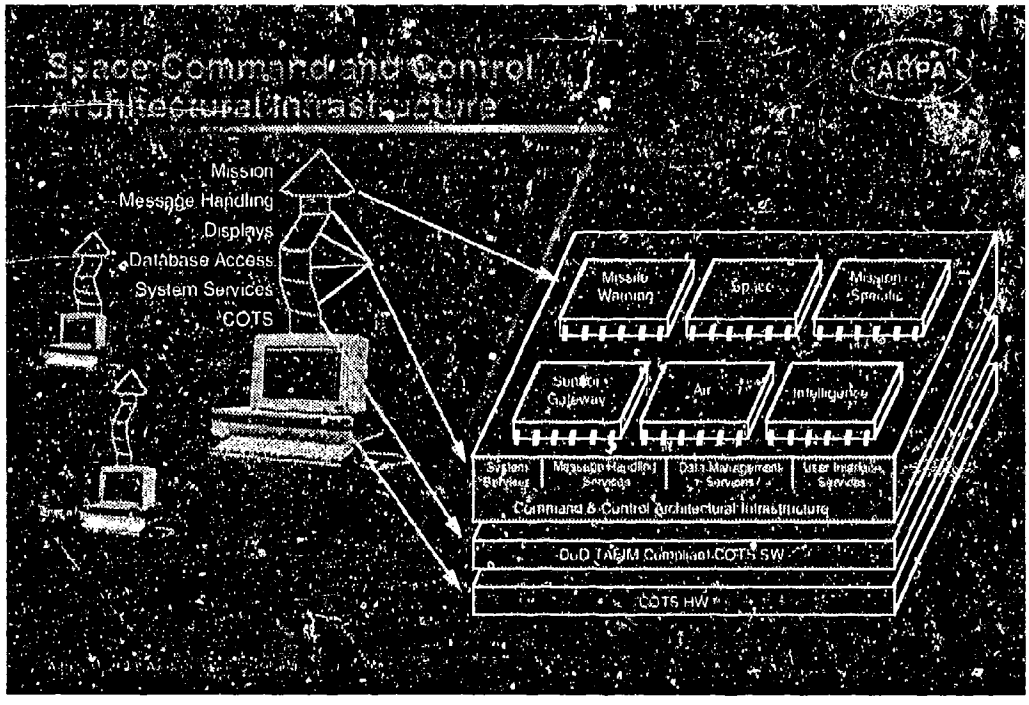
A Very key idea in the product line approach is to think about 2 life cycles, instead of just 1. The Bottom half of this chart (application development) is generally the typical single systems development approach (remove the references to architecture however).

One of the main problems with single systems development is that it doesn't pay any focused attention to results available from similar systems. This is an artifact of our acquisition approach and of course affects program offices, contractors, and government post deployment support organizations. Over time, we have learned that a 2nd life cycle, called Domain engineering is needed. This life cycle exists in a parallel with application development, and focuses on common assets and procedures within an application domain or line of business.



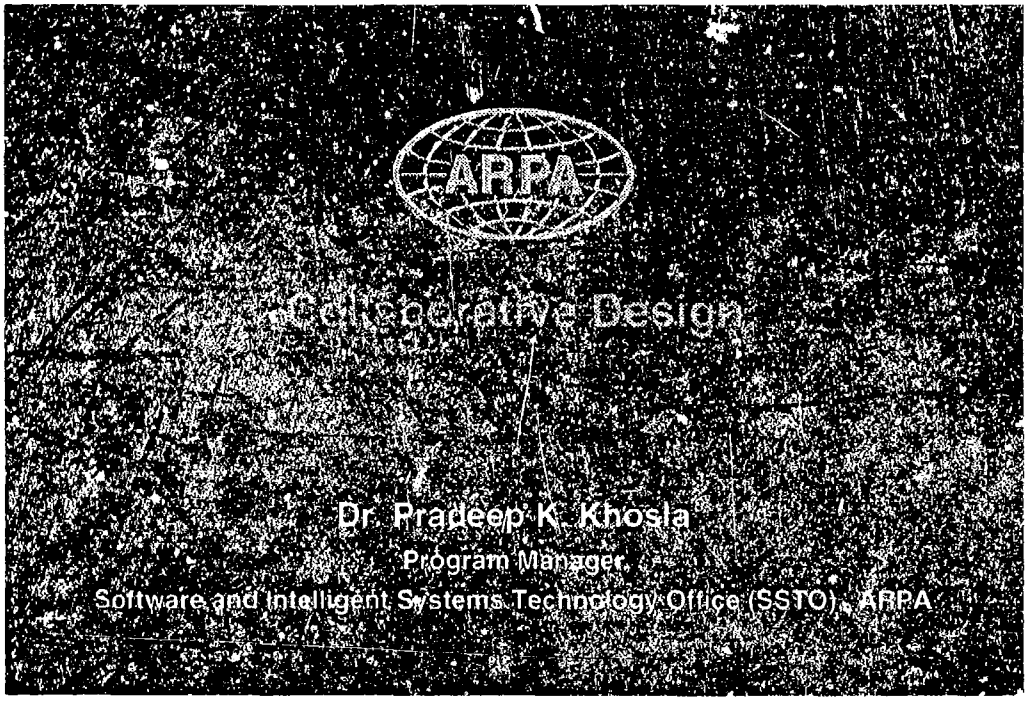
A consequence of single systems development approached is shown in this chart. We have all heard about stove pipe systems, and they exist in many places. Here is an example from Air Force Space Command, with whom ARPA is working to minimize the consequence of this problem, using the 2 life cycle approach. SPACECOM has a significant # of systems in the Cheyenne mountain complex and when you step back and look at them, they are very similar with respect to the software that constitutes them.

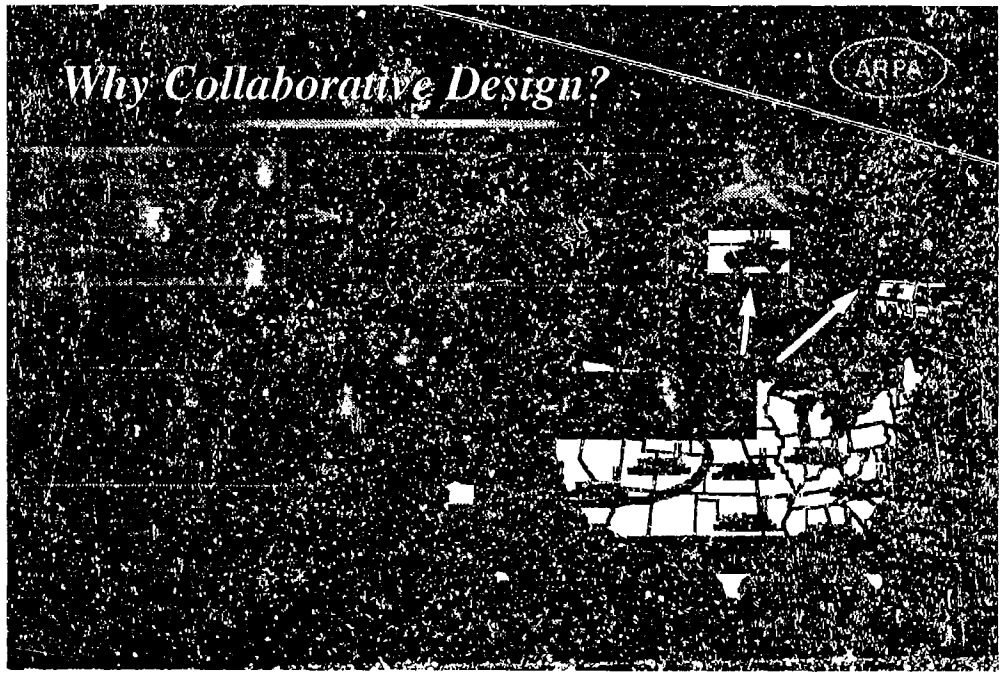
At SPACECOM, they have < go thru the bullets at the top of the chart > which has significant ipact on staffing, responsiveness to users, afford-ability, budget, etc.



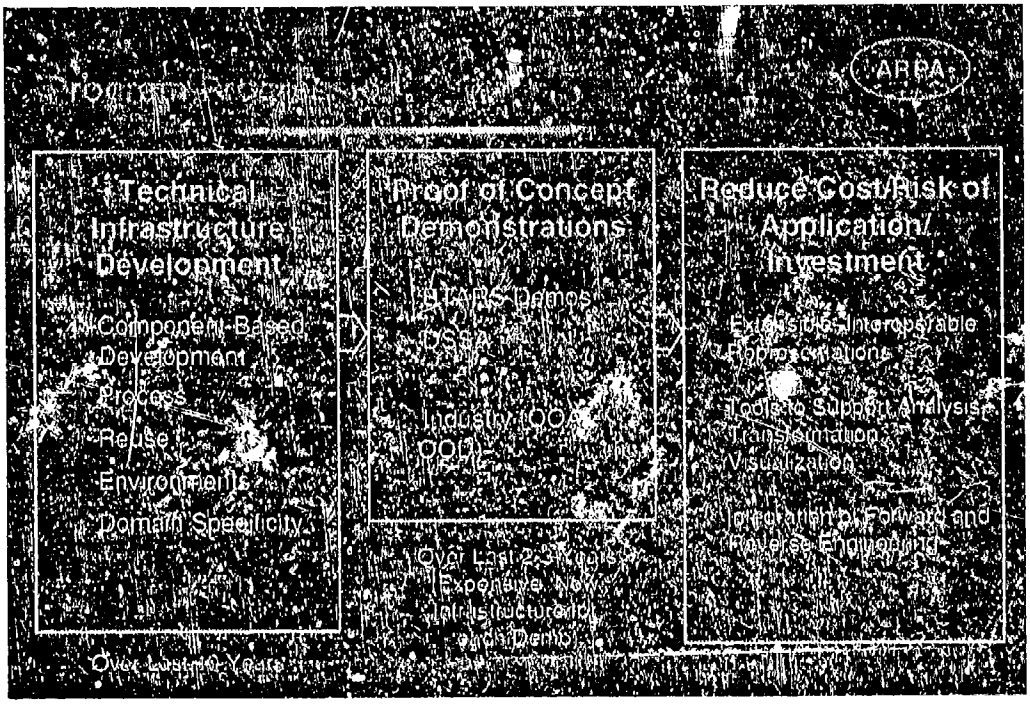
The question is "we have inherited all these developments, what to do about it." Much of this work is being driven from the perspective of the software maintenance world, because the development community still tends to think single system and doesn't see the consequences of that approach. The approach at SPACECOM (and the approach everywhere) is to figure out where each system is unique (ie what mission capability it provides that other systems don't) and also figure out what the common services are that systems of this class need, and to separate the 2.

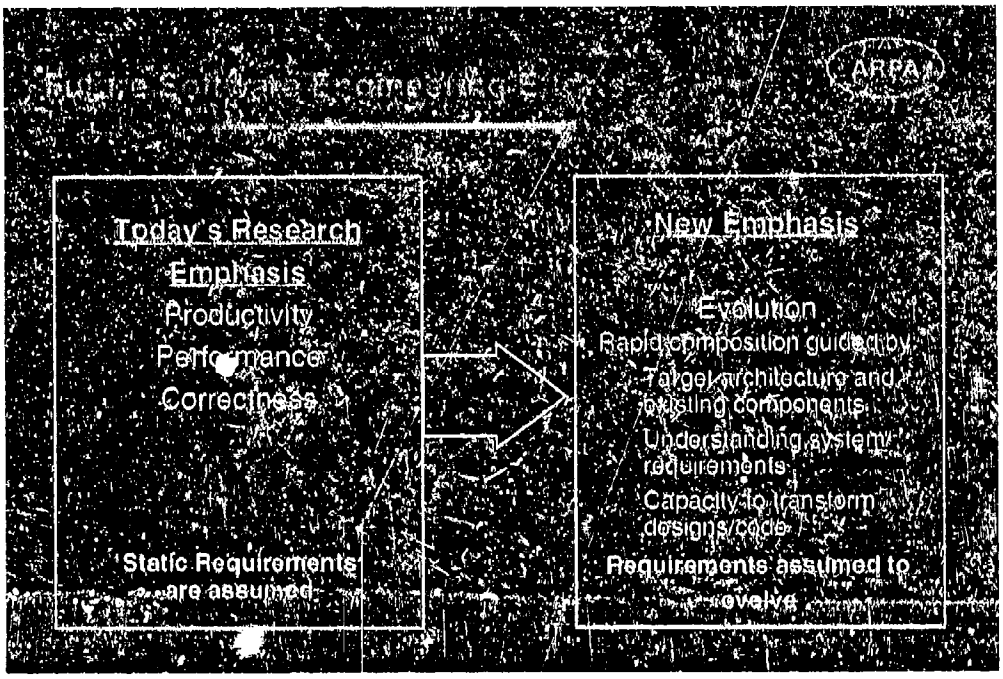
Thru much work, they are making those distinctions and have developed a layered architectural infrastructure shown. This approach really minimizes the amount of mission specific code that has to be maintained and makes for a more effective maintenance organization, because now not every system has to focus on common type services (displays, database, etc)

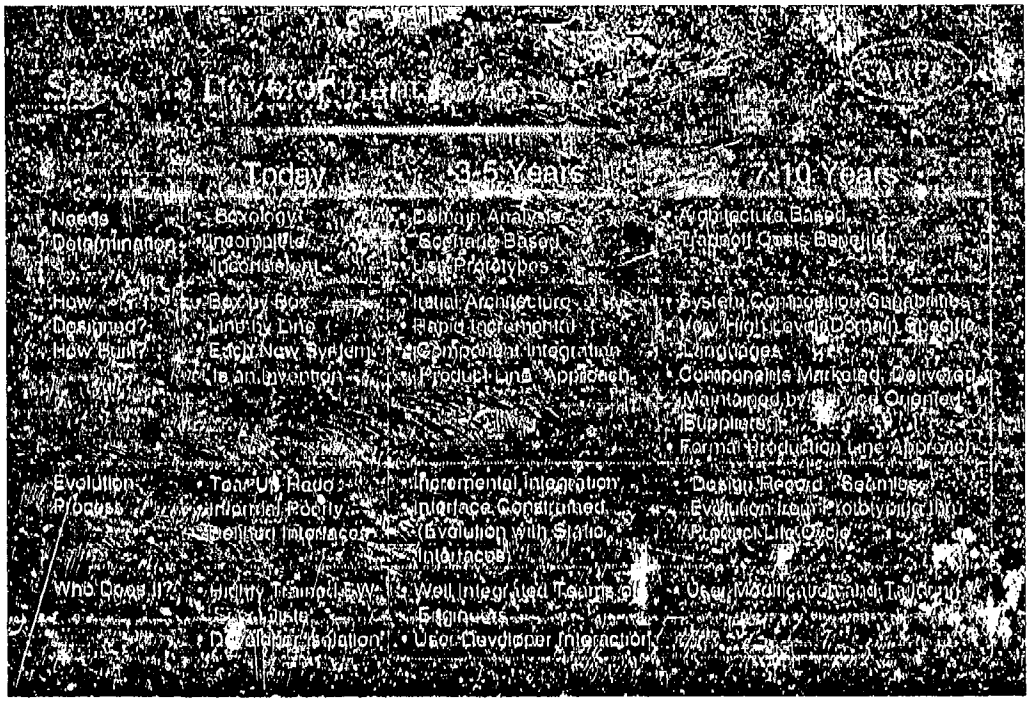

ARPA
Collaborative Design
Dr. Pradeep K. Khosla
Program Manager
Software and Intelligent Systems Technology Office (SSTO), ARPA



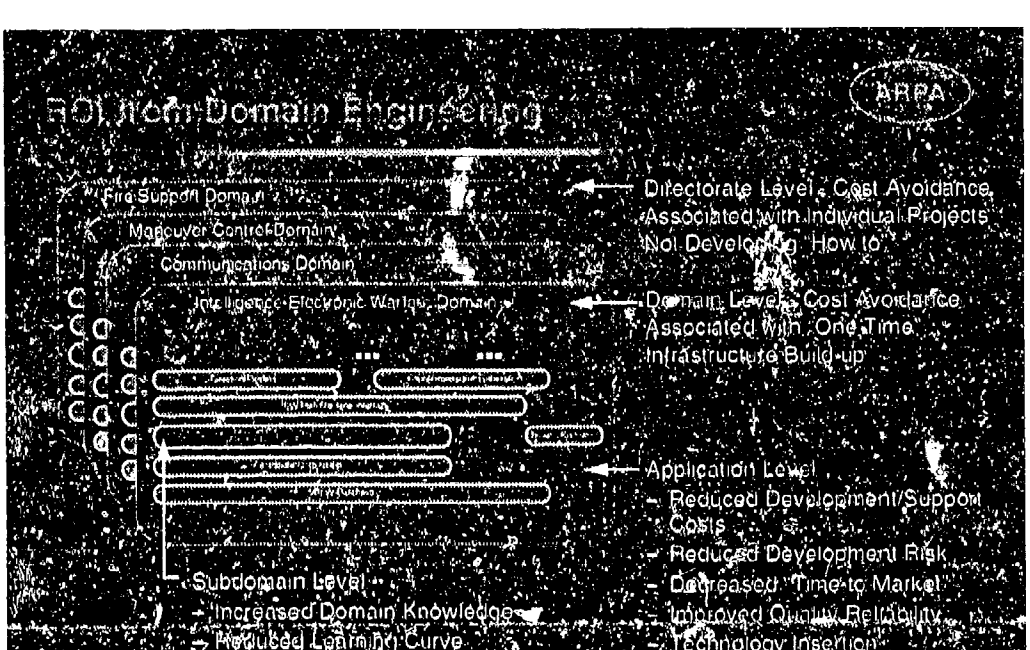
ARPA's interest in Collaborative Design and Manufacture stems from the fundamental need to address Affordable acquisition of Defense systems. Currently DoD acquires its components and systems from a set of contractors that are commonly referred to as "Defense Contractors". These contractors and their capabilities constitute the Defense Manufacturing infrastructure of the country. Severe reductions in DoD acquisitions budget will result in a reduction in the size of the defense industrial infrastructure. If nothing is done to counter this, it will impede our goals of improving the level of readiness and acquiring systems affordably. In order to meet these goals, in light of budget reductions, it is important to develop technologies that will allow us to integrate the commercial infrastructure with the defense infrastructure. While such a policy is in place, the technologies to make this happen are not. The goals of the 3 programs described in this briefing (MADE, SBD, and IPPD) are to develop and demonstrate technologies that will accomplish this objective.


ARPA
Technical Infrastructure Development
Component-Based Development
Process
Reuse
Environments
Domain Specificity
Over Last 10 Years
Proof of Concept Demonstrations
STARS Demos
DSSA
Industry OOA
OOD
Over Last 2-3 Years
Expensive, Non-Infrastructural Demos
Reduce Cost/Risk of Application/ Investment
Existing, Interoperable Representations
Tools to Support Analysis
Transformation
Visualization
Integration of Forward and Reverse Engineering

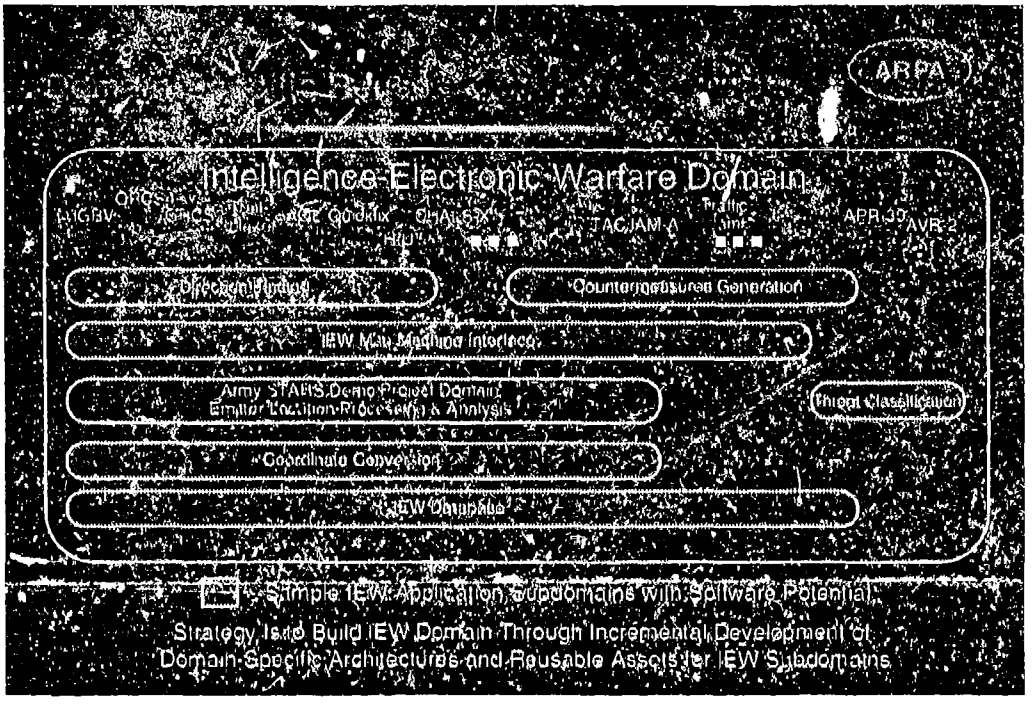

ARPA
Today's Research Emphasis
Productivity
Performance
Correctness
Static Requirements are assumed
New Emphasis
Evolution
Rapid composition guided by
Target architecture and existing components
Understanding system requirements
Capacity to transform designs/code
Requirements assumed to evolve



The purpose of this slide is to show where software development activities aretoday, where the new technologies are leading us in the 3-5 year time frame...ie hoping for common practice in that time frame, and where subsequent ARPA investments will be made so that additional supportive technologies are available in the 7-10 year time frame

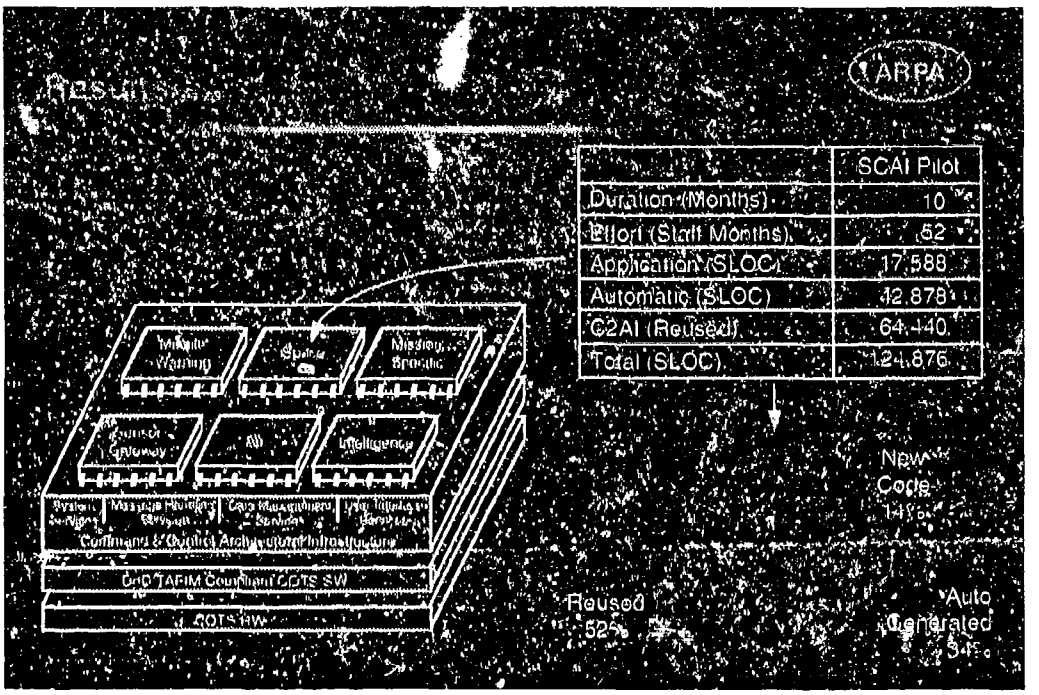


Results to date (including cost data for doing the processes repetitively) indicate applicability to all the software domains maintained at Ft Monmouth, with different types of savings accruing at different organizational levels. This again comes viewing Software as a set of product line assets, instead ofjust from a single system approach. I would acknowledge that major challenges lie ahead in taking the approach to acquisition world because of the way systems are acquired. Perhaps the maintenance community which inherits the results of acquisition programs ought to have a larger voice in acquisitions.

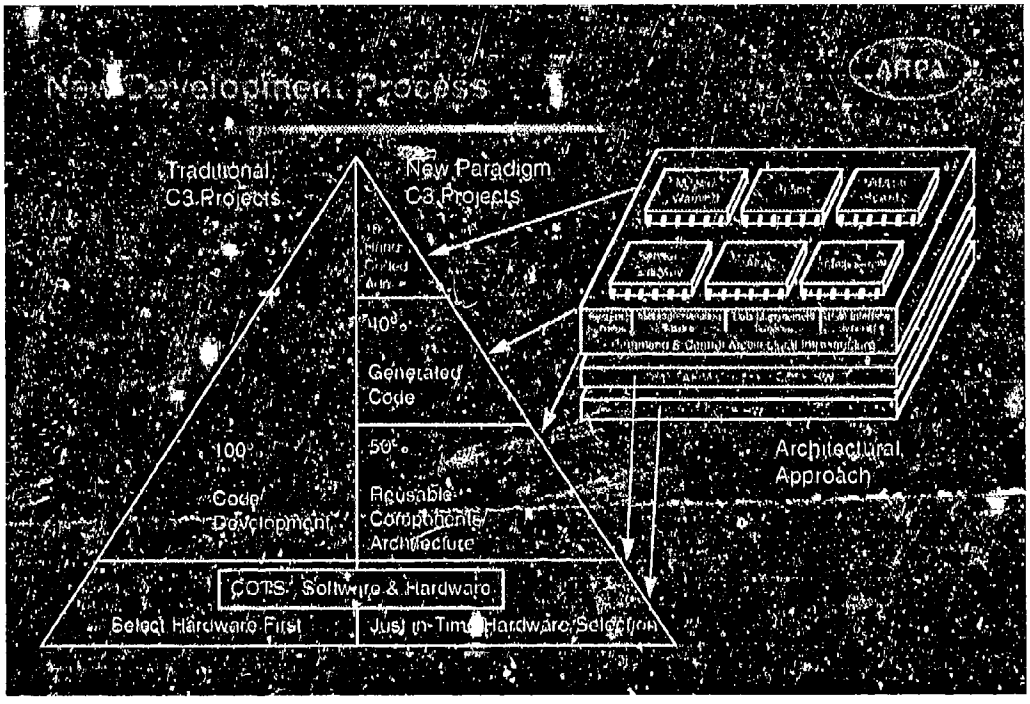


Similar efforts are also ongoing in the Army at Fort Monmouth, again in postdeployment software support.

As an example, the army has some 80+ electronic warfare systems, and high level domain analysis of those systems has revealed significant commonality in functionality and lots of different versions of code to maintain. In fact there are 27 systems where ELPA - emitter location positioning analysis - is used. The Army is doing detailed domain analysis of this sub-domain and then will insert that new code into a member of the Guardrail application family. They intend to accomplish similar domain engineering and insertions over a # of systems. And this is not something just for the IEW world.



The results from this approach to date (in building one of the individual applications) have been quite significant. Productivity has been about 2,000 LOC/per staff month, but the most significant item is how that was achieved. 52% of the code was reused (its the infrastructure layer), 34% of the code was auto generated to the requirements of the application, based on some domain specific tools that are aware of the infrastructure layer, and only 14% was hand generated. Thus, the individual application engineers/developers can concentrate on the application/mission specifics of their problem, instead of worrying about re-developing lots of infrastructure code.

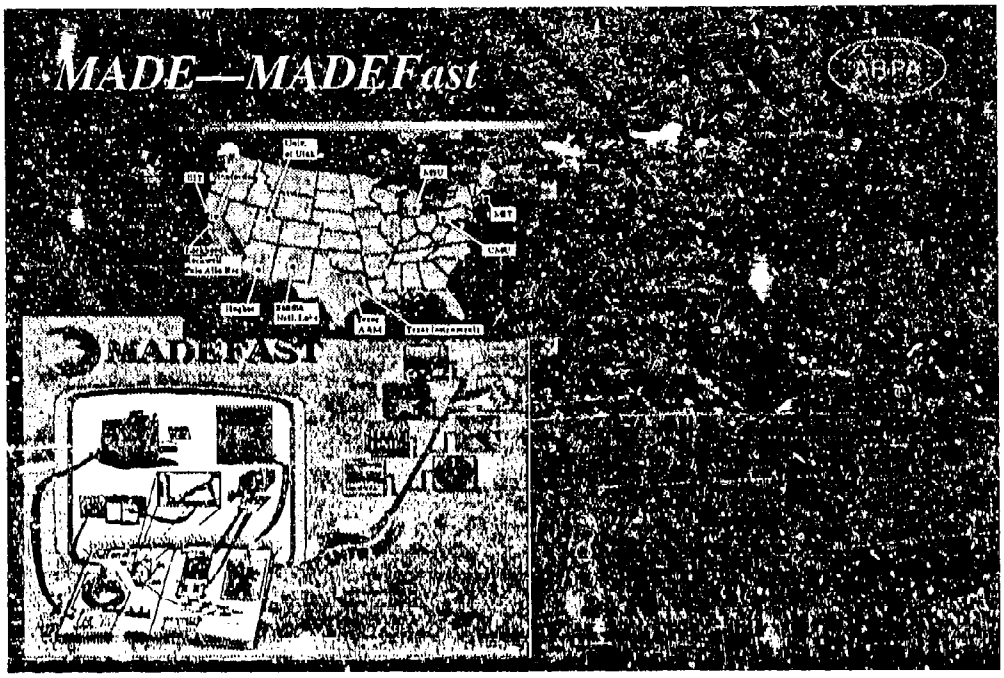


The previous info leads to the next slide which illustrates that a new development process is possible/doable. 2 key ideas:

* it is possible to isolate the mission specific portions of the system by using a layered infrastructure approach thus reducing complexity, and development time

* this approach is also very flexible and allows the layers to grow and evolve

* Hardware selection decision (which often are the pacing factor in acquisitions CAN be delayed until its just in time



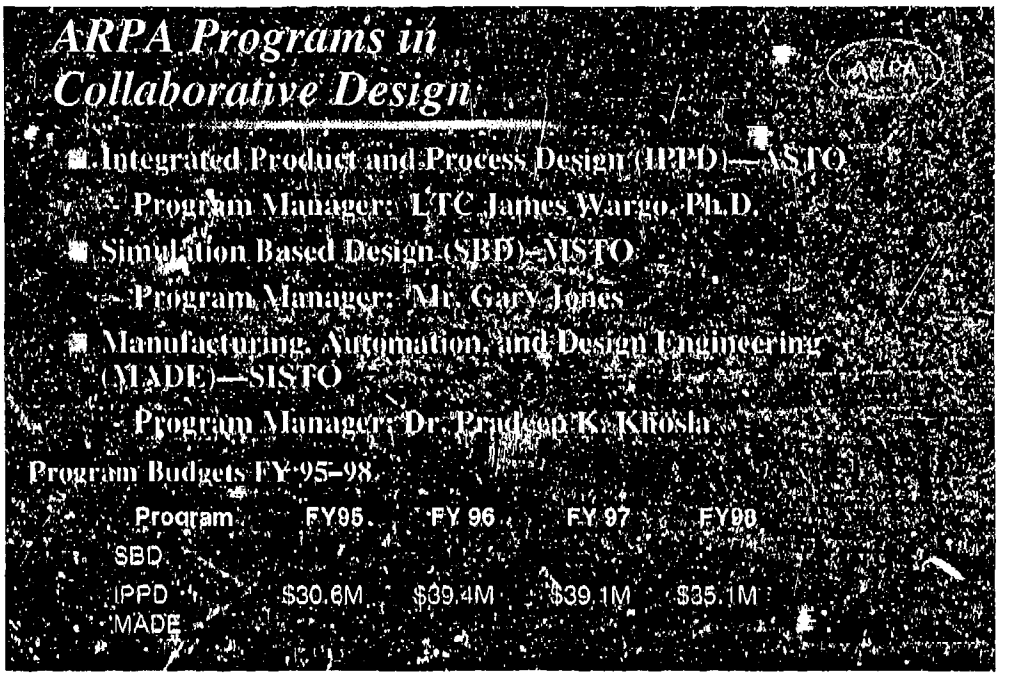
MADEFAST is an experiment within the MADE program. The goal of this experiment is to demonstrate collaborative engineering over the internet and in the process create an infrastructure for collaborative design.

The MADEFAST vision includes members of a distributed design and prototyping team collaborating over the Internet and availing themselves of an array of tools and services including: electronic design notebooks, catalogs, analysis tools, prototyping services, etc.

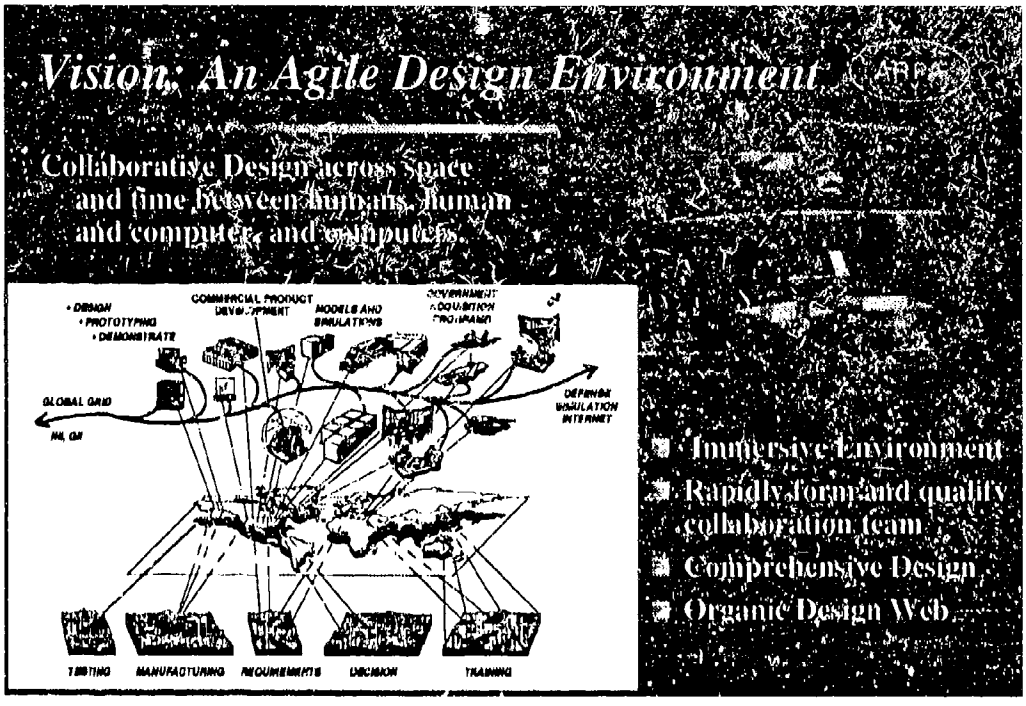
All documentation is on-line and in hypermedia form.

Team members interact through shared notebooks, teleconferencing, email, etc.

One of the outcomes of the MADEFAST experiment is an "organic" project web useful for redesign and engineering education.



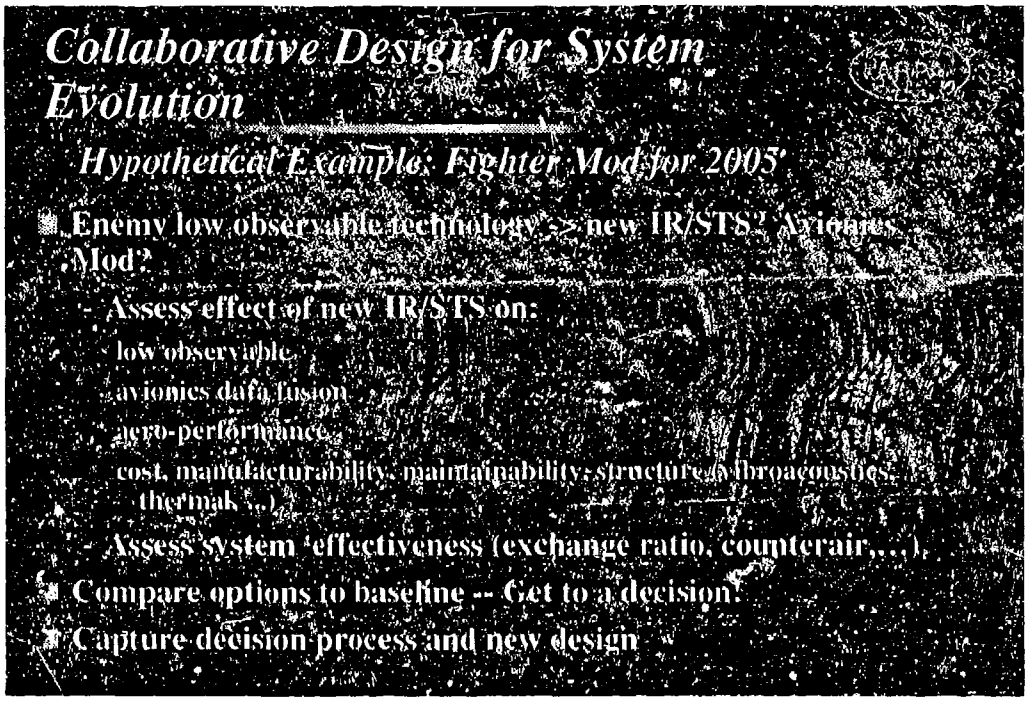
ARPA has 3 programs related to Collaborative Design and Manufacturing of electro-mechanical systems. These are Integrated Product and Process Design (IPPD) that addresses the design and manufacture of vehicles, Simulation Based Design (SBD) that addresses simulation of design and manufacture of ships, and Manufacturing Automation and Design Engineering that aims to create the base technologies, tools, and infrastructure in the area of manufacturing and design. This vu-graph also shows the cumulative budget for the 3 programs from FY95 through FY98.



Future collaborative design environment will utilize several technologies. Such an environment, for example, will consist of completely immersive environments that will allow remote designers to interact. The environment will provide tools for accessing remote product models and integrating them with existing designs. It will allow designers to manipulate object models and simulations simultaneously. It will allow for creation of complex simulations with relative ease and through simple manipulation of object models.



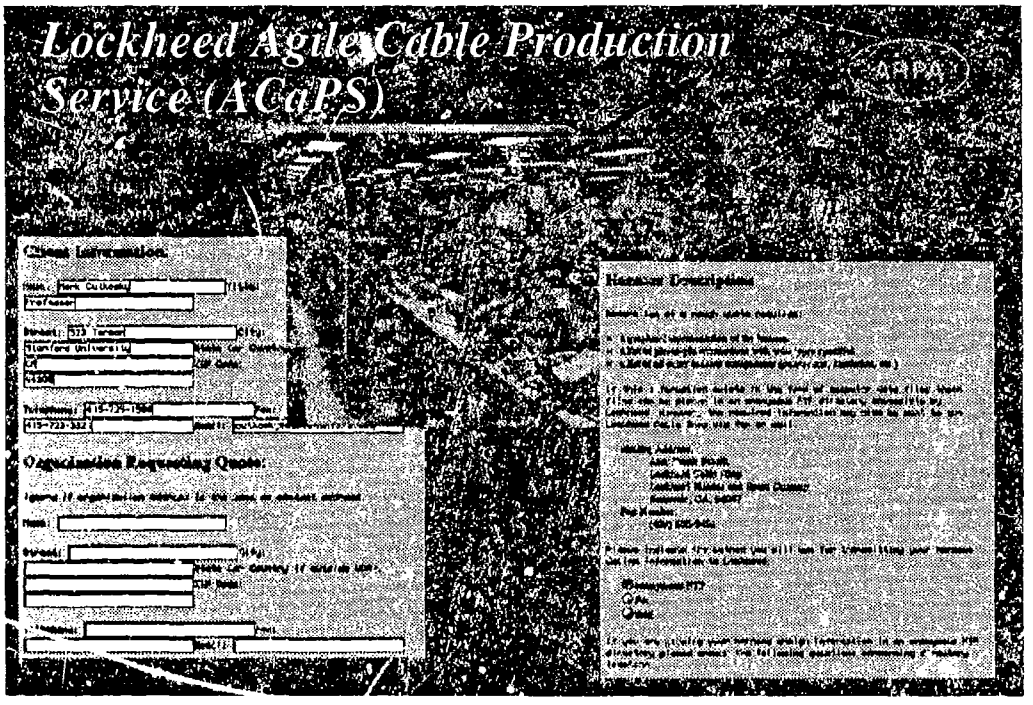
Collaborative Design and Manufacturing requires several layers of infrastructure. ARPA's strategy is to create these layers of infrastructure through a combination of Core programs, TRP and Advanced Technology demonstrators (ATD).



Based on the current acquisitions budget, it is conceivable that future DoD requirements for new capabilities would require upgrading existing systems instead of design, manufacture and acquisition of completely new platforms. This in turn would involve redesign of current systems and subsystems in order to incorporate new technology.

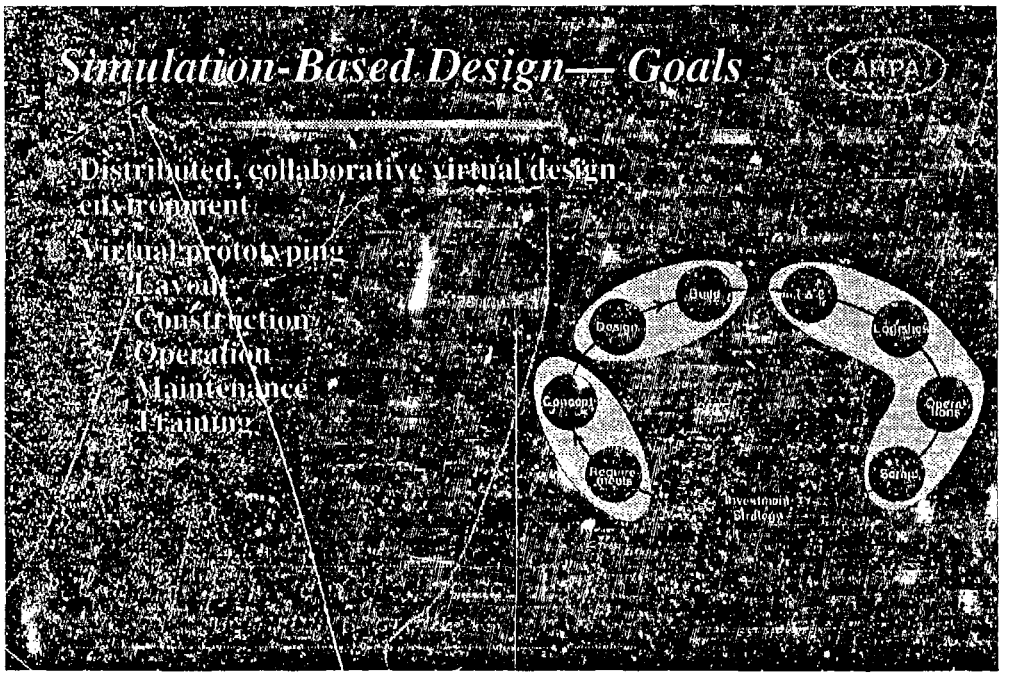
This vu-graph shows an example of a scenario in 2005 wherein the enemy has developed/acquired a Low Observable technology. This will impact the F-22 and the issue is whether this threat should be countered by incorporating a new IR/STS (Infra-Red Sensor Tracking System) or by making a modification of the avionics. The effect of either of these choices on several subsystems should be considered. The answers arrived at must be compared to the baseline. In order for any of this to be realized, it is important and necessary that the design process be captured and new design created.

If the above scenario were to to happen today, it is clear that we will not be able to do upgrades or insert new technology in existing platforms affordably because we do not have tools that capture the complete design and manufacturing cycle including rationale for choices made during design and manufacture. What is therefore needed is an infrastructure and tools that will allow us to insert new technology for upgrades affordably.

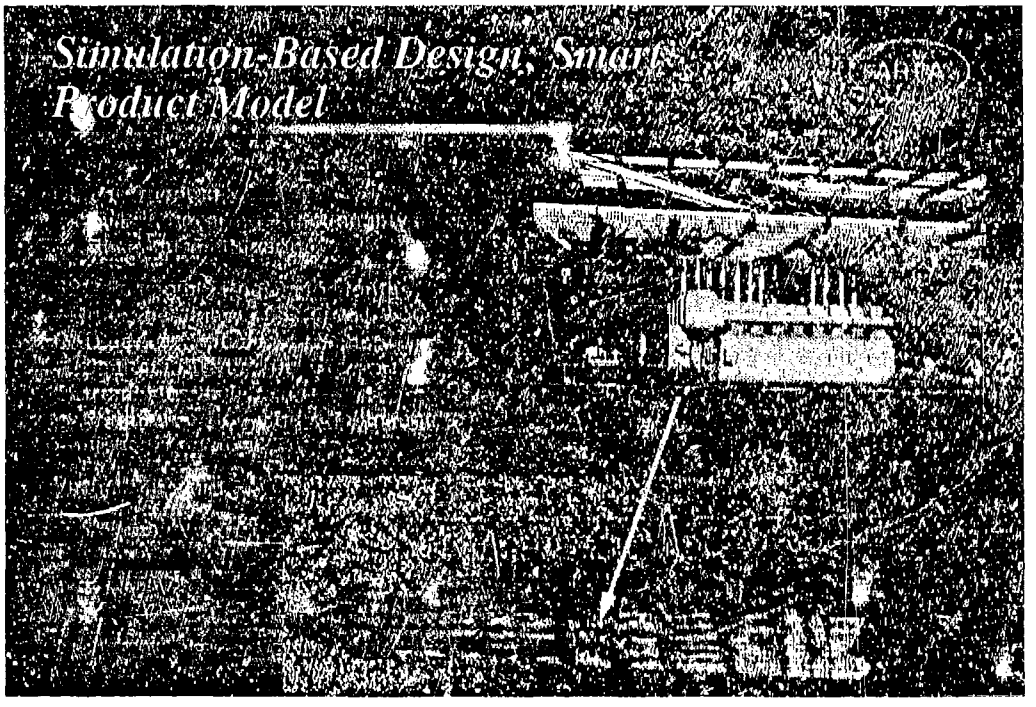


One nice industrial example is the Lockheed Agile Cable Production Service in Sunnyvale, CA. The ACaPS facility allows users to order custom cables using an electronic order form that is available on-line. The system returns an initial rough estimate quote electronically based on the data provided in the order form. The goal of this facility is to demonstrate a turn around time of 48 hours from initial order to delivery of cables.

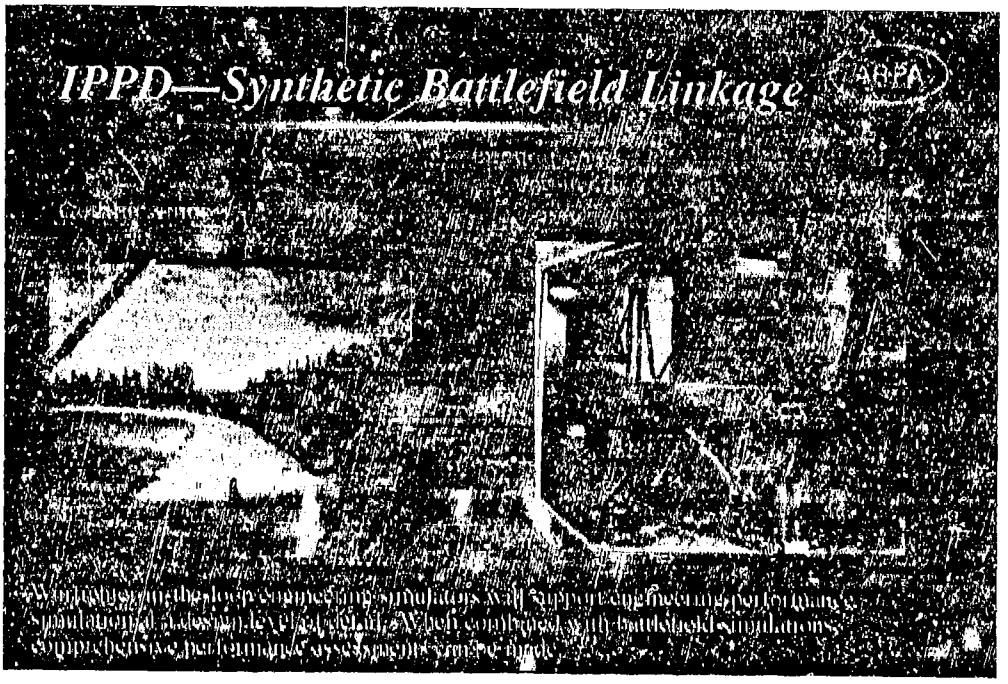
This project is partly a spin-off of ARPA supported research at Stanford and Lockheed.



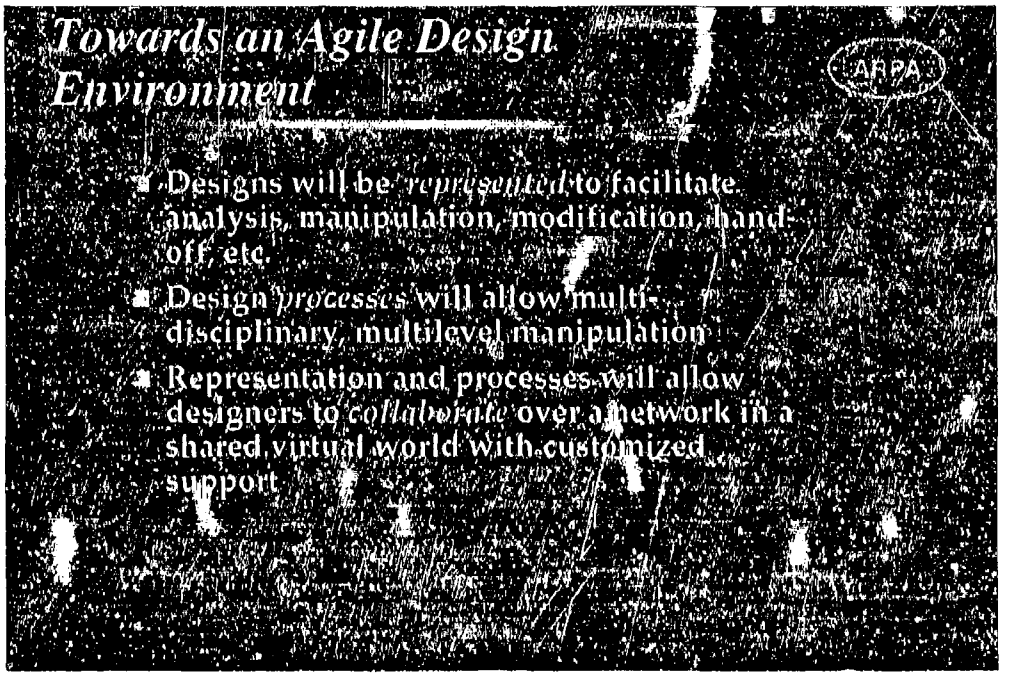
The goal of the SBD program (in MSTO) is to create an environment that would allow for collaborative and distributed virtual design. These goals are being demonstrated in the context of ship design. Traditional emphasis has been on T&E, Logistics and Operations. The SBD emphasis is on Requirements capture, Conceptual design, Detailed design, Immersive Environments, and Manufacture.



One of the accomplishments of the SBD program is the development of the smart product model. This model is based on object oriented technology and is the basis for multi-disciplinary simulations and it links parametric modeling to analytical tools. The SBD program has recently completed a 15 month feasibility phase and a Virtual Shipyard project has been initiated.



This is an example (in the IPPD program) wherein a terrain has been digitized and is being projected through wrap-around screens. The driver is sitting in the physical simulator (shown in the picture on the right) and what he views is shown in the picture on the left in the vu-graph. The roughness of the terrain is mapped into the physical vehicle through the 6 degrees of freedom base that is connected to a computer. Environments like this will provide future training capabilities and also be used for evaluating designs and comprehensive assessment analysis for future land vehicles and other platforms.

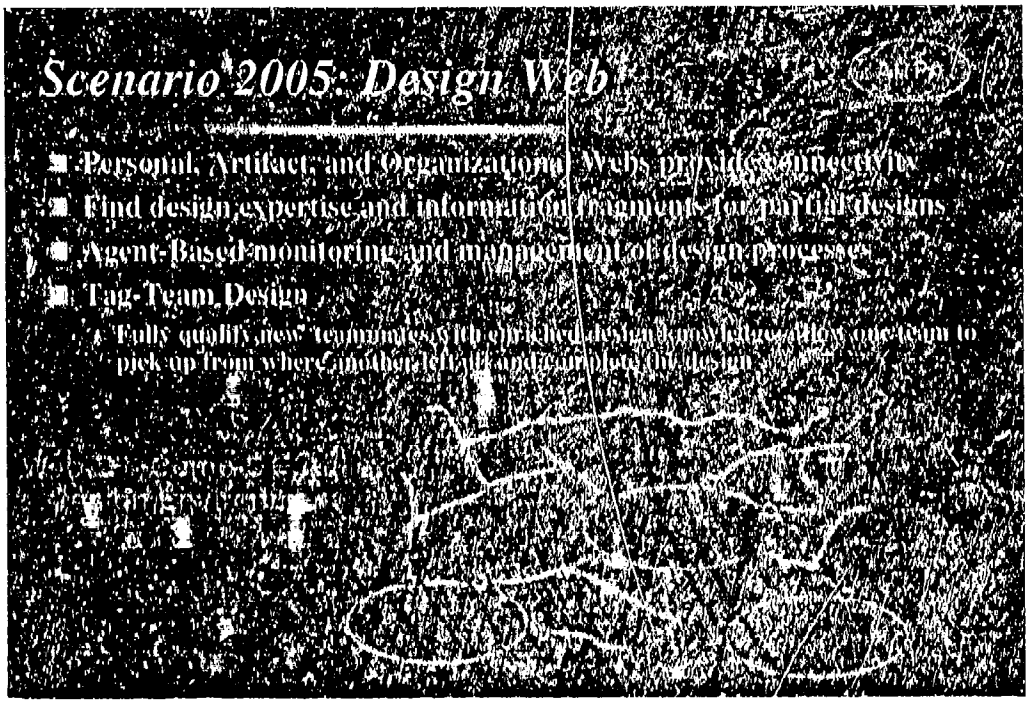


The creation of an Agile Design Environment will allow representations of design to facilitate analysis, modification, etc. Design processes will allow multi company teams to perform multi level manipulation of designs. And finally, designers will be able to collaborate in shared and virtual worlds with powerful representations and processes to support them. The Agile Design environment will consist of Comprehensive Design and a Design Web.



ARPA's investments in Collaborative design would make the following scenario a reality.

It would be possible to find design information and information fragments for the design/redesign in question. It would be possible to semantically link models and simulations across disciplines, levels of abstraction and levels of detail. For example, it would be possible to link structural models and simulations with aeroperformance, etc. It would be possible to propagate the effect of design changes across large multi-disciplinary integrated product teams. And finally, it would be possible to do tag-team design and fully qualify teammates with enriched design knowledge.

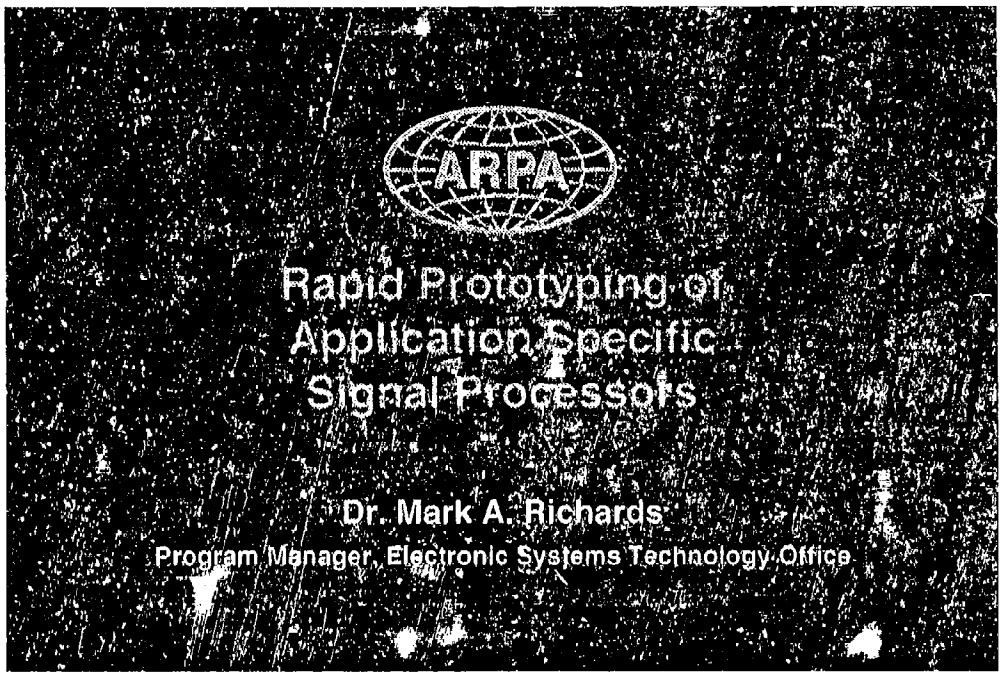


In the Agile Design environment, the Design Web will play a very important role. This "organic" web will be the basis for collaboration and exchange of information regarding designs. The Design web will consist of Personal, Artifact and Organizations webs which will be seamlessly integrated and provide connectivity of information. The web will be populated with intelligent agents who will assist the designer in finding design information or partial design fragments. The agents will also be used for monitoring and management of a distributed design activity (across space and time). The web will enable the vision team of tag-team design wherein it would be possible to qualify new design team mates with enriched design knowledge. More importantly, it will allow one team to pick up from where another team left without having the need for physical interaction.

Summary

ARPA

- Significant ARPA investment in Collaborative Design
- Coordinated and Cohesive Programs
- SBD BAA still open (deadline has passed for first round of FY95 funding)
- MADE BAA for FY95 funding should be published around January 95 (approximate date).
  - Balanced investment in both University and Industry research and development programs.
  - For more information contact pkhosla@arpa.mil

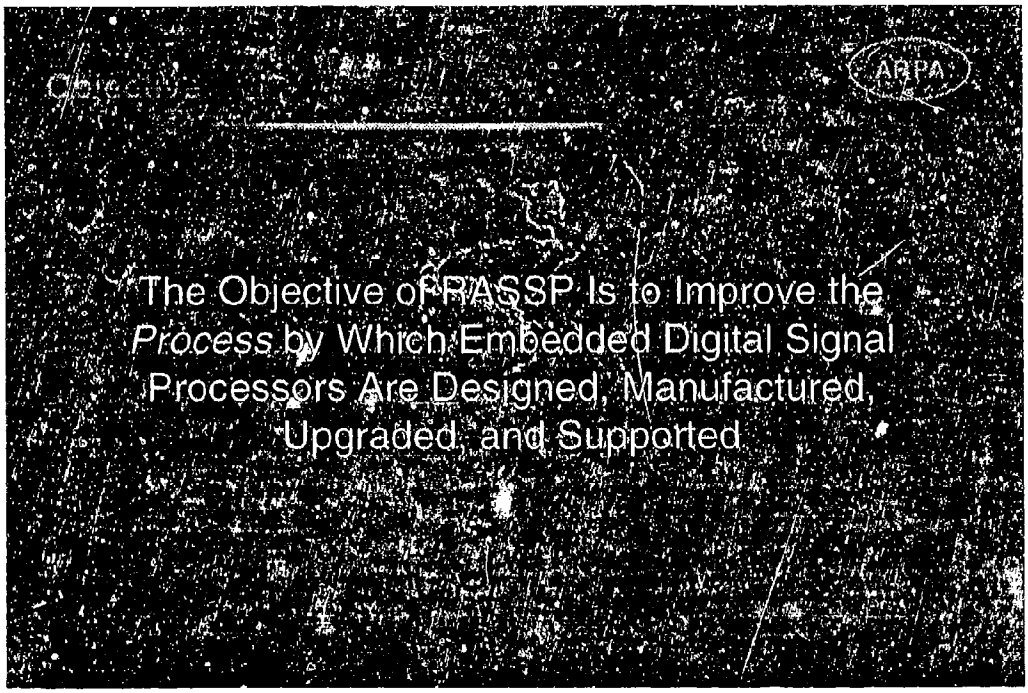


I'd like to give you an overview of the RASSP program.

RASSP is a 4.5 year, $150M program which began life as an Advanced Technology Demonstration (ATD) for DoD Science and Technology Thrust 7, "Technology for Affordability"

In this talk, I will describe the goals of RASSP and the main technical ideas on which it is based.

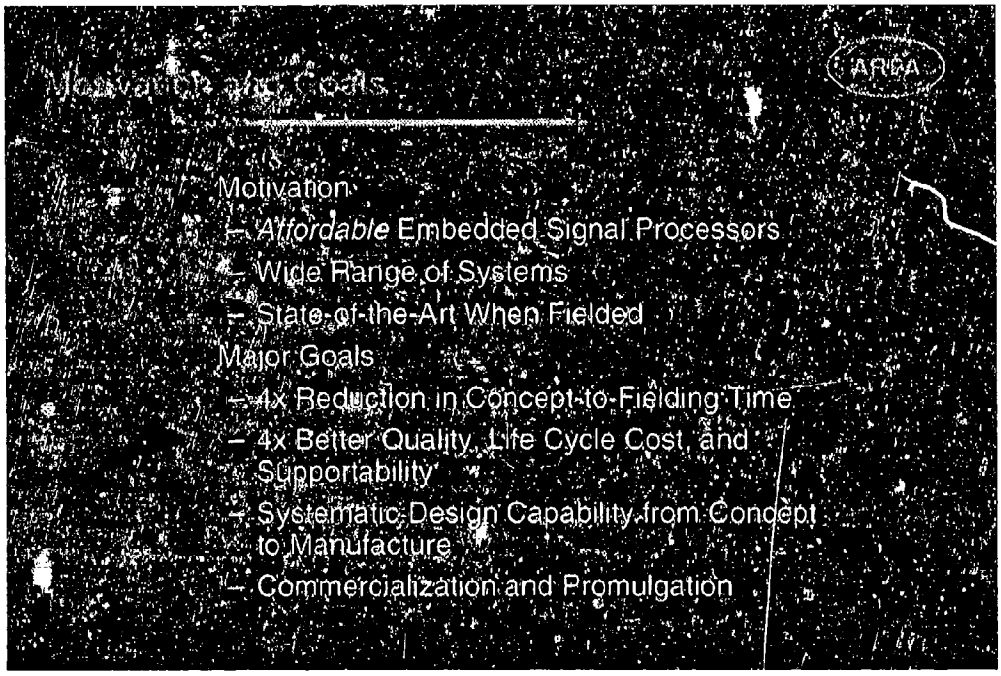
I will also briefly update you on the government and industry organizations involved in the program, and our early accomplishments.



RASSP is an ARPA/Tri-Service initiative to improve the *process* of designing embedded signal processors

We chose the domain of embedded DSPs because virtually every weapons, surveillance, and communication system in the DoD inventory requires a signal processor

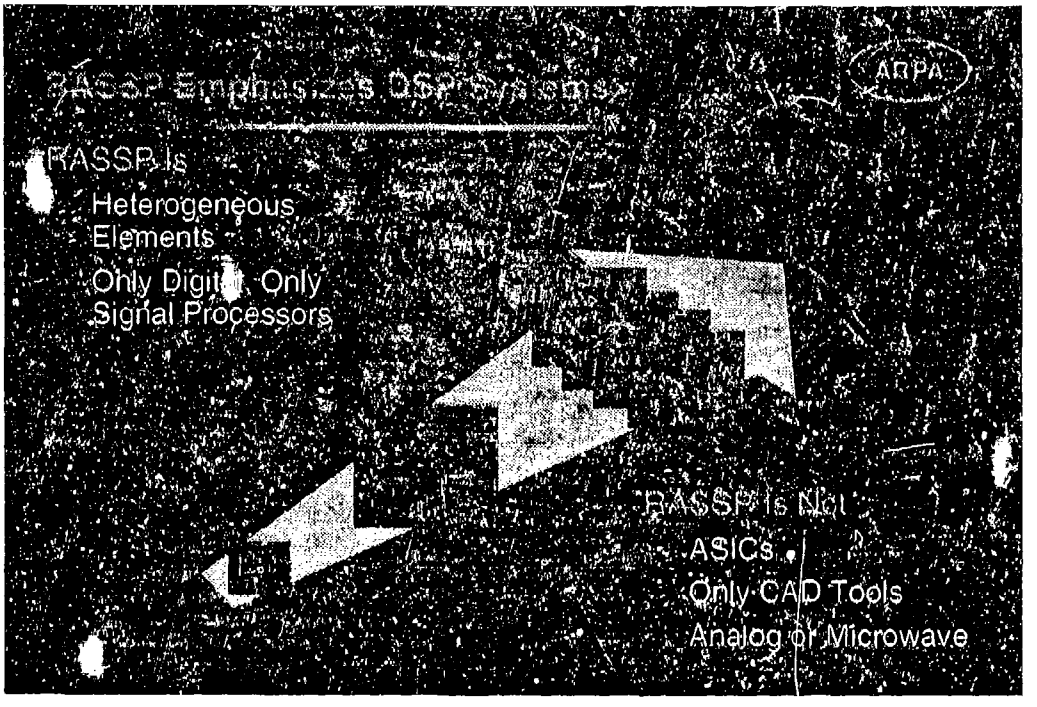
It is important to note that RASSP is not just concerned with initial design capability, but with the full life cycel of the signal processor



The major motivation for RASSP is to get DoD systems on the commercial technology curve and make it possible to keep them there over an extended life cycle.

The program's top-level goals are

- 4x or better design and redesign speed improvement
- 4x or better improvement in life cycle cost
- development of an advanced, systematic design capability to achieve these goas, and commercialization and promulgation of that capability to the US electronics design community

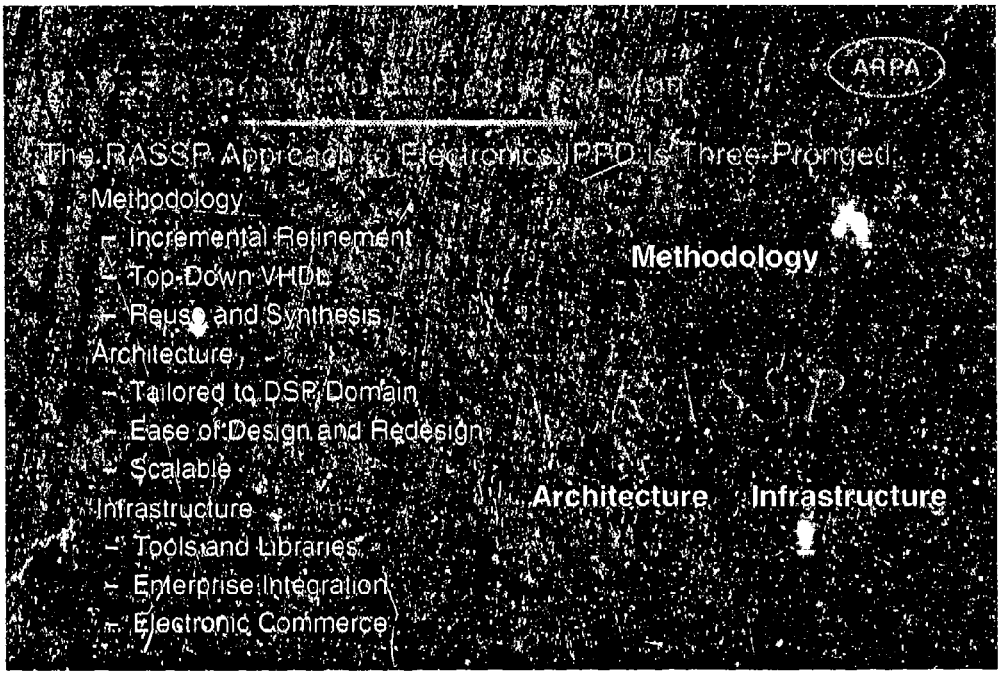


To help understand what a program *is*, it sometimes helps to emphasize what is is *not*. RASSP is *not*

- an ASIC design program. It deals with larger, more complex systems at the single and multiple board level. Consequently, it involves ASICs, but it also involves FPGAs, MCMs, programmable processors, and glue logic.

- a CAD tool development program. While CAD tools are important, we will see in a minute that they are only one aspect of the program, and not the most important one.

- dealing with microwave or analog signals. RASSP is restricted to digital circuitry only, and only signal processors at that. This gives us a way, even if somewhat arbitrary, to constrain the problem to a workable size.

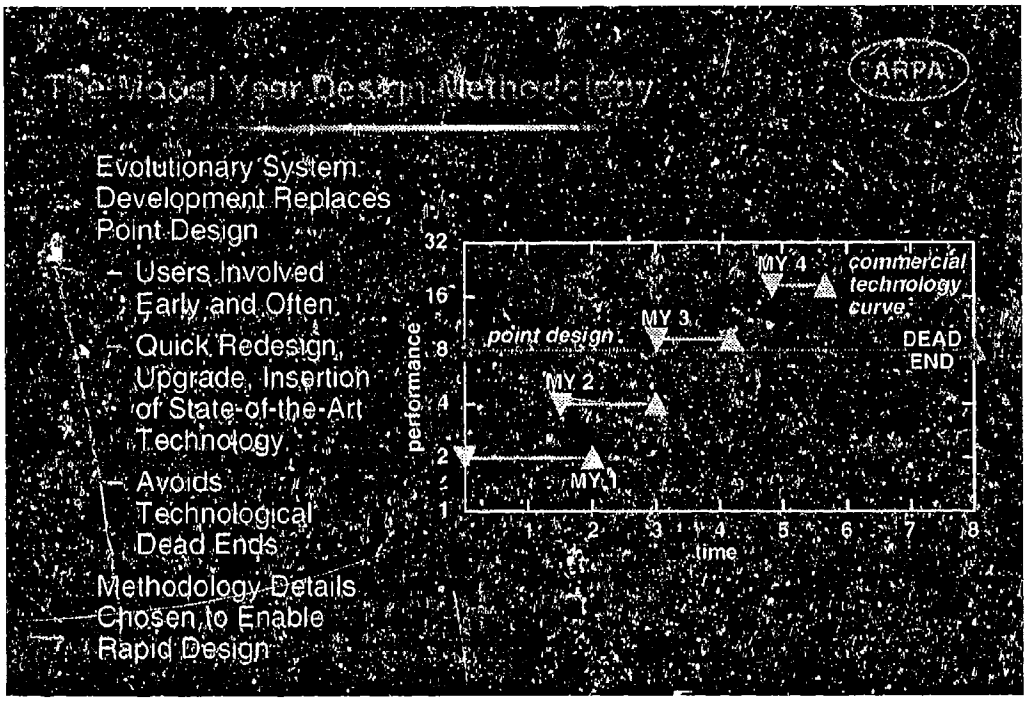


The RASSP technology triad of methodology, architecture, and infrastructure is fundamental to the program, and the order of these items was not chosen casually.

The number one task of the RASSP program is to develop an intelligent methodology for designing embedded DSPs for DoD application. You can give a designer the best tools in the world, but if he doesn't choose a good architecture you will still get a bad product; and if he doesn't use the tools well, you will still get a bad product. RASSP is exploring methodologies based on the incremental refinement, heavy use of VHDL and virtual prototyping, and heavy use of HW and SW module re-use and synthesis.

The choice of methodology is supported by smart choices of architectures. We want to develop architectural approaches which make it inherently easier to design a product, and then to maintain, upgrade, or redesign it in the out years. It is in architecture that we hope the DSP domain restriction will provide some advantages.

Once you have a good process and architecture, only then should you choose or develop tools, libraries, networking, and other EDA infrastructure capabilities needed to support your architectures and your methodology



Some more words on RASSPs incremental refinement methodology, which we have likened to the "model year" concept in automobiles, are in order.

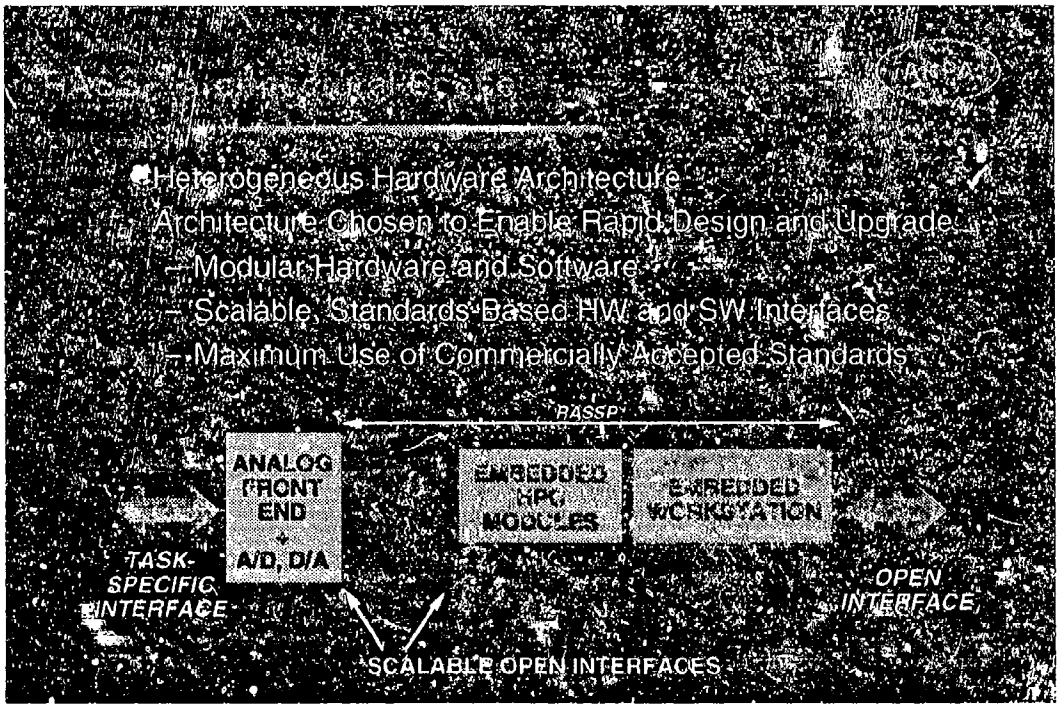
Current military design practice emphasizes development of the best possible technology at the time of initial design

- "point design"
- better performance than obtainable from standard commercial practice at the same time
- very long development cycle
- technological dead ends result from not being based on commercially supported standards and parts families

Rapid technology development often means that the point design is no longer state-of-the-art when finally fielded

RASSP proposes an evolutionary "model year" development paradigm

- initial design conforms to best current commercial practice, gets into field much faster
- design system makes it easy to insert improved technology every 1 to 3 years, increasing functionality and better tracking the technology curve
- user gets early prototypes much sooner *and* better ultimate performance



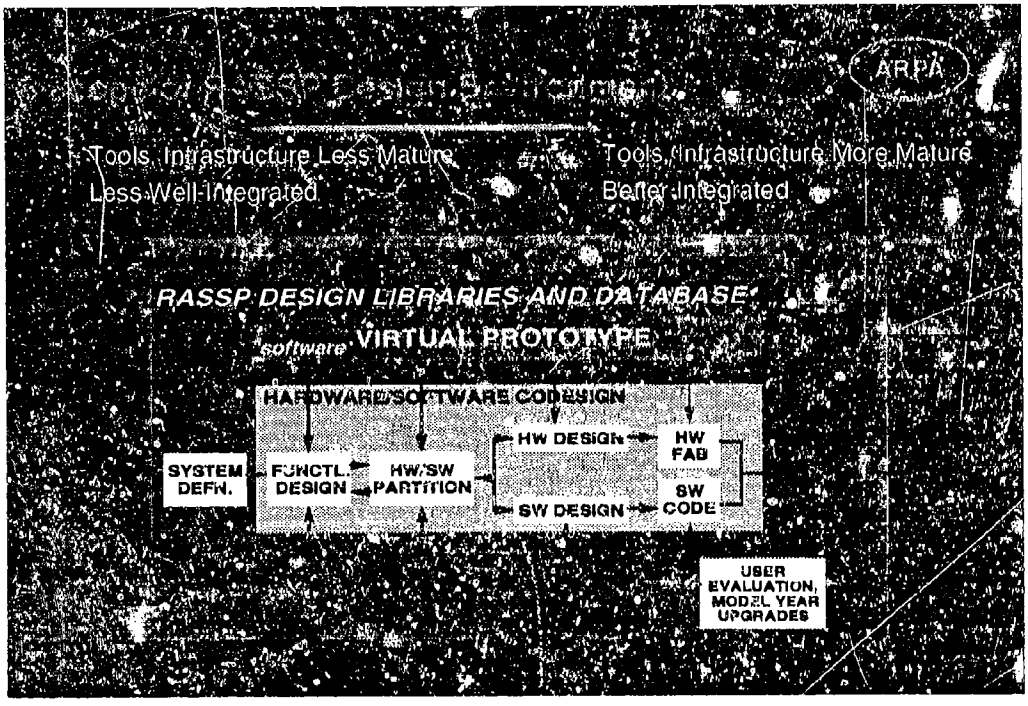
A signal processor may have some or all of the following components

- analog front end plus A/D and D/A converters, typically to interface to a sensor such as radar, IR, or sonar
- a relatively "hard-wired" or custom digital front end, comprised of on-programmable or semi-programmable high speed parts such as FPGAs and ASICs
- a programmable embedded processor comprised of COTS DSP and RISC chips and other standard parts, or even HPC modules

Thus, RASSP design systems must deal with a heterogeneous mix of components

Subsystems will be connected via scalable, open interconnect fabrics

- minimize the number of custom interface (hardware and software) designs required
- enable technology or functionality upgrades to one portion of the RASSP processor without requiring redesign of other portions

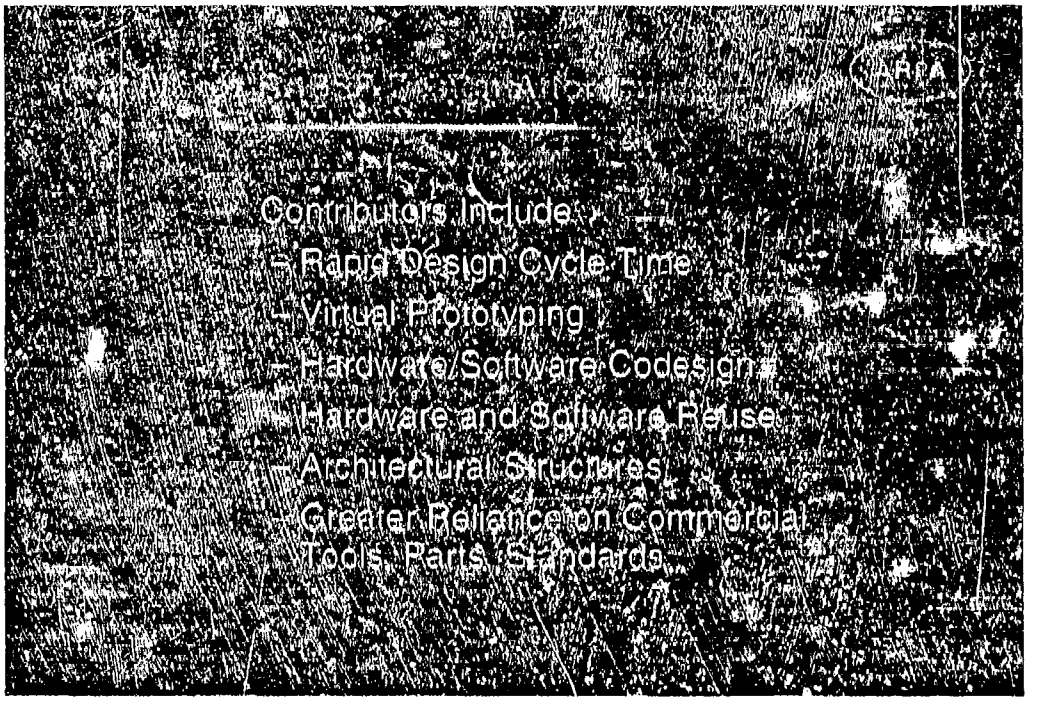


The EDA infrastructure of tools and libraries needed to support the RASSP design approach is very comprehensive

- begins with system requirements
- includes hardware/software codesign, which involves algorithm optimization, partitioning, and preliminary design. This is a key concept which we believe can have a major impact on the quality of designs, but requires great progress in system engineering tools
- includes tools for detailed hardware (including board, MCM,FPGA and ASIC) design and fabrication, and detailed software coding

The design system also relies heavily on virtual prototyping, that is, extensive simulation at increasging levels of fidelity to ensure the hardware and software meet specs and will work together

Tools on the left side of this figure are less complete, less mature, and less well-integrated than those on the right. Consequently, RASSP developments are focused on the high end tools for system engineering, virtual prototyping, and codesign, and also on library development.

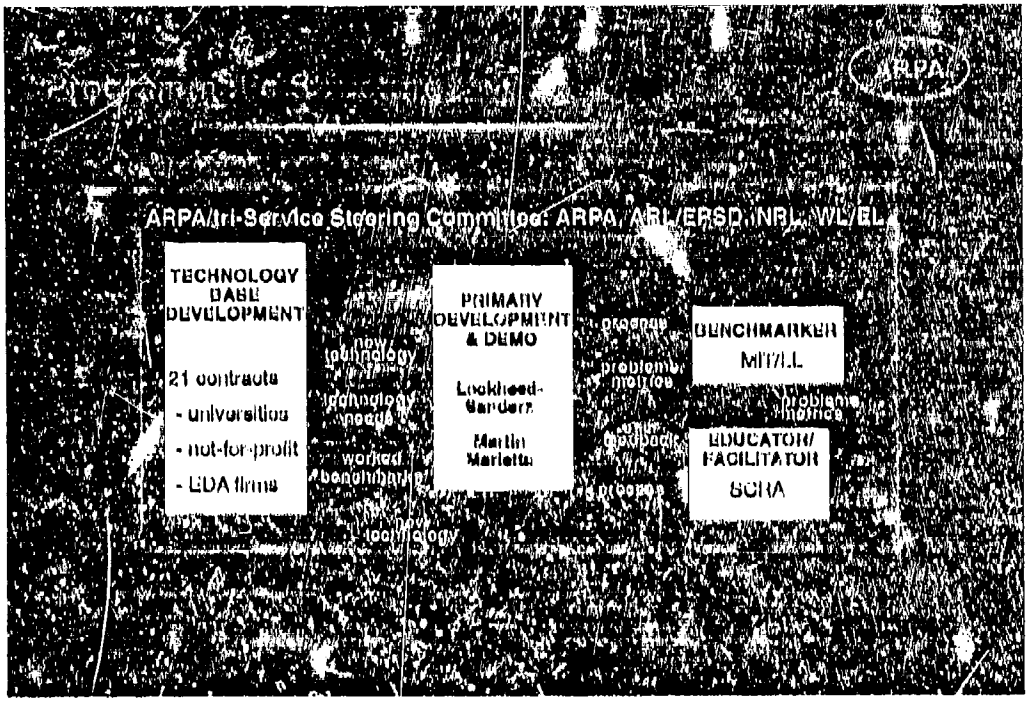


This is a session on "Affordable Design," so one might ask what there is in what I've told you that contributes to affordability.

First, bear in mind that RASSP is aimed at life cycle cost improvements.

Given that, we believe that savings will result from

- direct time and labor savings through more rapid development of prototype designs
- reduction of design "re-work" through virtual prototyping. VP also gives us the capability to upgrade and redesign portions of a system at later dates with much less effort than currently required
- choosing from architectural approaches that are standardized and well-tailored will allow the use of less expensive commercial part families, and will support design based on re-use libraries
- codesign, done well, can lead to much better decisions about processor architectures which directly save boards and parts
- Re-use is a direct time and cost saver. This is accepted in software, and we want to extend it to hardware as well. This requires a lot of VHDL library development
- The ability to use commercial tedchnology allows us to share in the short- and long-term savings of that much larger market



The Primary Development Contractor teams are the central players in the RASSP program

- responsible for development, integration, and demonstration of the RASSP process

Other directly contracted players include the Technology Base BAA contractors, the Benchmark Contractor team, and the Facilitator/Educator Contractor

The Tech Base BAA contractors are the winners of two separate BAAs

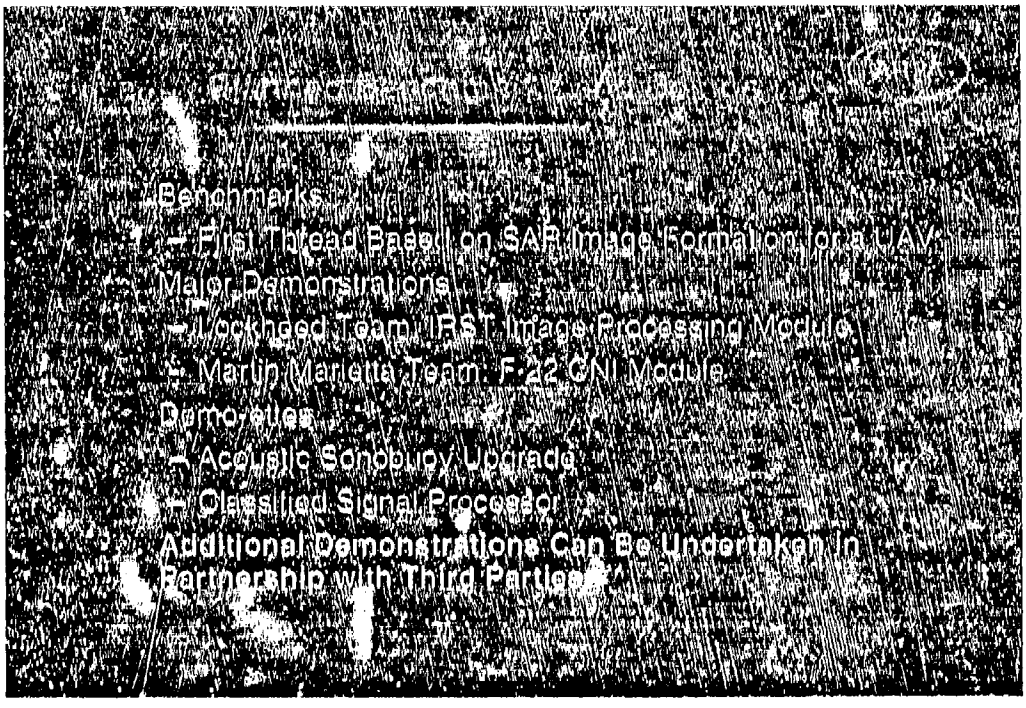
- 21 universities, not-for-profit firms, and commercial firms
- provides new CAD technology for insertion into the RASSP process

The Benchmark Contractor team is responsible for defining, conducting, and assessing semiannual "quizzes" of the evolving RASSP process

The Facilitator/Educator is an independent source of knowledge and emissary to the larger community about the RASSP process

The Government Steering Committee provides program management and oversight

The RASSP program draws extensively on existing EDA industrial infrastructure for independent development, products, subcontractors, and technology base contractors



A major goal of the RASSP program is to ensure that the evolving design process is exercised

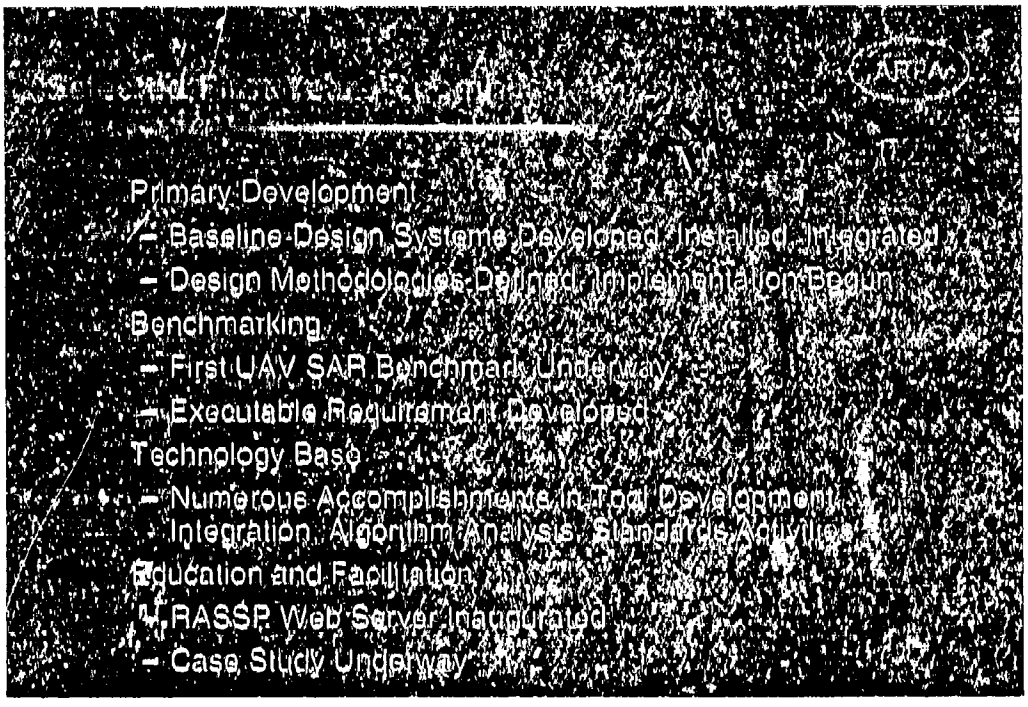
- early and often
- on problems of real interest
- on problems covering a wide range of architectures, applications, and rates

The program provides two types of exercises

- demonstrations by primary development contractors on systems for specific military applications
- exercises defined by the benchmarking team

Demonstration and benchmark exercises are required to demonstrate model year methodology

Benchmarks and results will be widely disseminated to the developer and user communities



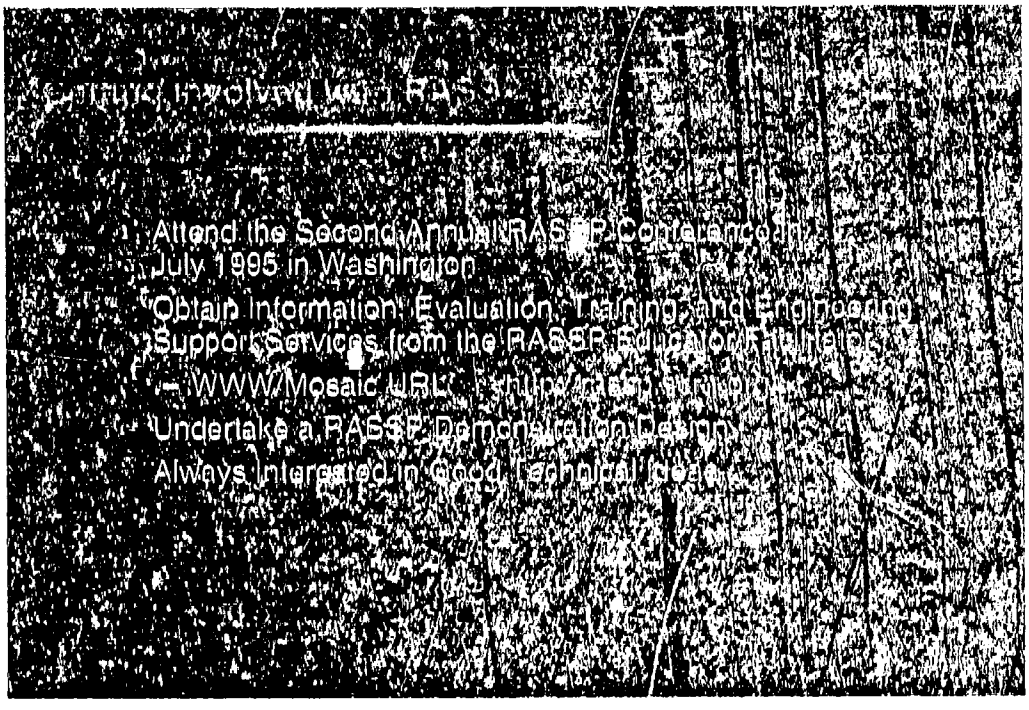
RASSP is only 1 year into a 4.5 year program. Nonetheless, we have made significant progress in a number of areas.

The prime contractors have established baseline design systems from which they are developing lessons learned to apply to their first real RASSP design systems, due next Summer. They are pushing the state of the art in VHDL-based modeling and virtual prototyping, and are leading the enhancement and integration of many high level design tools.

The first benchmark exercise, which involves architectural tradeoffs and virtual prototyping of the UAV SAR image formation processor, is under way and will be completed in January.

The RASSP Education and Facilitation team has just begun work on a variety of tasks, from implementing a web server which will be the interface of choice to their RASSP information system, to beginning an electronics design case study to help us better quantify the most important factors in reaching our goal of 4x.

The first 10 technology base contractors have been at work a year and produced too many accomplishments to mention here. The second group of 11 is just coming under contract.



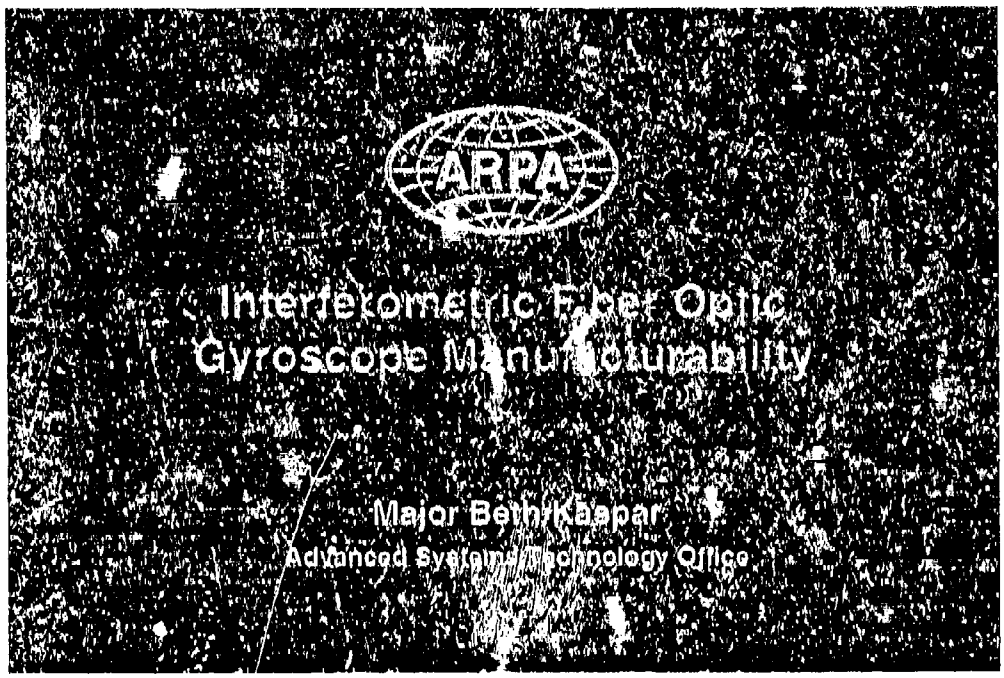
There are several levels of involvement available to parties interested in RASSP.

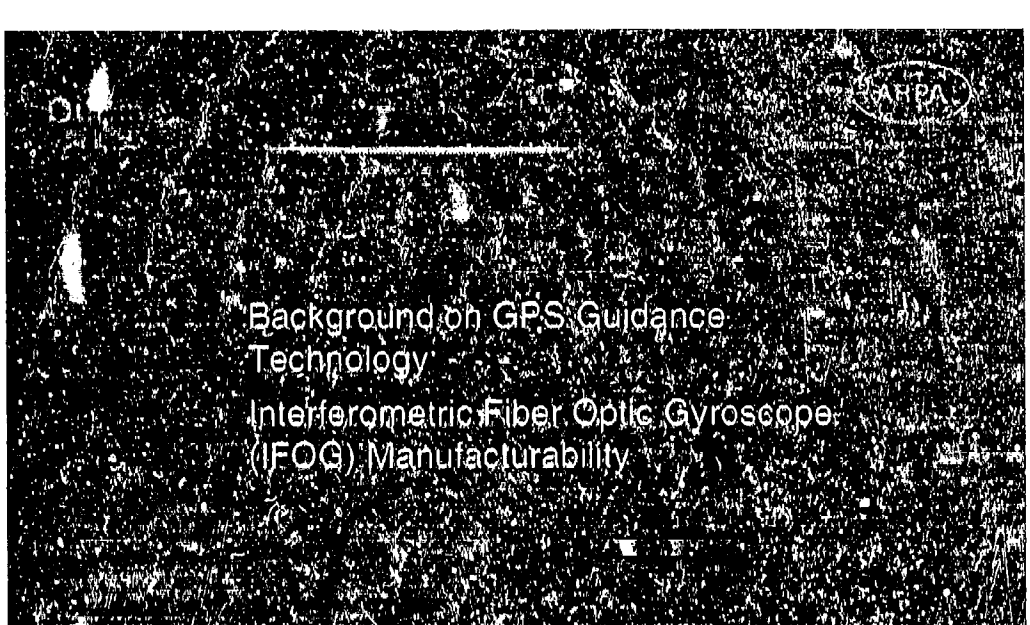
A very successful first annual RASSP conference, attended by some 400 persons, was held in August in Crystal City. This annual event will be held in the DC area every year, probably in July in 1995. This is a good place to get an efficient and comprehensive look at the entire program and talk to many of the performers, and see the work at the exhibits.

The RASSP Education and Facilitation contractor provides a single point of contact for extensive program information resources. While this effort is new, it will spin up rapidly. A good way to explore what is available is through Mosaic or other Web browsers, using the URL shown on the chart.

Companies and programs interested in trying out RASSP design process and taking advantage of ARPA's investment in this program can explore with us the possibility of a demonstration design project.

Finally, I am always interested in good design technology ideas.

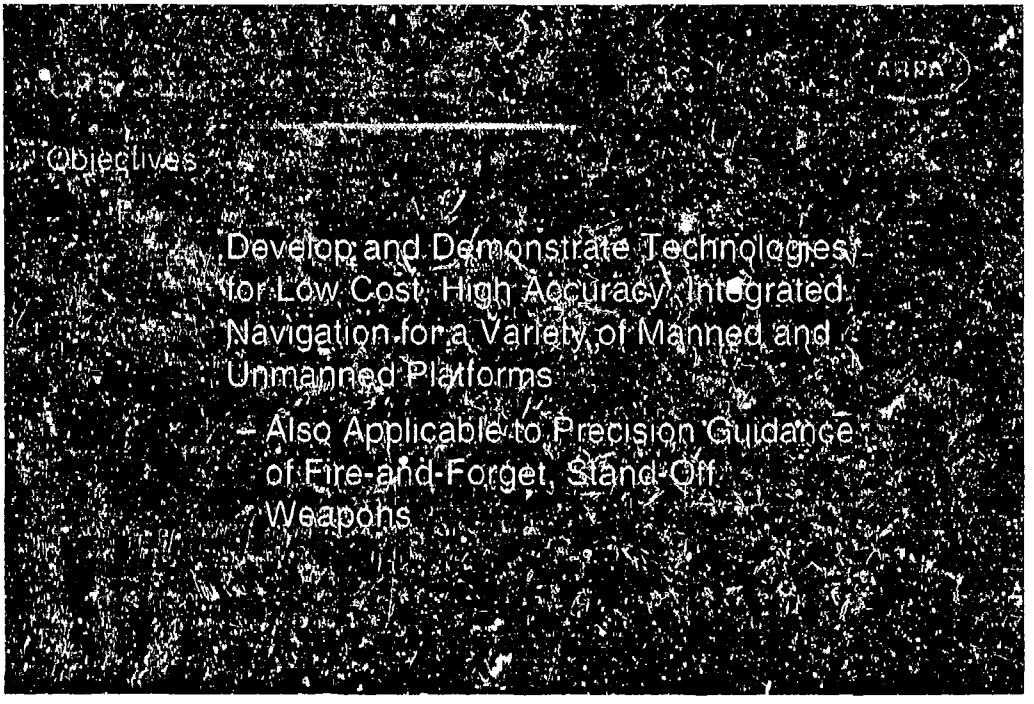

ARPA
Interferometric Fiber Optic
Gyroscope Manufacturability
Major Beth Kaspar
Advanced Systems Technology Office



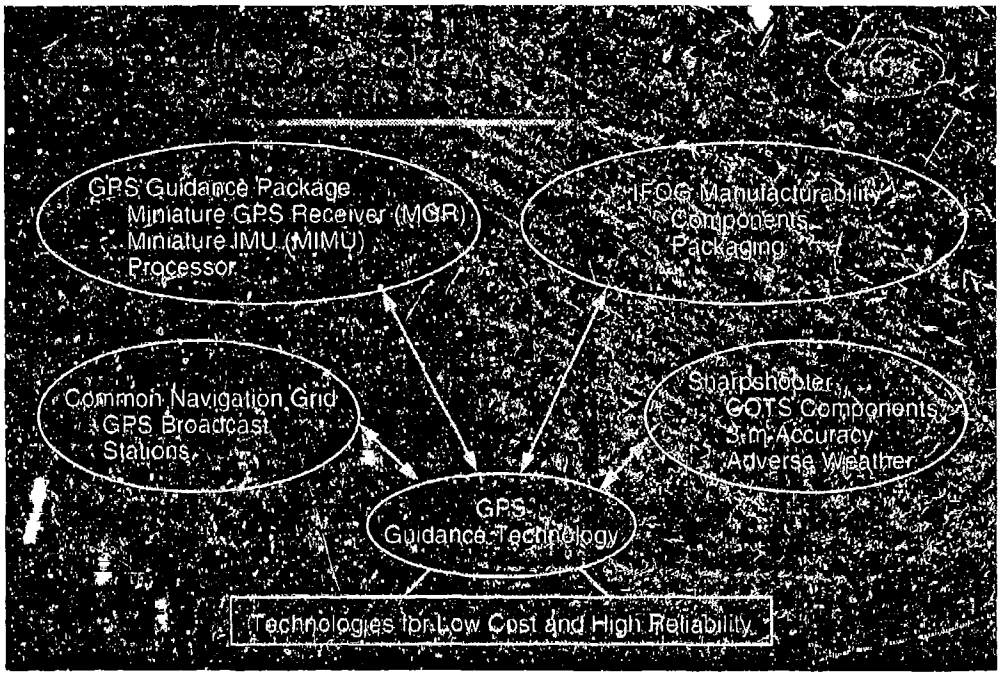
This briefing is in two parts, as shown in this outline. First, as background, I will describe briefly the overall ARPA Tri-Service Guidance Technology Program.

Then, the IFOG Manufacturability presentation will address the following questions:

- Why are we pursuing it?
- What are our objectives?
- How will we do it and what do we get?



The ARPA objectives are to develop & demonstrate technologies for low cost, high accuracy integrated navigation and precision guidance. Applications include manned and unmanned airborne platforms, land and sea vehicles and stand-off weapons.



Four components of the ARPA program are shown on this chart.

The GPS Guidance Package (or GGP program) combines a miniature GPS receiver with a miniature Inertial Measurement Unit (IMU) to form a tightly integrated navigation sensor. This combination couples the high quality long term performance of a GPS receiver with the relatively short term, high performance of an IMU. Associated digital processors are included to form a high quality, integrated navigation unit. The ARPA solid state, miniature IMU features IFOGs. Hence IFOG manufacturability is a natural outgrowth of this program.

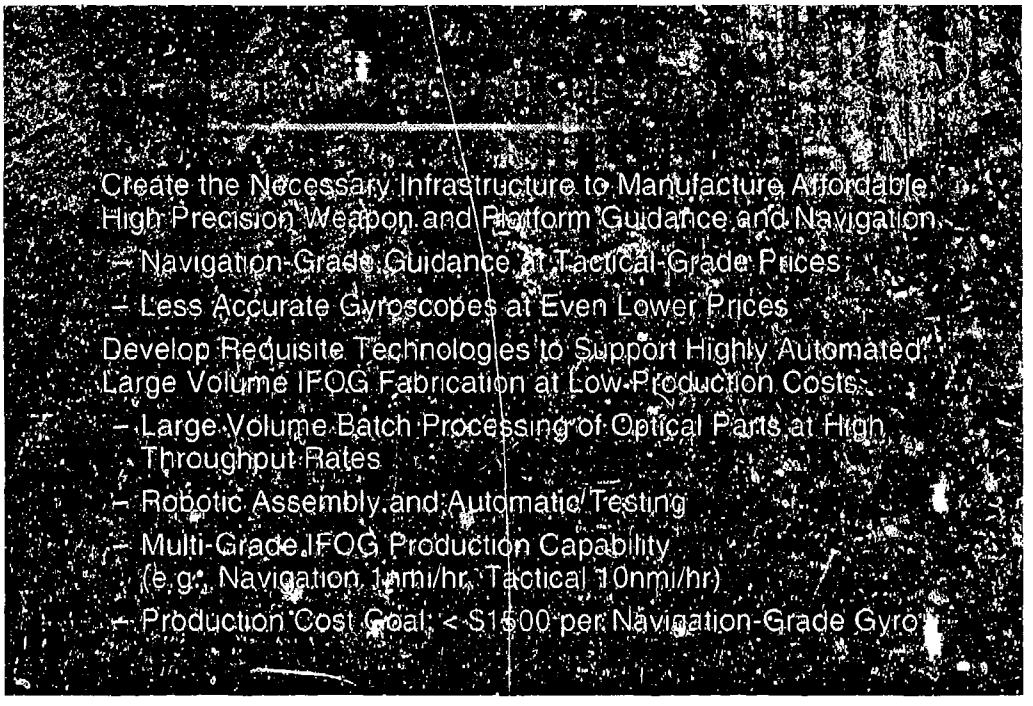
The Common Grid program will provide a theater-wide, highly accurate common position and timing reference grid for targeting and navigation. Common Grid capitalizes, among other things, on the miniature GPS receiver developments in GGP.

The IFOG Manufacturability component will provide for the development of the manufacturability infrastructure to develop high performance, navigation grade, low cost IFOGs. The fabrication technologies needed to produce such an IFOG will be developed. This effort will develop the capability to produce highly reliable miniature IFOGs at low cost and will develop improvements in the components and in the packaging to meet these goals.

For many applications, an end game seeker will be required. This is addressed by the Sharpshooter program. Most mobile and many fixed potential targets are not and will never be accurately positioned with respect to the GPS coordinate system. Their location may be approximately known but the final target location will have to be determined by an end game seeker. This program exploits the midcourse accuracies provided by the GGP program to reduce the complexity and cost of the endgame seekers. This would be exemplified by a smaller seeker field of view and shorter range for terminal acquisition. This program will be addressed in a later presentation by Dr. Larry Stotts. These technologies will be available for insertion into a number of systems such as:

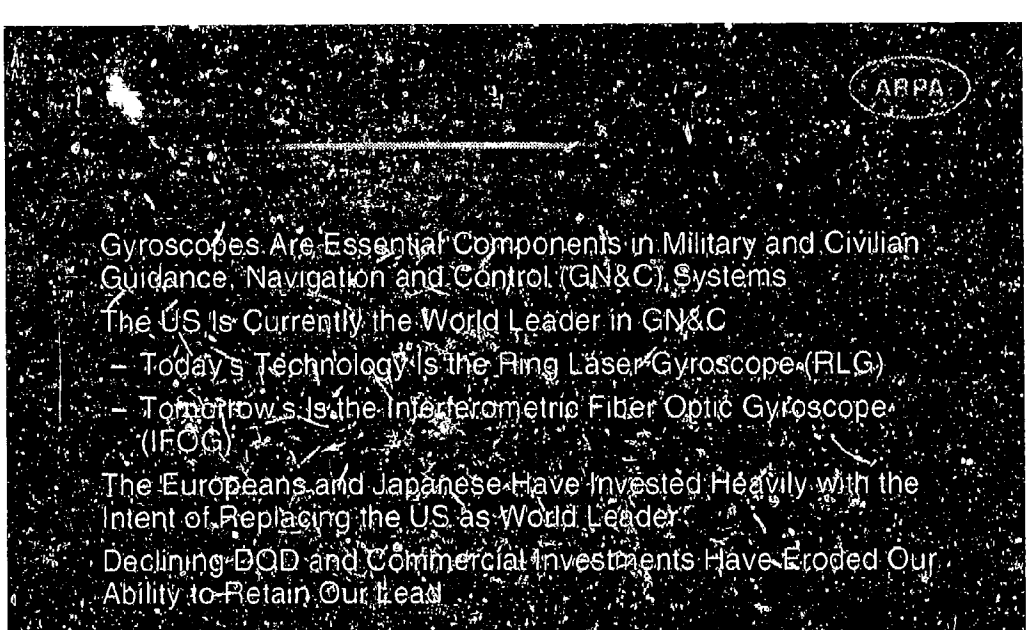
- Surveillance and Targeting Platforms
- Launch/Strike Platforms
- Precision Guided Weapons
- Mission Planning and Control

The bottom line is that we are trying to capitalize on advanced guidance technologies in order to increase force effectiveness with an emphasis on low cost and reliability. We now move to the specifics of our IFOG manufacturability program.



The objectives of the IFOG Manufacturability program are to provide the necessary infrastructure to support low cost navigation grade (£ 1 nm/hr drift rate) FOG performance and to develop the requisite technologies for automated, large volume IFOG fabrication. This will be achieved by employing highly automated, large volume production assembly and test manufacturing processes and machinery. Some of the required capabilities are:

- Large volume batch processing of optical parts with high throughput rates
- Robotic assembly and automatic test
- High optical quality assembly with base capability of providing "navigation grade" performance (£ 1 nm/hr) at under $1500/axis or $5000/triax unit
- The capability of scaling up production for lower performance (e.g., tactical grade, £10 nm/hr) at even lower cost

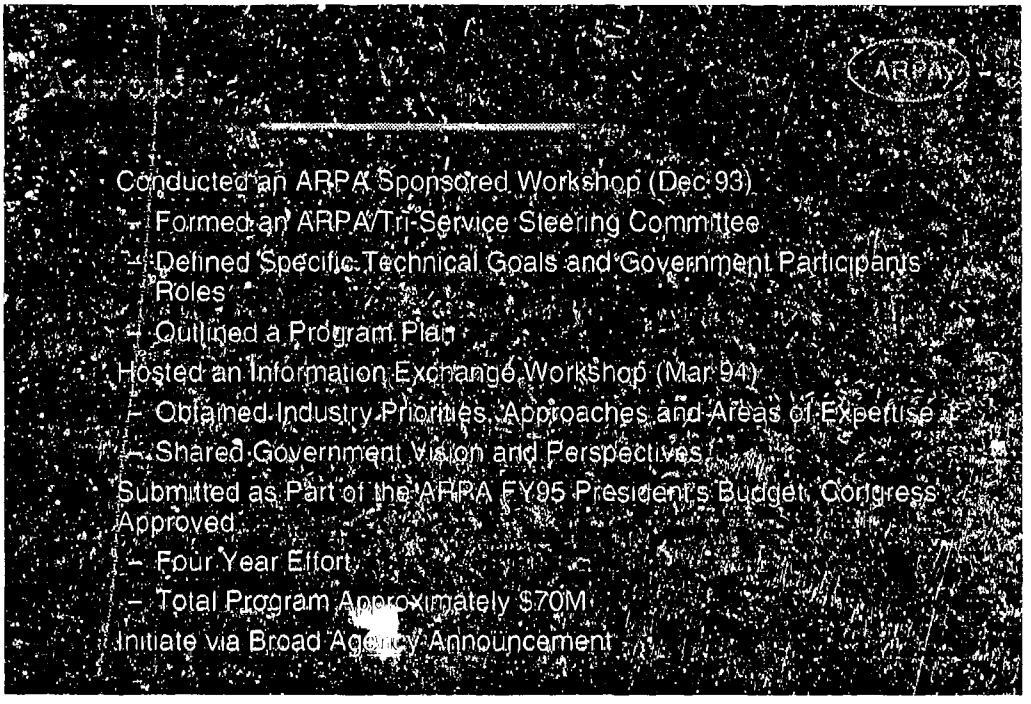


The motivation for pursuing an IFOG manufacturing effort are many fold. Rotation rate sensors Gyros, are essential generic elements for providing spatial orientation (attitude) data to vehicle and sensor systems, commercial as well as military,
(e.g., aircraft-ships-cars, radar-electro-optics, etc.) Low cost devices must employ high-volume, solid-state foundry fabrication and robotic assembly to minimize the cost. In particular, the GPS Guidance Technology Program incorporates IFOG rotation rate sensors.

The U.S. is the world leader in GN&C today, due to its preeminence in the manufacture of the Ring Laser Gyro (RLG). The IFOG will be the technology of the future, replacing the RLG technology. This is due to its inherent advantage in manufacturing and its comparable capability to support high quality angular rate measurements in a small, cost effective package. It shares a common optical technology base with the telecommunications industry and its physics and risks are well understood.

The current U.S. world leadership in guidance and control systems is threatened by rapidly developing foreign IFOG producers. The Japanese are well ahead in low end IFOG production for auto applications and nearly on a par with the U.S. for high end IFOG performance achieved. The Europeans are only lagging the U.S. by 1 year in high end gyro applications.

Both commercial and military U.S. investments in IFOG manufacture are declining. This is leading to an erosion in the U.S. lead in GN&C technologies which must be addressed if the U.S is to maintain it's position as world leader in GN&C technologies.

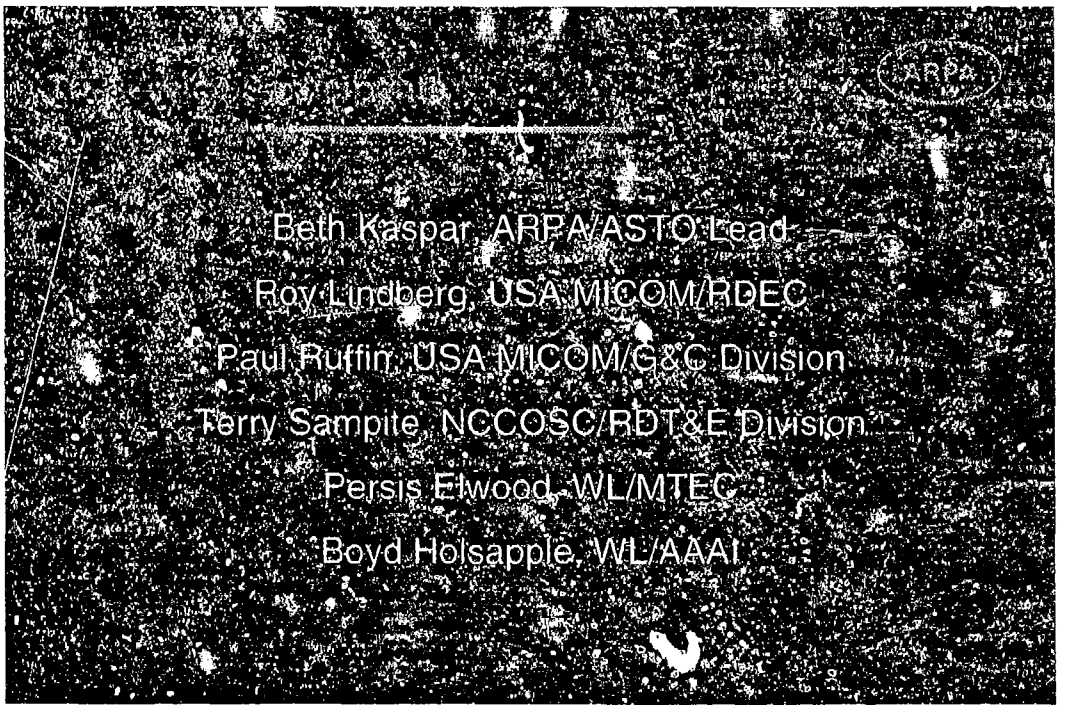


ARPA began preparing for the IFOG manufacturing effort by sponsoring a workshop involving ARPA and representatives from the three services. This workshop lead to the formation of an ARPA/Tri-Service steering committee which helped to define the program technical goals, the participant's roles in the program and provided an outline of a program plan.

In March of this year, an information exchange workshop was held in which the government representatives shared their vision and perspectives on the IFOG manufacturing program with industry representatives. Industry views and inputs were obtained to ensure a sound technical and management approach. This workshop also incorporated a general session in which the industry representatives could meet and speak with each other.

The IFOG program was included in the ARPA submittal for the FY95 President's budget. Congress has approved. We currently plan a four-year effort for a total of about $70M.

Formal industry participation in this program will be initiated via a Broad Agency Announcement.



The program will be coordinated through periodic meetings of the ARPA/Tri-Service steering committee. The steering committee is composed of representatives from the US Army Missile Command from both the Research, Development and Engineering Center and from the Guidance and Control Division, from the Naval Command, Control and Ocean Surveillance Center, RDT&E Division and from the AF Wright Laboratory in both the Manufacturing Technology and the Avionics Directorates.



The payoffs of this effort will include the development of affordable (£ $5000) navigation grade miniature Inertial Measurement Units (IMUs). These IMUs will be available for insertion into a multitude of military platforms and systems (including the GPS Guidance Technology program) such as:

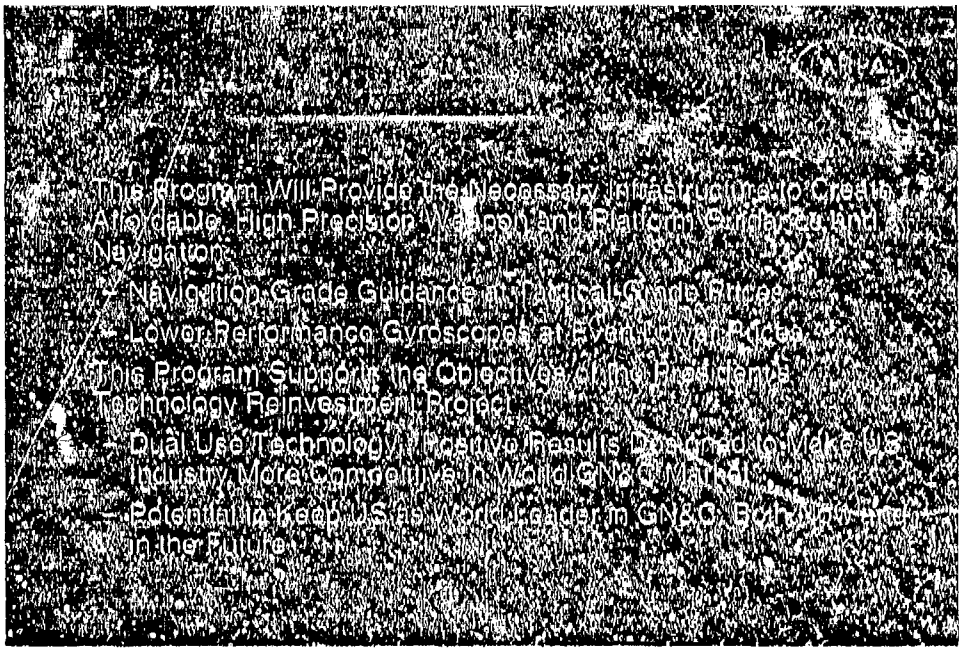
- Precision guided munitions
- Unattended sensors
- Standoff weapons

These small, lightweight, miniature IMUs will be available for tight integration with appropriate sensors and systems. Due to their low cost and high accuracy, the IMUs will find applications in many more sensors and systems than currently. Some examples are:

- At the focal plane of an Infrared sensor to maintain pointing accuracy.
- At the phase center of a radar or other antenna to improve signal tracking, coherence and pointing.
- As an affordable, non magnetic compass for use in armored vehicles to provide a high quality "unjammable" compass.

The IFOG manufacturing technology will be available for transition to the commercial sector. This will undoubtedly lead to a number of new, emerging and innovative applications such as:

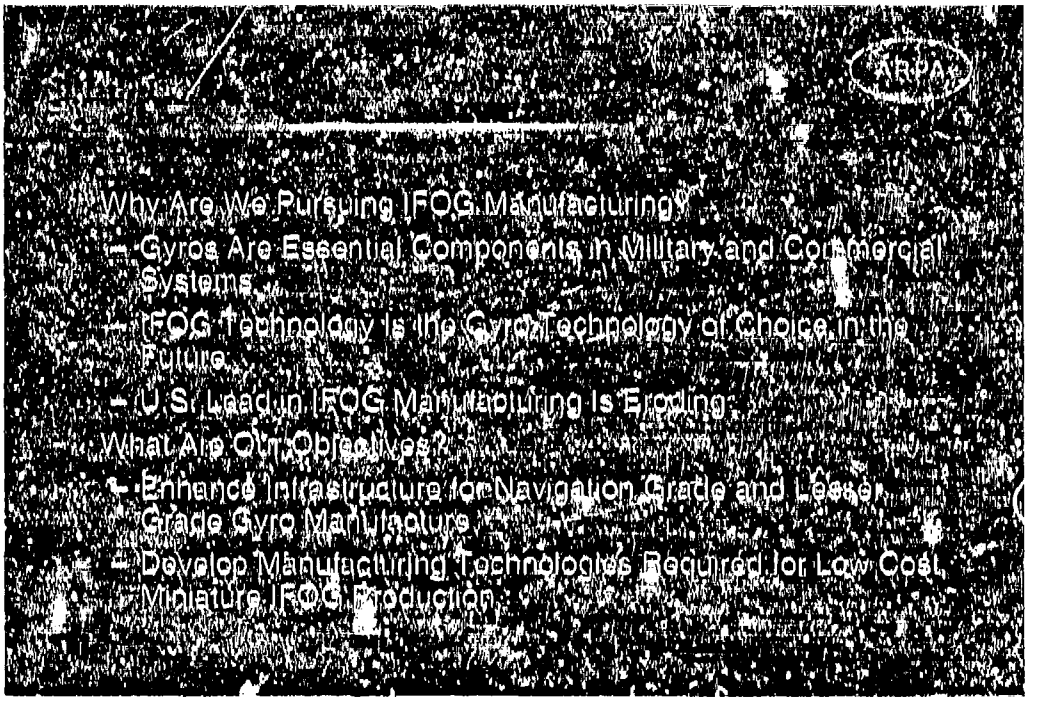
- Intelligent vehicle highway systems and related automatic vehicle location systems
- Advanced vehicle suspension systems
- General aviation applications
- Marine applications
- Other applications not yet envisioned



Infrastructure for affordable manufacture of FOGs will be created by this program.

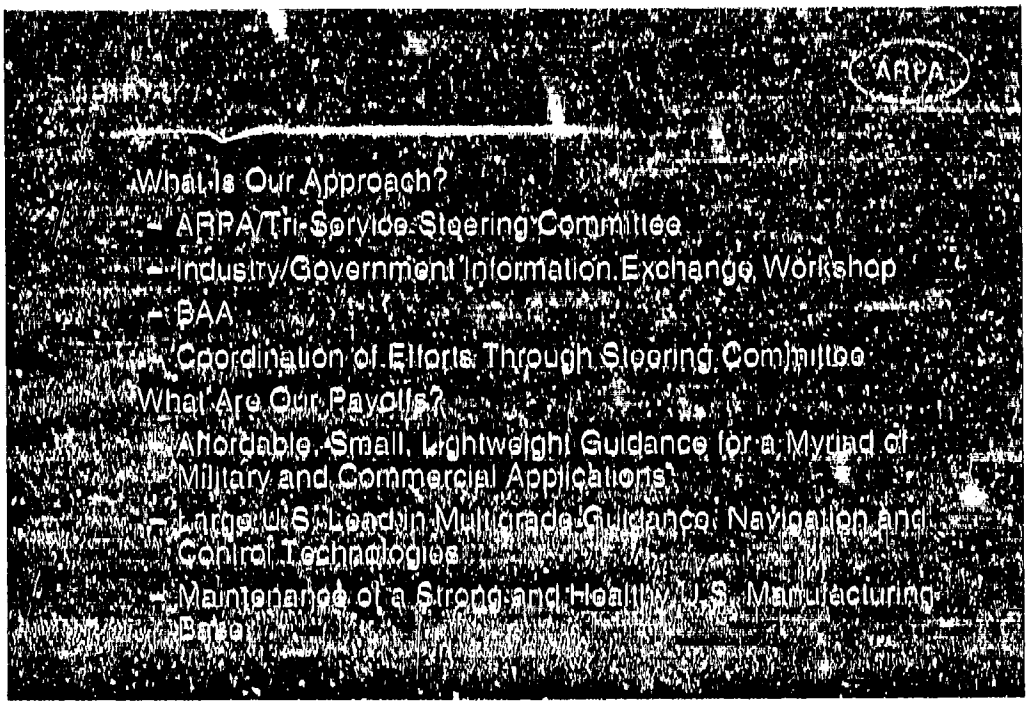
– Navigation grade gyros at tactical grade prices and lower grade gyros at even lower costs

The infrastructure thatber-optic gyros and so supports the objectives of the Presidents Technology Reinvestme will be created will aid both the defense and commercial manufacture of interferometric fint Program. This will strengthen the competitiveness of the US industry by lowering production costs. Hence, it will help to maintain the US as the world leader in the GN&C market, both now and in the future.



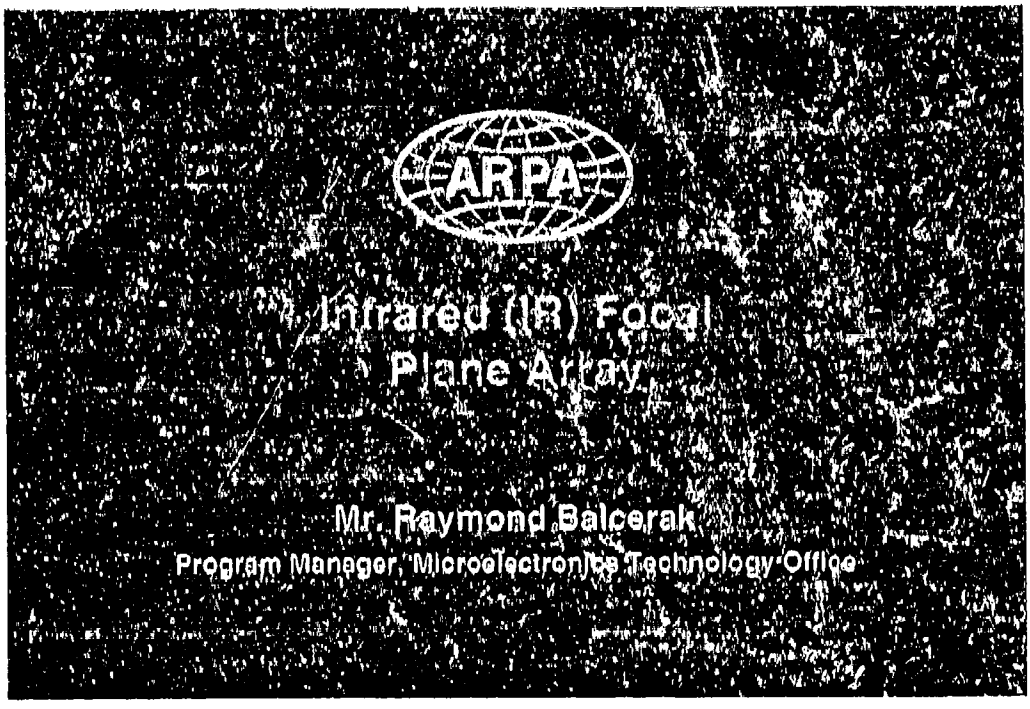
To summarize, we are pursuing IFOG manufacturing because of the importance of GN&C technologies, especially gyros, in military and commercial GN&C systems. Due to its potential for low cost, small size and high performance, IFOG technologies will become the gyro technology of choice in the future. The U.S. lead in IFOG manufacture is threatened by Japanese and European IFOG manufacturing efforts. To ensure a strong and viable U.S. IFOG manufacturing base will require addressing many technological issues in IFOG manufacture.

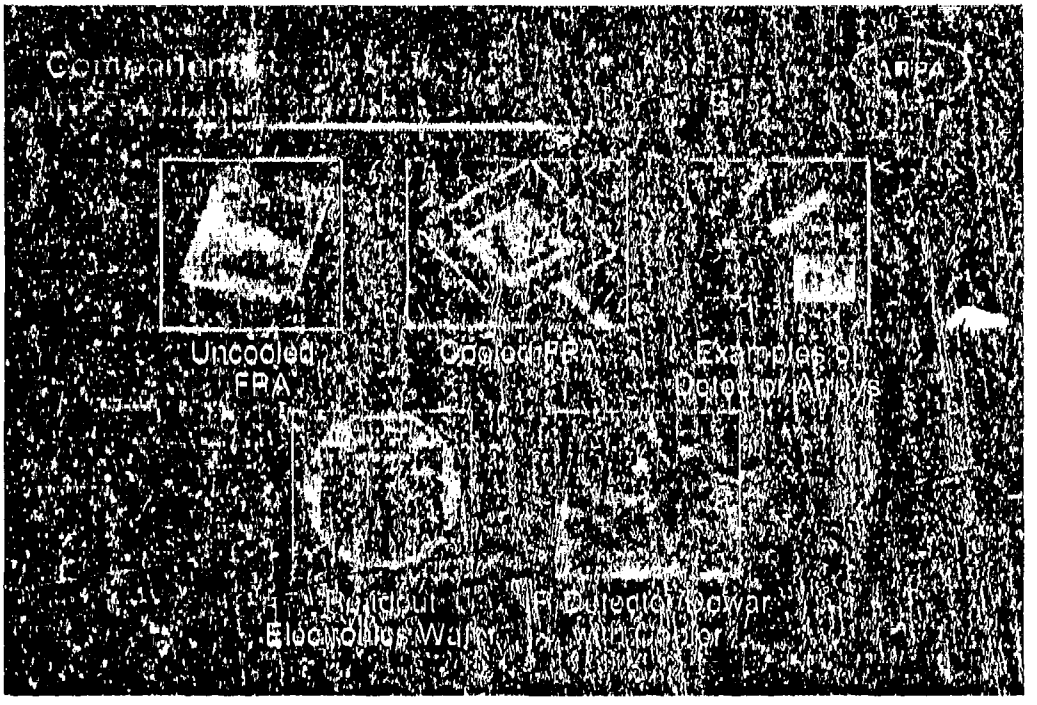
Our objectives will be to provide the necessary infrastructure for low cost navigation grade IFOGs, the capability to produce lesser grade performance at a lower cost, and the development of appropriate manufacturing technologies required for low cost, miniature IFOG production.



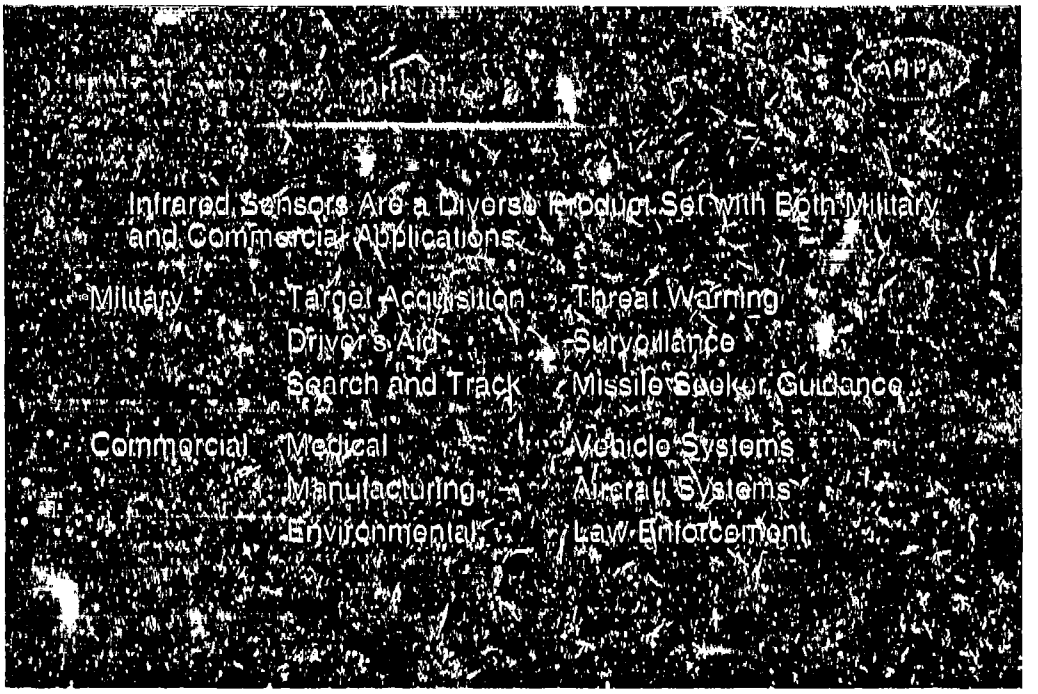
The approach has included the formation of an ARPA/Tri-Service Steering Committee to define specific technical goals, develop programmatic plans and interfaces, and outline a program plan. One or more broad area announcements will be made in support of the IFOG manufacturing effort. Theses efforts will be coordinated by the ARPA/Tri-Service Steering Committee.

The payoffs will be the development of affordable, small, lightweight guidance for a myriad of military and commercial systems and applications. Due to their small size and high performance, IFOGs will find applicability in many new and innovative applications. Finally, the U.S. will have a large lead in multigrade GN&C technologies. The U.S. manufacturing base will be strong and healthy in a high tech technology of the future.

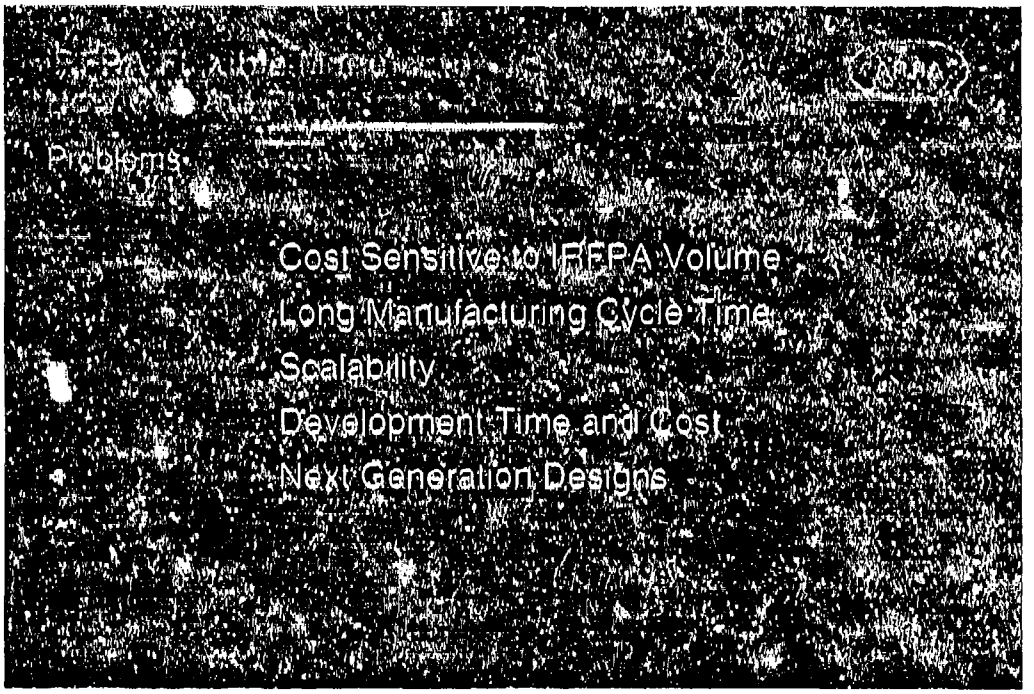

ARPA
Infrared (IR) Focal Plane Array
Mr. Raymond Balcerak
Program Manager, Microelectronics Technology Office



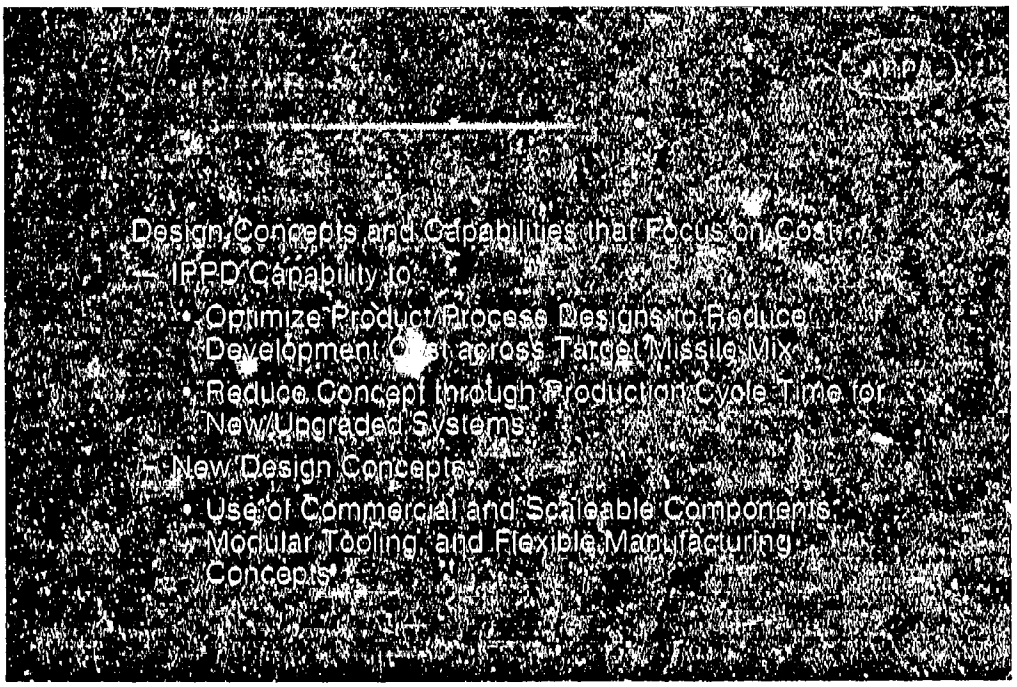
The infrared focal plane arrays are used in both military and commercial applications. The military applications dominate the requirements today, especially for the cooled arrays. The general set of military applications range from target acquisition to tracking for missile seekers. The commercial applications are evolving, with the uncooled infrared arrays leading in the commercial applications. The most immediate applications are in law enforcement and vehicle systems. No single infrared sensor design or material system meets all the requirements of this broad application base.

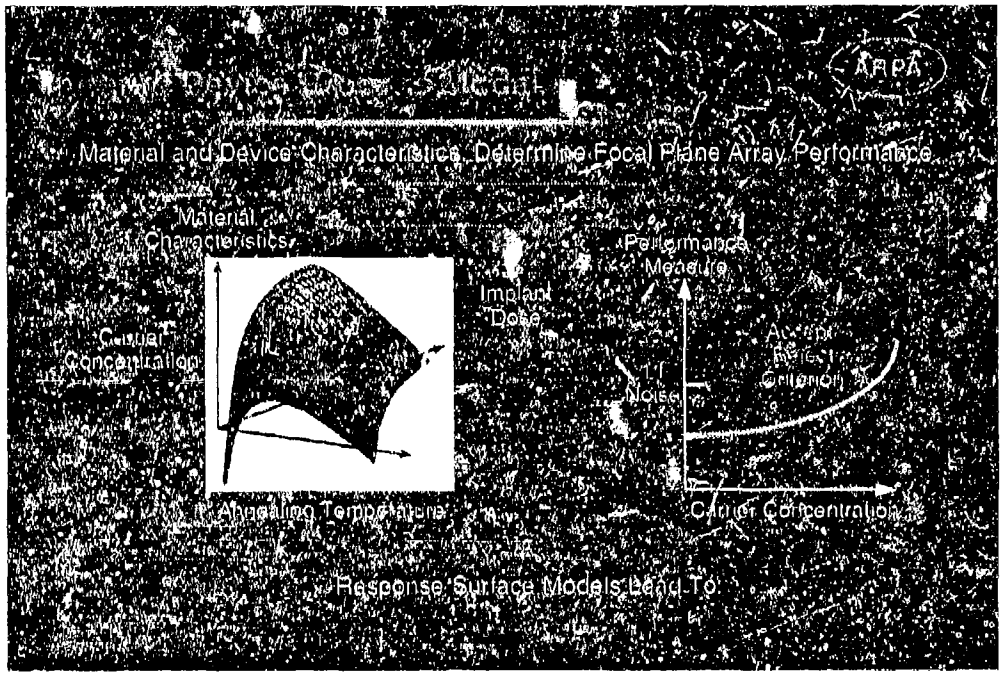


The focal plane array sub-components required to meet this broad application base include both cooled and uncooled infrared arrays in multiple types of packages integrated with state-of-theart electronics. IRFPA flexible manufacturing systems must therefore include all aspects of the infrared detector module, including the packaging and readout electronics. The flexible manufacturing system must also have the capability to produce both cooled and uncooled infrared detector types.



The issues (problems) with the production of infrared focal plane arrays involve primarily the cost of the arrays, especially at low volumes. The cost issue includes both the recurring cost to produce multiple device types on the same line and, the nonrecurring cost to introduce a new design into the manufacturing line. The non-recurring time required to complete and verify a new design is also long, and complicated by the unique requirements of focal plane array electronics and cryogenics considerations. Compounding this issue is the relatively long amount of time required to complete the manufacturing cycle for a focal plane array. The major objective of the flexible manufacturing program is to address these problems and demonstrate the production of arrays of both existing and new designs in the various configurations required by infrared system developers. Development of this capability will also lead to a more rapid evolution of the next generation of array designs.

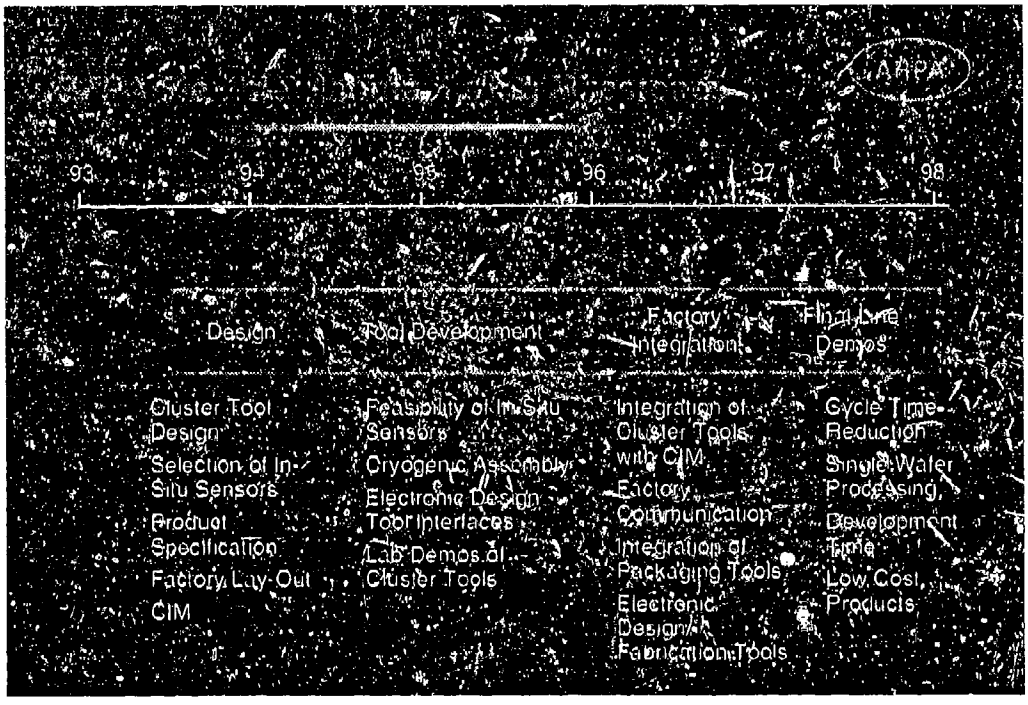

Design Concepts and Capabilities that Focus on Cost
– IPPD Capability to
• Optimize Product/Process Designs to Reduce Development Cost across Target Missile Mix
• Reduce Concept through Production Cycle Time for New/Upgraded Systems
– New Design Concepts
• Use of Commercial and Scaleable Components, Modular Tooling, and Flexible Manufacturing Concepts



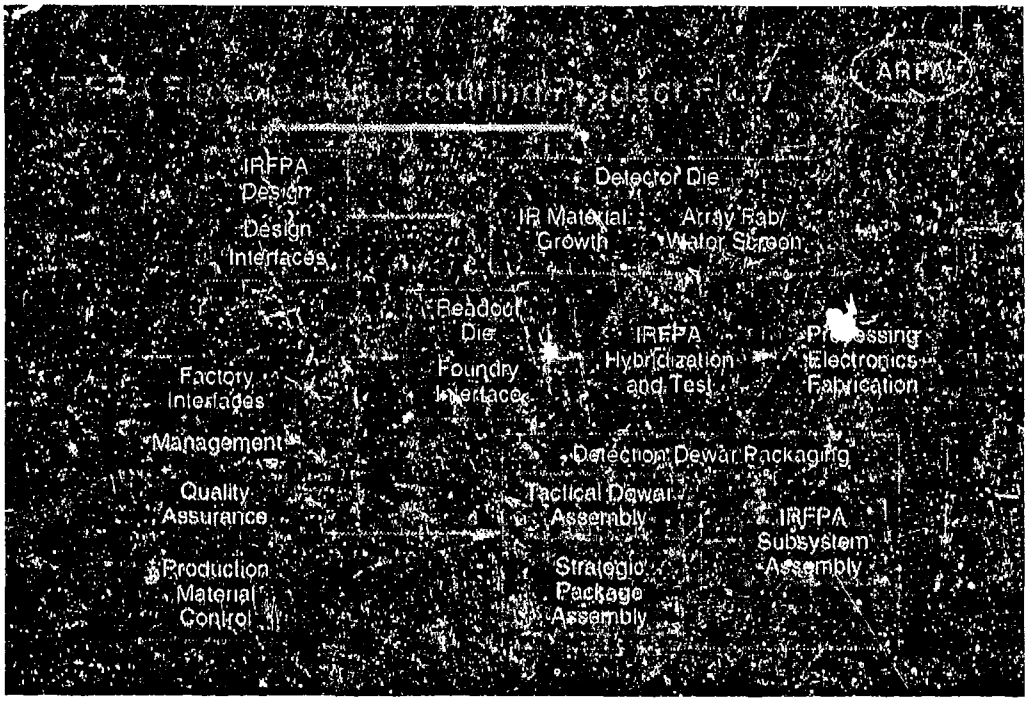
An important consideration in the design of the processing equipment is the response to changes in processing conditions. This equipment response model must take into account the material characteristics as modified by processing conditions. The material parameters are usually affected by multiple processing parameters and a response surface relating multiple variables must be developed. Material characteristics are then directly related to the performance metrics of the device. The completed process model defines the equipment and process parameters required to maintain the material within acceptable limits, which meet performance characteristic required for the device.



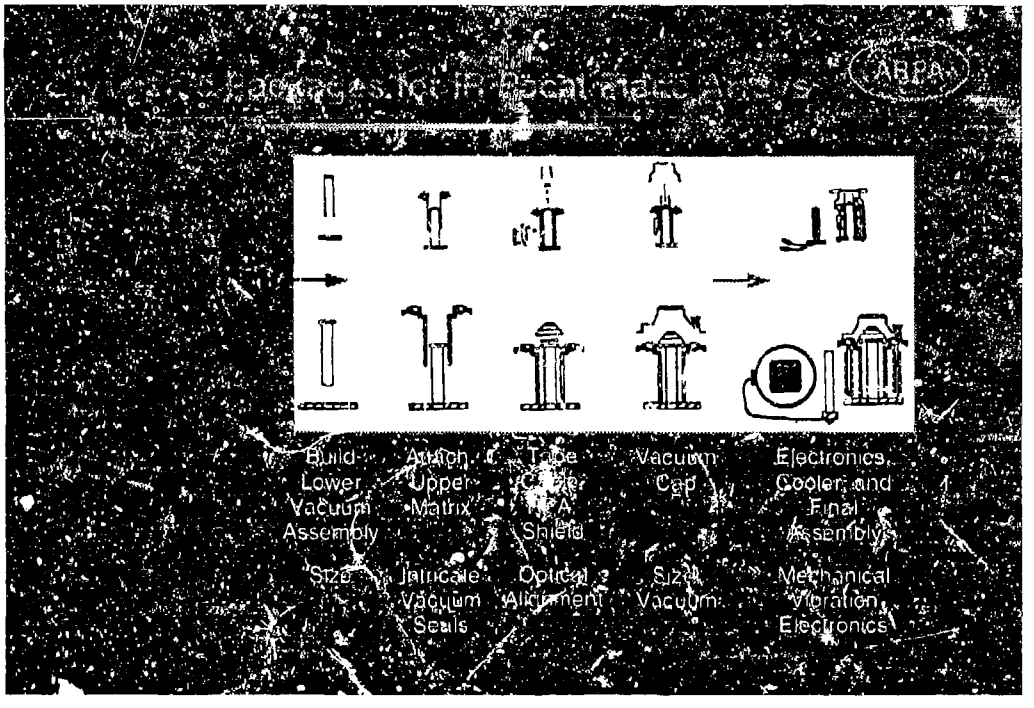
In order to address these problems, the flexible manufacturing program will demonstrate technology to produce arrays at low cost in low volume, minimize the cost of introducing a new product into the line, and address a broad product range. The reduction of fixed factory cost is a major factor in the production of arrays at low volume. Fixed costs can be minimized by designing equipment to be as versatile as possible, ie. producing a wide range of infrared and related products. The rapid turn-around of new array types will be facilitated by development of new design tools, which integrate the total considerations associated with a new design into a single comprehensive software tool. These considerations include the electrical and optical performance of the array, and the mechanical considerations involved in producing and assembling new components.



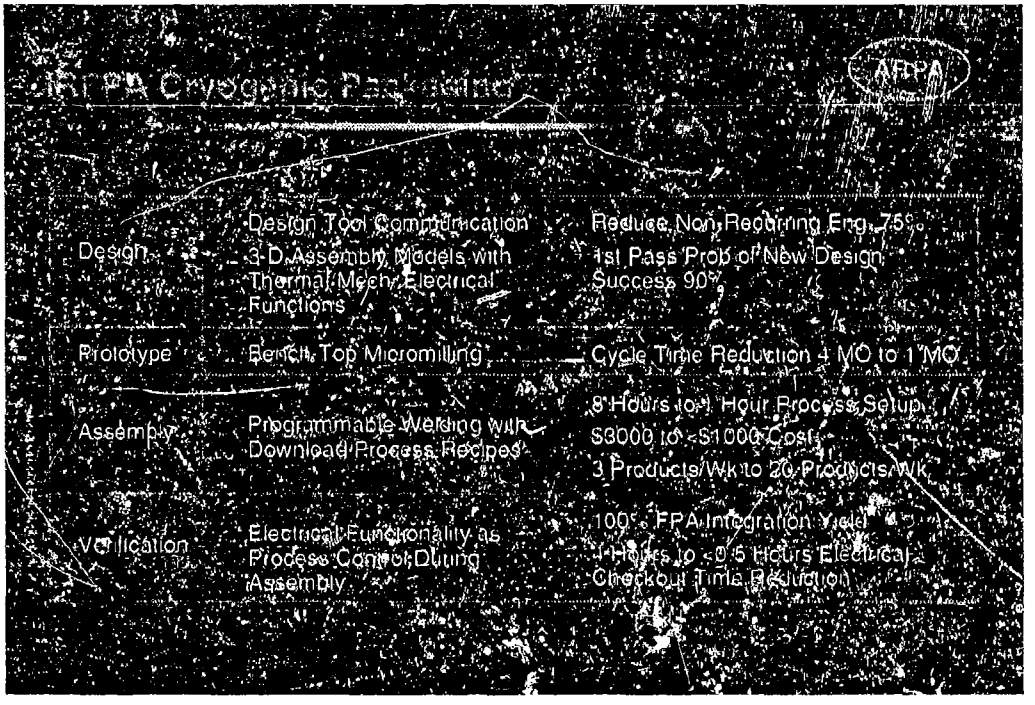
The flexible manufacturing development phases include the design of the factory, development of fabrication tools, integration of these tools into the factory, and final demonstrations. The tool development will include the demonstration of in-situ sensors to control the manufacturing process, allowing the process to be monitored and controlled as the process recipes are changed for the various array configurations. An important part of the tool development is the cluster tool demonstration, which show the integration of multiple processes into a single tool. This reduces the cycle time through the line, and reduce handling required to manufacture the array. The final integration line demonstration will include fabrication of various infrared detector devices at reduced cost and with rapid cycle time through the line.



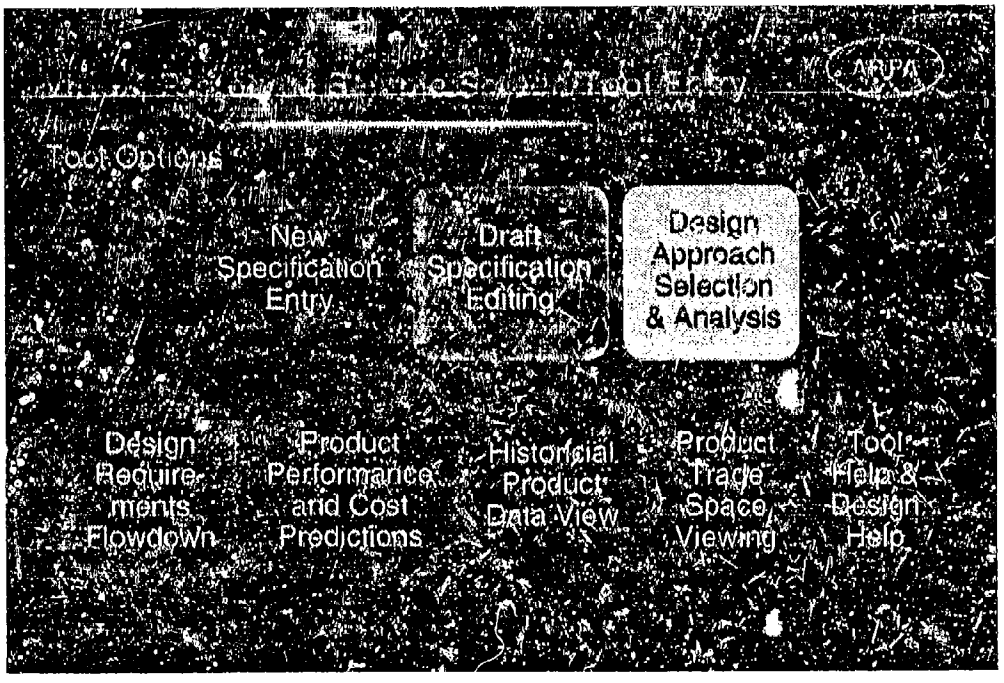
The flexible manufacturing the includes all aspects of array development necessary to design, fabricate, and package the array. These functions must be integrated so that the completed array meets the system design requirements.



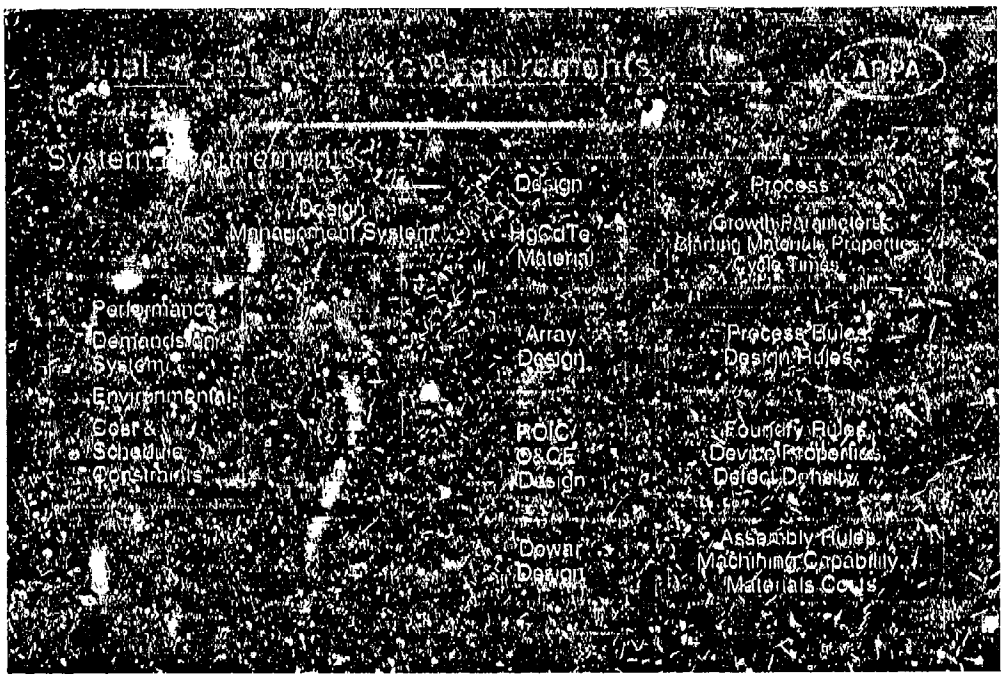
Cryogenic packages for infrared focal plane arrays are vacuum sealed enclosures in which the infrared focal plane array is mounted and maintained at temperature of approximately 80k. Since the IRFPA is part of the optical system, the alignment and positioning of the array is crucial to system performance. Since the array configuration must also be matched to the system application, the package design is different for each array configuration. These requirements lead to the need for flexible manufacturing capability for the cryogenic packa; An example of two dramatically different package configuration are the packages for missile seeker applications and target acquisition arrays. This designs graphically illustrate the need for a flexible manufacturing capability.



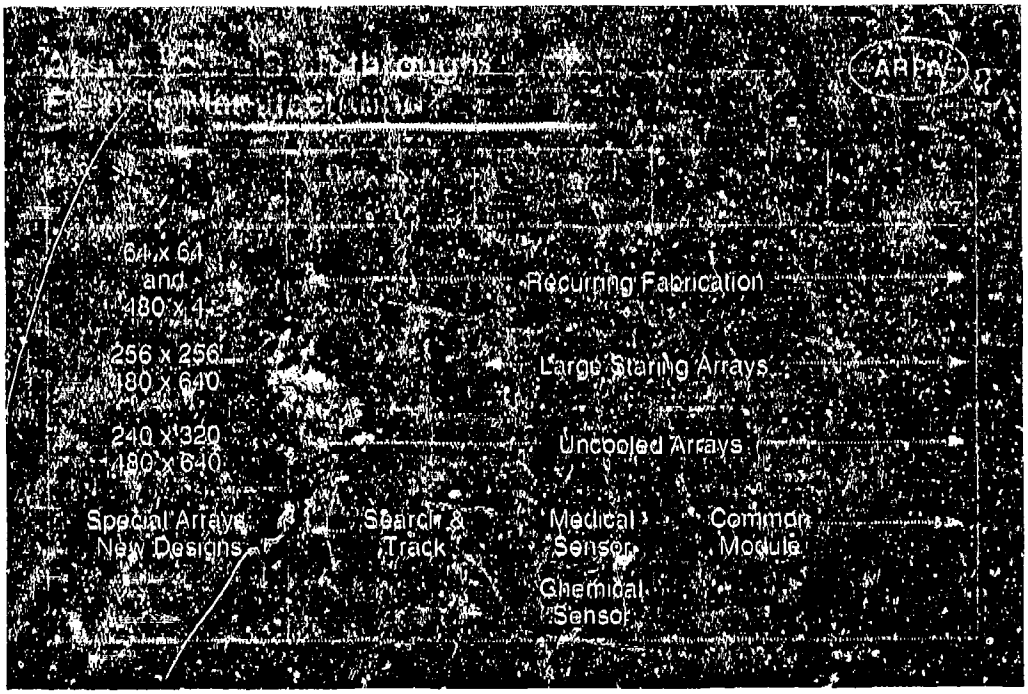
The flexible assembly and manufacturing of the cryogenic package will be integrated into workstations which perform the assembly operations. The workstation will include a design station that simulates the mechanical assembly and also performs modeling of thermal and electrical properties of the package. The assembly workstations will simplify the assembly process and reduce the cost of integrating a new assembly into the line.



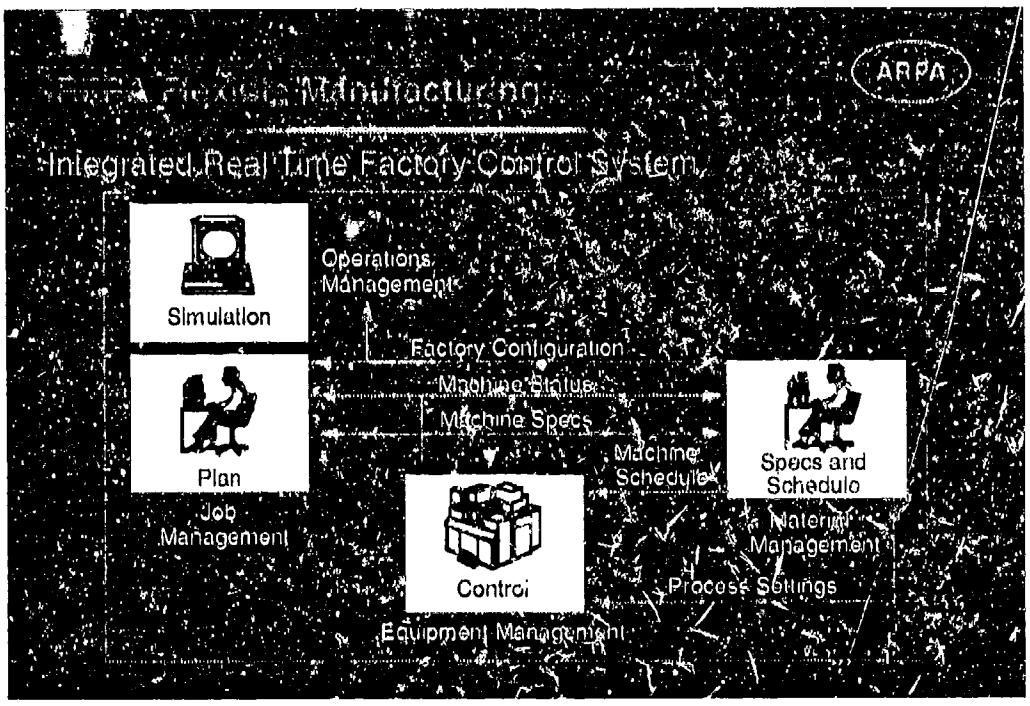
The design and manufacturing of infrared focal plane arrays is closely linked to the system design. A virtual prototype is being developed to ensure that the array meets the system requirements, and can be built within the constraints of the factory.



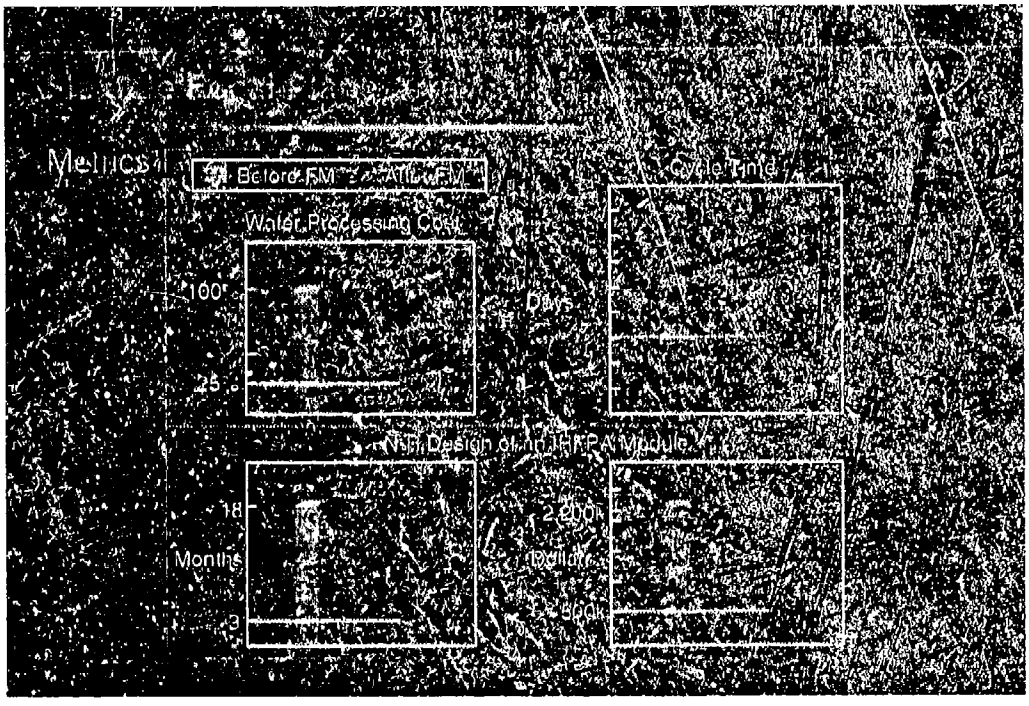
The Virtual Prototype will include the capability for entry of new specifications, selection of the design approach, cost and performance predictions, and an historical view of the specified product and related product types. An important aspect of the virtual prototype is the product trade space, allowing the user to trade-off design parameters and optimize the cost of the device. In each area, default values will provide a baseline from which to build new designs. The product trade space will lead the user through the design process providing guides on selection of design parameters. Through use of the design and process information contained in the virtual prototype, the infrared manufacturing processes can be simulated, allowing the user to perform essential design trades before committing the product to manufacturing.



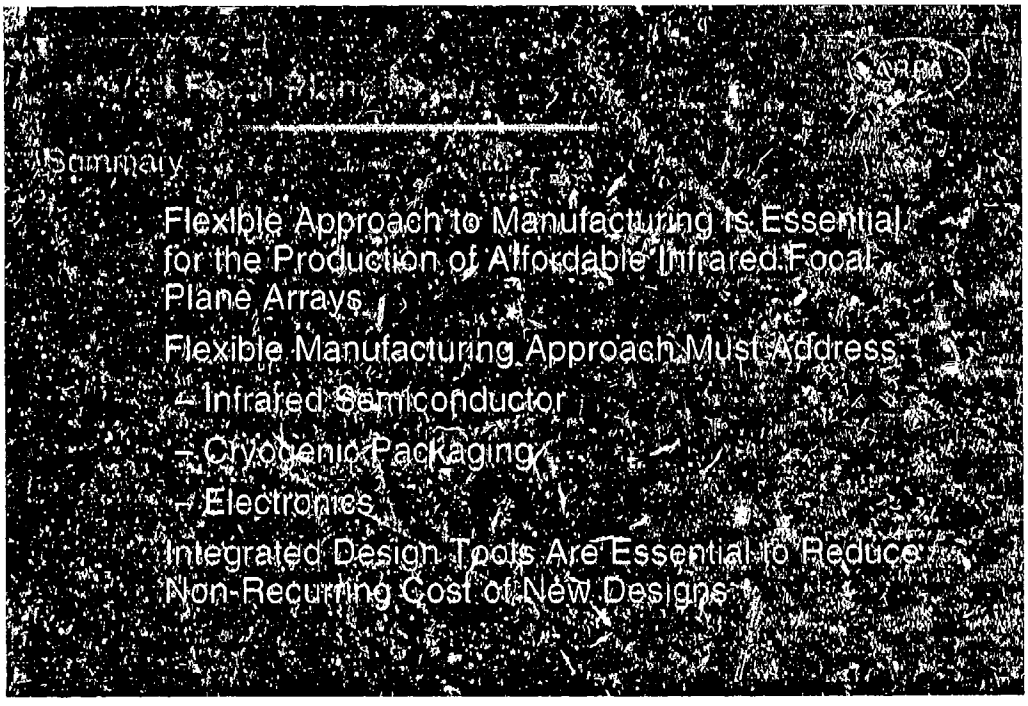
The arrays to be built during the flexible manufacturing development include scanning and staring arrays which are designed consistent with DoD needs. This output of measurable hardware verifies that the manufacturing lines are capable of producing useful products. There are also new designs to built which stretch the limits of the manufacturing capability to larger array configurations. The array new designs also exercise the design tools and provide feedback to both manufacturing and the design tool development effort.



The flexible manufacturing system is integrated into a design network, which links the various elements of the manufacturing line. This network provides the capability to enter new processes, update existing processes, and schedule flow through the manufacturing line. The network is linked to process equipment so that recipes can be directly download to modify the process for new designs, with distribution of processing and equipment specifications to the manufacturing line.

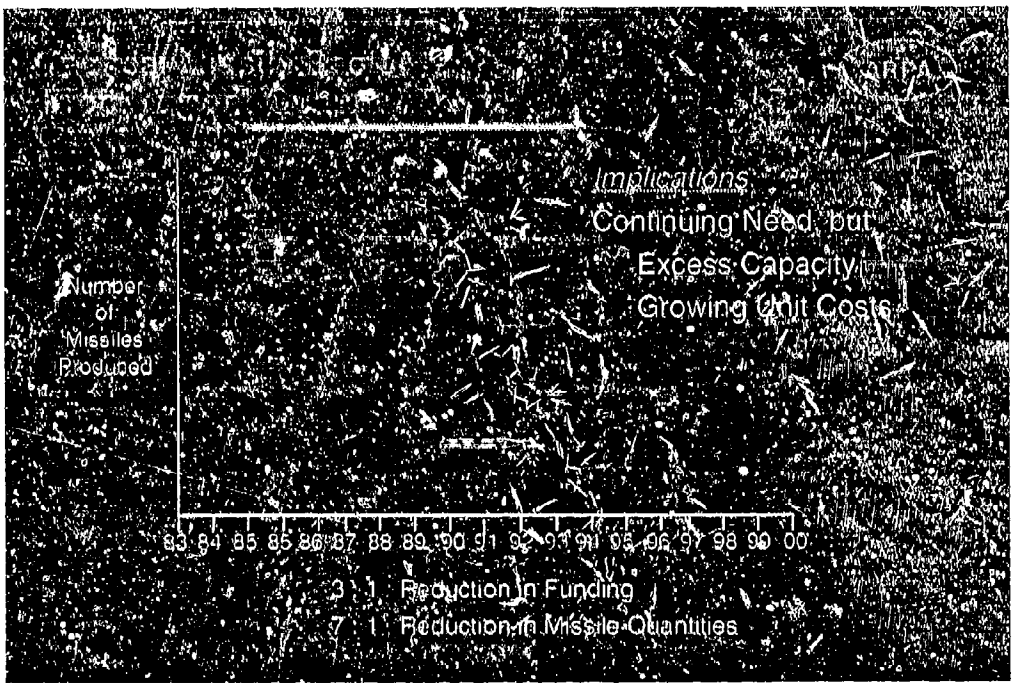


The flexible manufacturing metrics are in terms of cost and cycle time. Reduction of the number of processing steps required to produce an array is an important consideration, which leads to lower cost and the capability to produce new types of array designs. Other metrics include the non-recurring cost of a new array design and the number of array configurations which can be produced on the focal plane array line.



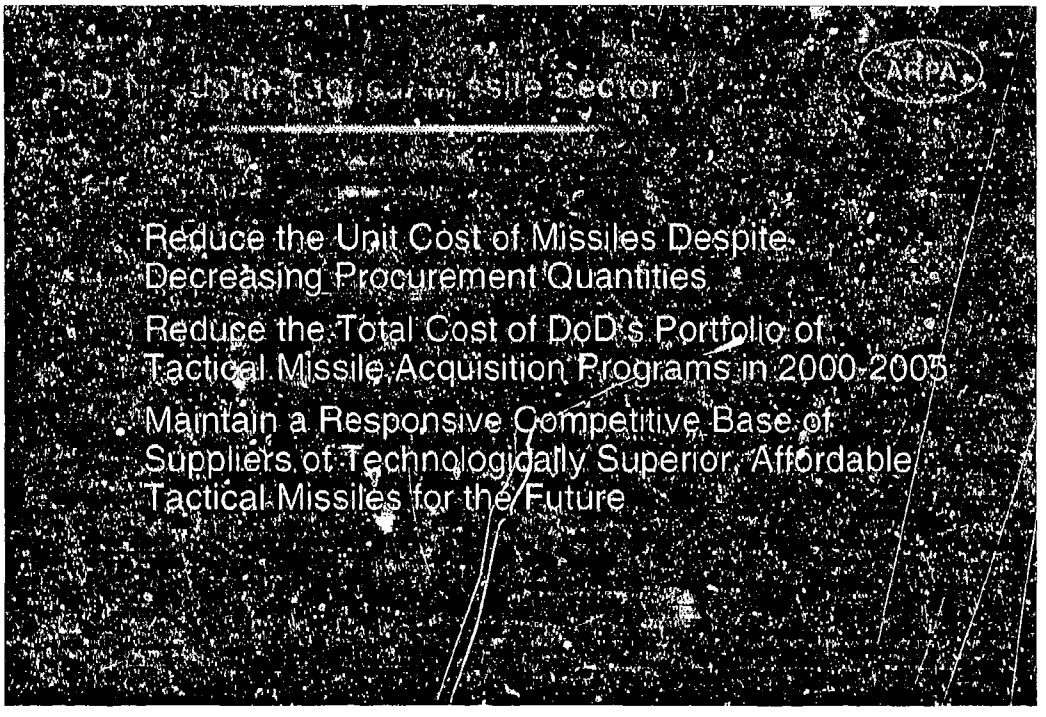
Flexible manufacturing provides the capability to produce a wide range of infrared focal plane arrays at low cost in low volumes of any particular array design. This is accomplished through integration of the design and manufacturing process. Equipment is designed to rapidly change from one process to another, and maintenance the process within limits. This leads lower cost for current array designs and rapid evolution of new array designs.


ARPA
Affordable Multi-Missile
Manufacturing Program (AMM)
Michael F. McGrath
Executive Director, Manufacturing, SISTO

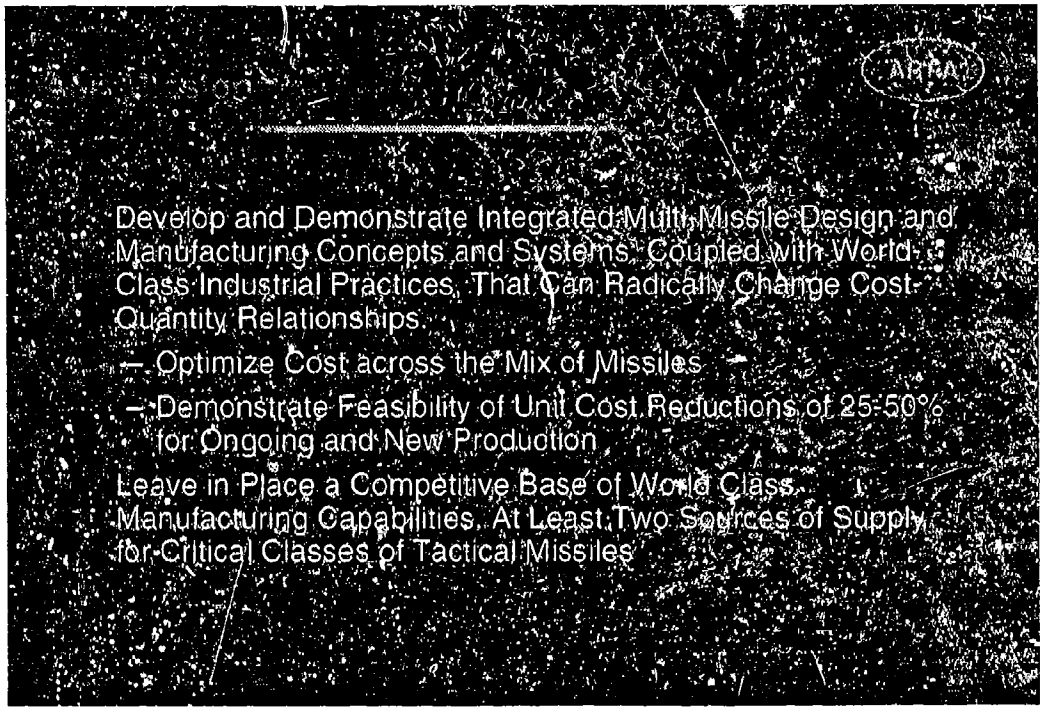


The reduction of Defense procurement funds in the post Cold War era has had a dramatic effect on the tactical missile sector. This sector includes the non-nuclear guided weapons used by Army, Navy, Air Force and Marines. Funding has declined from a peak of about $9B per year in the mid 1980s to about $3B per year in 1995, a factor of three reduction. Quantities of missiles have declined by considerably more than a factor of three, as shown in this chart*. This indicates a substantial increase in the unit costs of missiles. A major cost driver is the overhead associated with excess capacity in this industrial sector. There are still eight or more major prime contractors in the tactical missile business, although the picture continues to change through mergers and acquisitions. The 1992 Bottom Up Review estimated a business base that would support only about four prime contractors, assuming we design and manufacture missiles the way we did in the 1980s.

*FY 1995 President's Budget Data

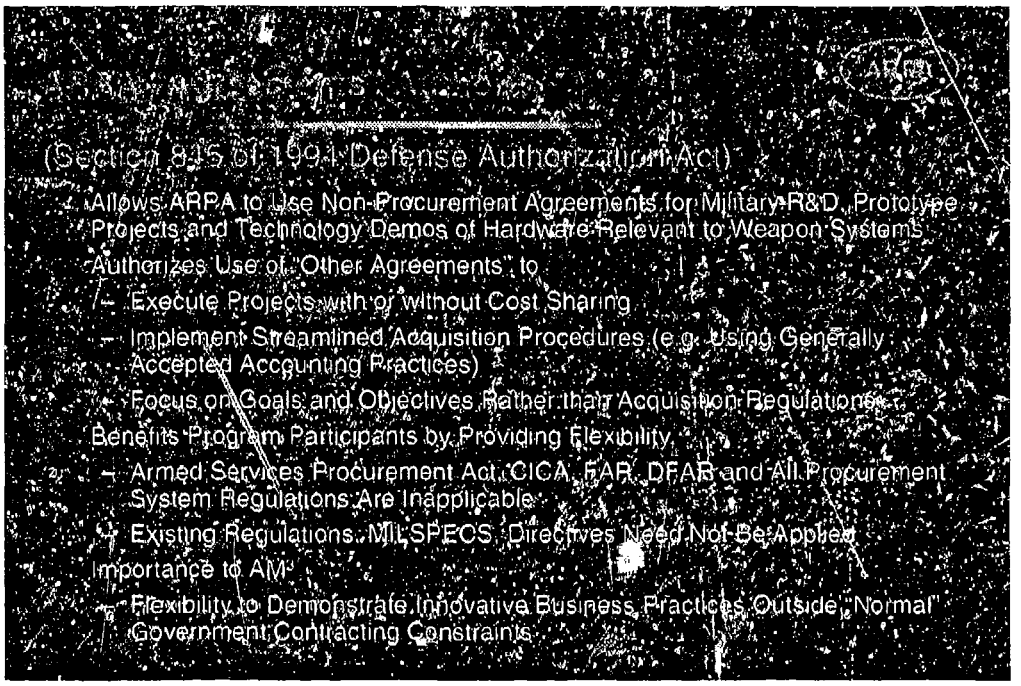


So the question is, "How will we design and manufacture tactical missiles in the year 2000?". This is the question addressed by the ARPA/Tri-service Affordable Multi-Missile Manufacturing program.

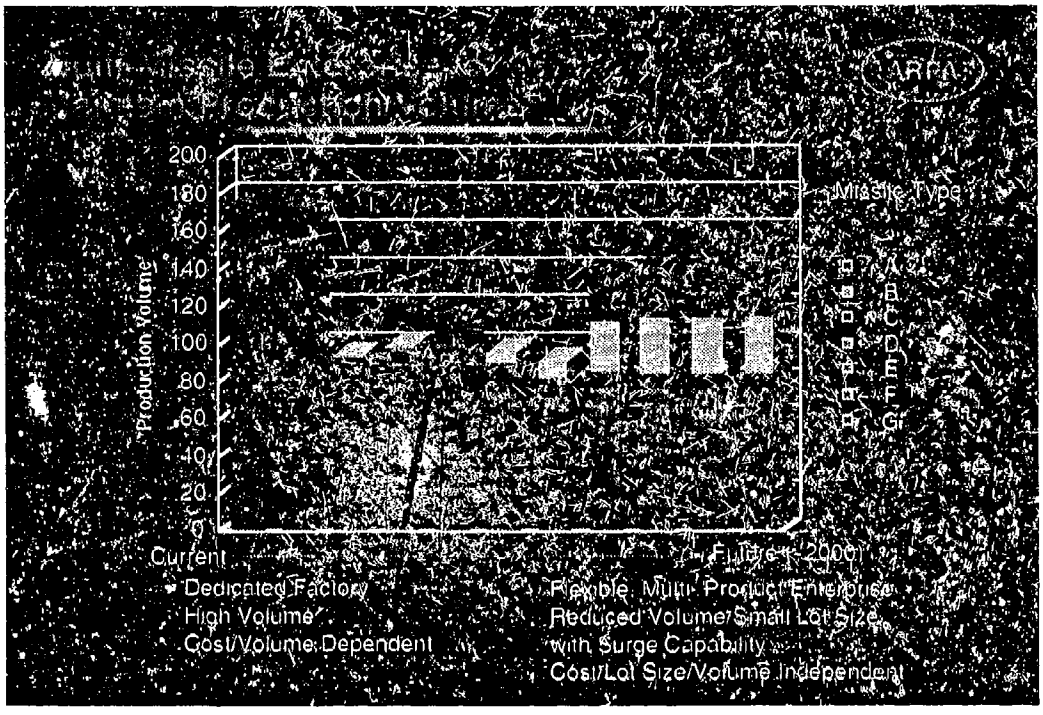


The mission of the AM3 program is to demonstrate concepts that can radically alter the cost-quantity relationship. These concepts include product designs, process designs, enterprise systems, and business practices which can be combined in a way that uses the mix of missiles to compensate for the decline in production quantities. The goals of AM3 are to:

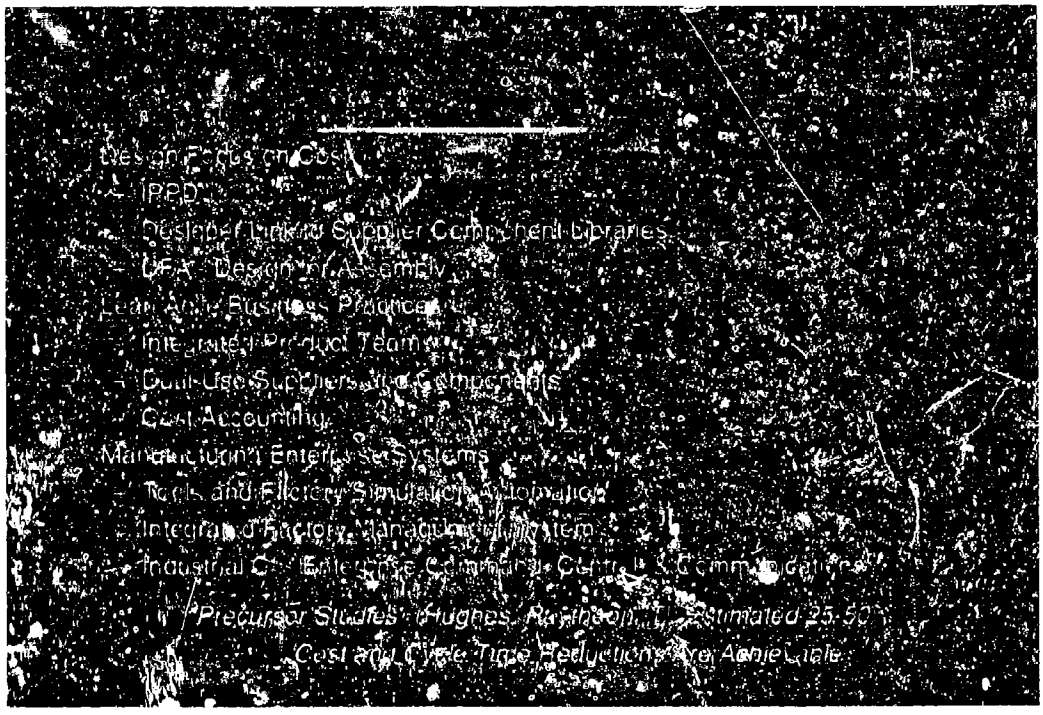
- Demonstrate the feasibility of 25-50% reductions in unit cost. This will not be achieved by marginal improvements, but rather through fundamental re-engineering of the manufacturing enterprise.
- Establish two "pilot" enterprises that remain beyond the demonstration phase as a viable competitive base for future missile production.



A key feature of the AM3 program will be innovative approaches to contracting for missile development and production. Congress has granted ARPA the authority to conduct demonstrations fo such innovations outside of the normal government procurement regulations, using "Agreements" authority rather than contracts. Our plan is to explore such authority as needed to support AM3 demonstrations in Phases 2 and 3.



The model for the future missile manufacturing enterprise might look something like this figure. The current paradigm of a production facility dedicated to one or two missiles will evolve to an integrated enterprise capable of producing a large family of missiles. The economies of scale are preserved by using the missile mix to compensate for the decline in individual missile quatities. This concept requires a degree of agility, or adaptability to change, that is beyond our current business practices and technical envelope of manufacturing flexibility. Within this framework of multi-missile manufacturing, we need to implement the innovations and radical process re-engineering that will allow AM3 to reach its goal of 25-50% reductions in cost.



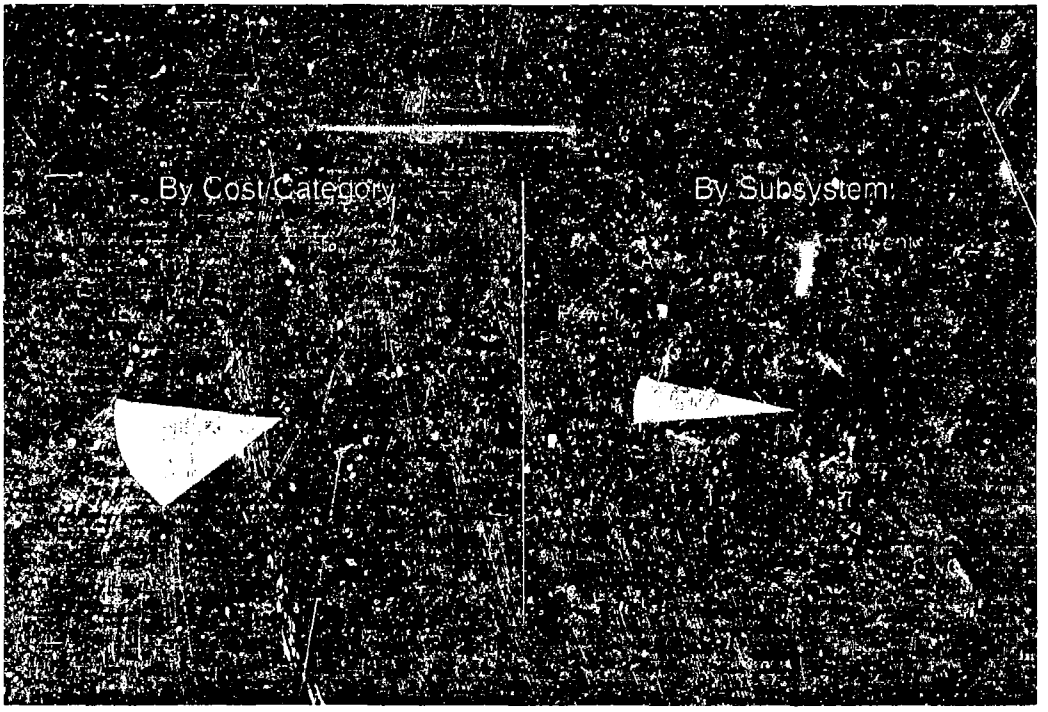
In FY 1994, ARPA sponsored studies to examine historical missile costs and determine where leverage could best be exerted to reduce future costs.

The studies concluded that the greatest leverage on product cost is available early in the design process. Integrated Product/Process Development (IPPD) needs to be implemented in the broadest sense, not only in the engineering process but in the organization and acquisition practices that govern the development phase. Cost targets must be established early and used to drive tradeoffs in product and process design. Design concepts that optimize across the mix of missiles for production in multi-missile factories, and concepts that make extensive use of commercial parts, can achieve large reductions in cost.

The manufacturing enterprise systems that support IPPD and flexible manufacturing are another source of high leverage. Information technology and networks are important enablers for the IPPD process, the flexible factory floor, and the enterprise functions that drive overhead costs.

Radical changes in the cost-quantity relationship will not result from technology alone. New business practices based on the concepts of lean and agile manufacturing need to be adopted by both missile contractors and government customers.

The studies estimated that savings of 25-50% in both development time and acquisition cost are achievable through these strategies.



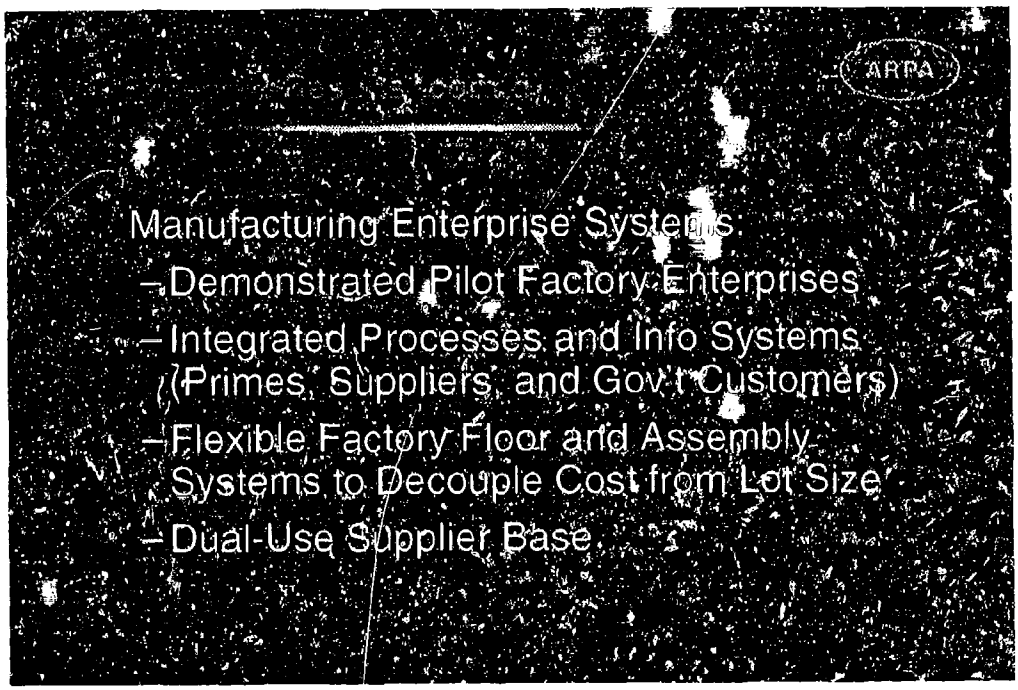
How can we reduce unit costs by 25-50%? First of all, we need to understand what drives cost in today's missile manufacturing approach.

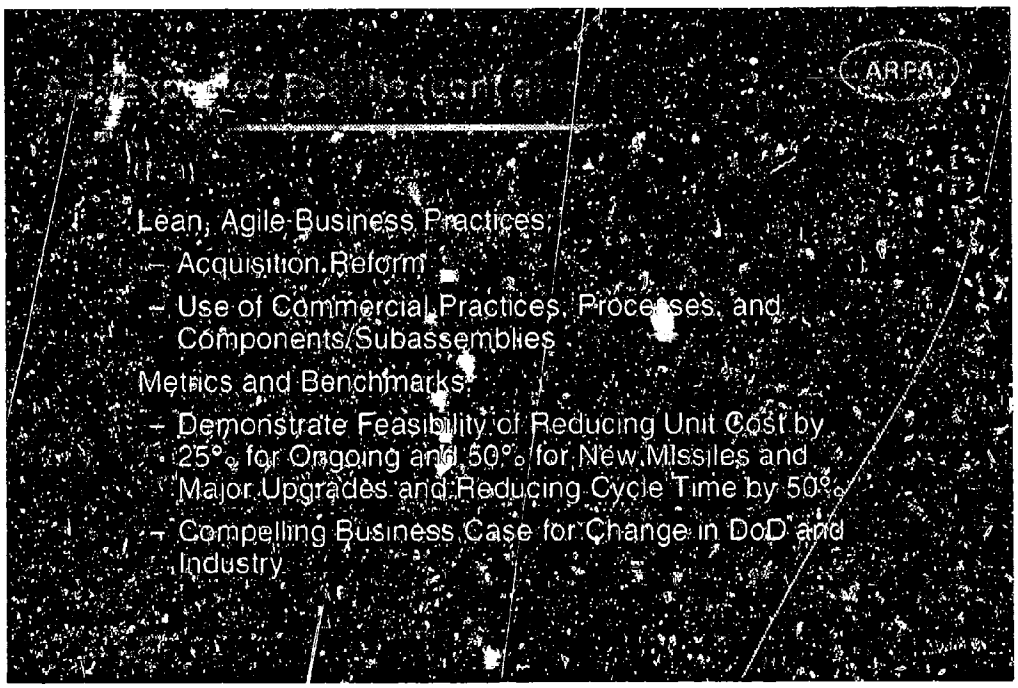
In terms of missile subsystems, 60-70% of the recurring cost is in the seeker and guidance and control (G&C) components. The seeker/G&C sections are also the dominant factors in development and support costs. Therefore, a major area of focus in AM3 will be on the seeker and G&C portion of the product.

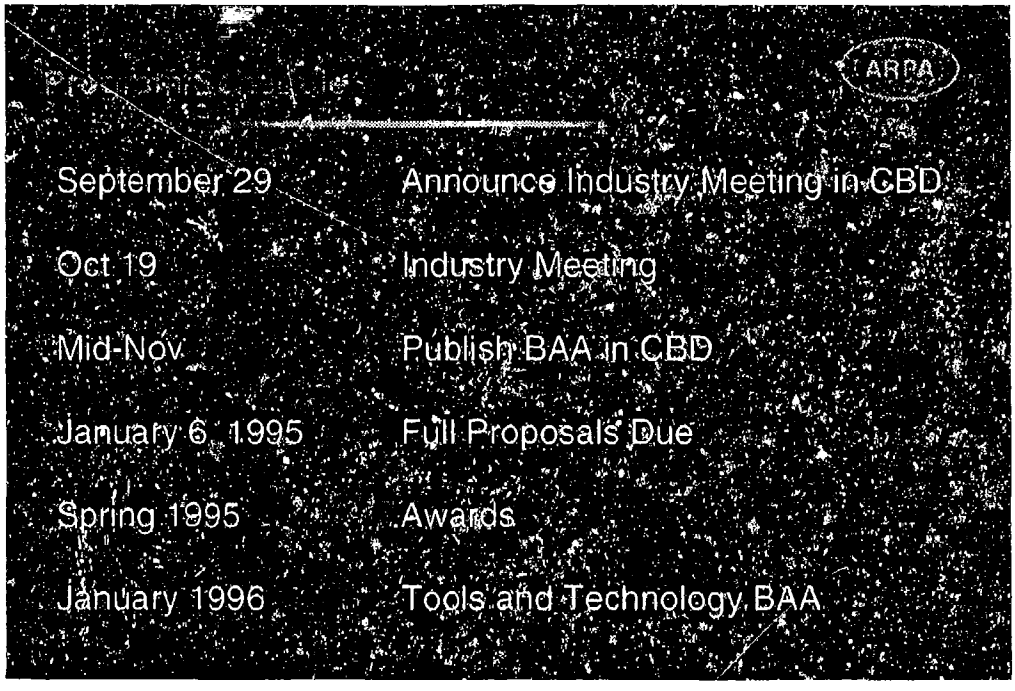
In terms of cost categories, about half of the product cost is in material, i.e. . purchased components from suppliers. The rest of the costs are accrued at the prime contractor level. Only 15% of the cost is labor at the prime contractor level, and the balance is overhead and facility cost. It should be noted, however, that the first tier suppliers have a similar breakdown of labor, material and overhead. That is of the 50% of supplier cost, about a third is overhead. Counting both prime and subtier contractors, overhead costs account for more than half of the total product cost. The message is that overhead costs and supplier interface costs need to be major targets in the AM3 program.



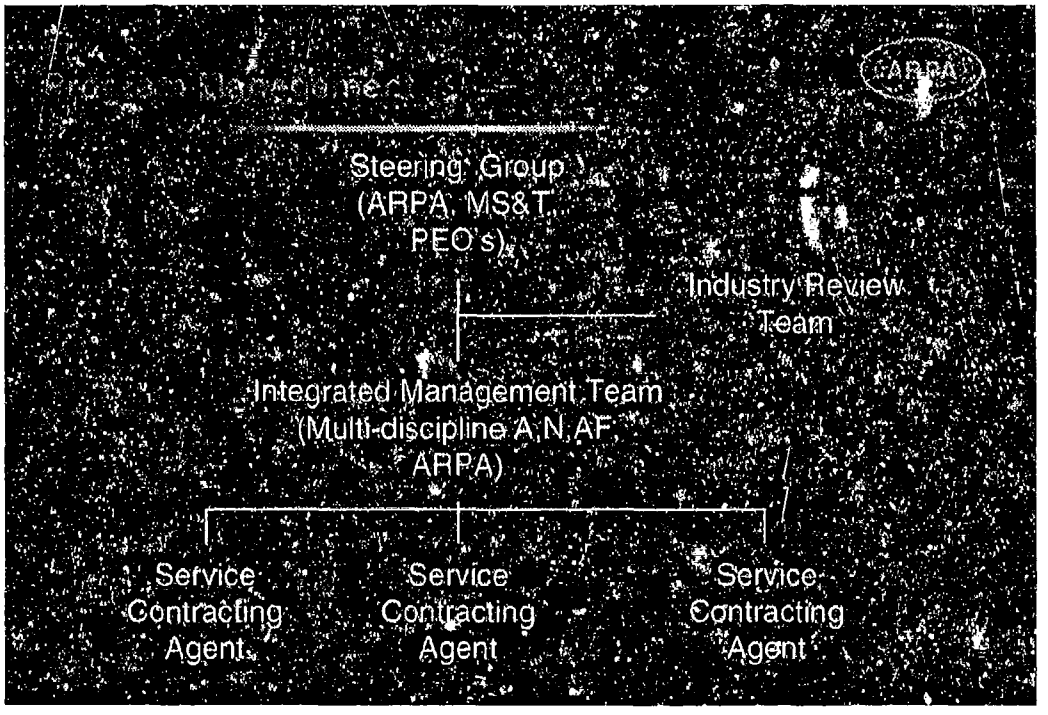
Over the past decade a number of leading U.S. firms have adopted new manufacturing approaches and acheived significant reduction of product cycle and costs, as well as improvements in quality. Future missile production costs however must be even lower still. Both industry and government are working together on several fronts to continue to find significant cost reductions.


ARPA
Manufacturing Enterprise Systems:
– Demonstrated Pilot Factory Enterprises
– Integrated Processes and Info Systems (Primes, Suppliers, and Gov't Customers)
– Flexible Factory Floor and Assembly Systems to Decouple Cost from Lot Size
– Dual-Use Supplier Base


ARPA
Lean, Agile Business Practices
– Acquisition Reform
– Use of Commercial Practices, Processes, and Components/Subassemblies
Metrics and Benchmarks
– Demonstrate Feasibility of Reducing Unit Cost by 25% for Ongoing and 50% for New Missiles and Major Upgrades and Reducing Cycle Time by 50%
– Compelling Business Case for Change in DoD and Industry



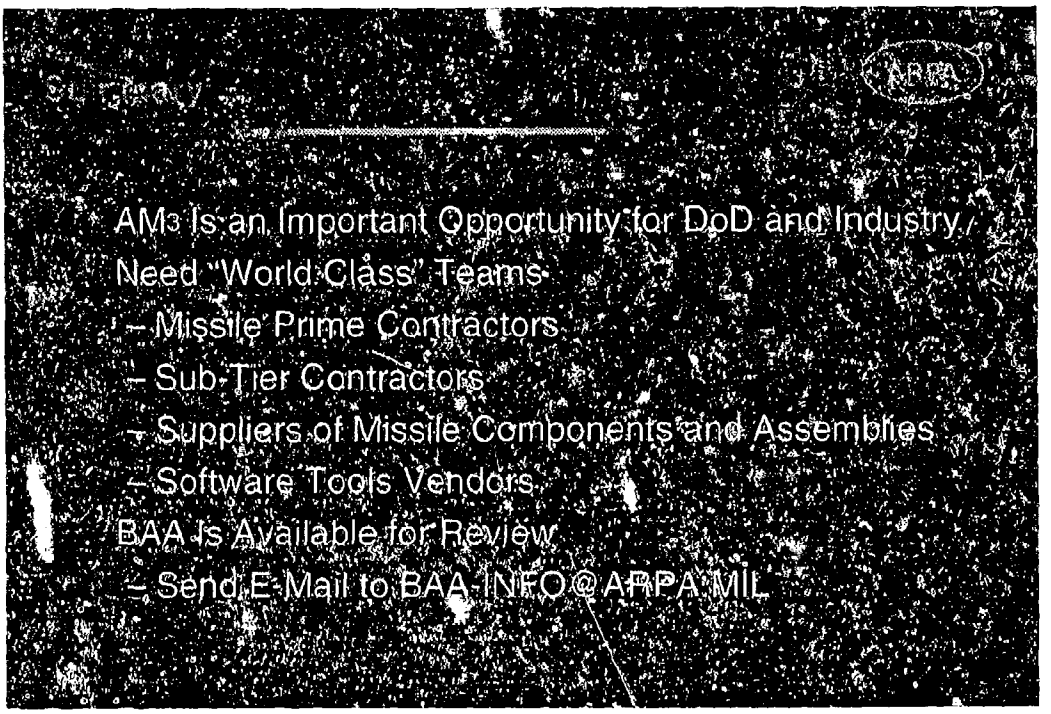
The near term schedule is shown in this chart. The draft Broad Agency Announcement (BAA) was released for industry comment in mid-October. The final solicitation will be issued in mid-November. ARPA anticipates broad interest from missile prime contractors and their suppliers, and from the vendors of engineering and manufacturing systems technology. A further opportunity for tools and technology development will come in 1996 in a parallel BAA. I encourage all of you to investigate the opportunities offered by this important program.



Management of the AM3 program will be guided by an ARPA/Tri-Service steering group that includes representation from the Service ManTech directors and missile Program Executive Officers.

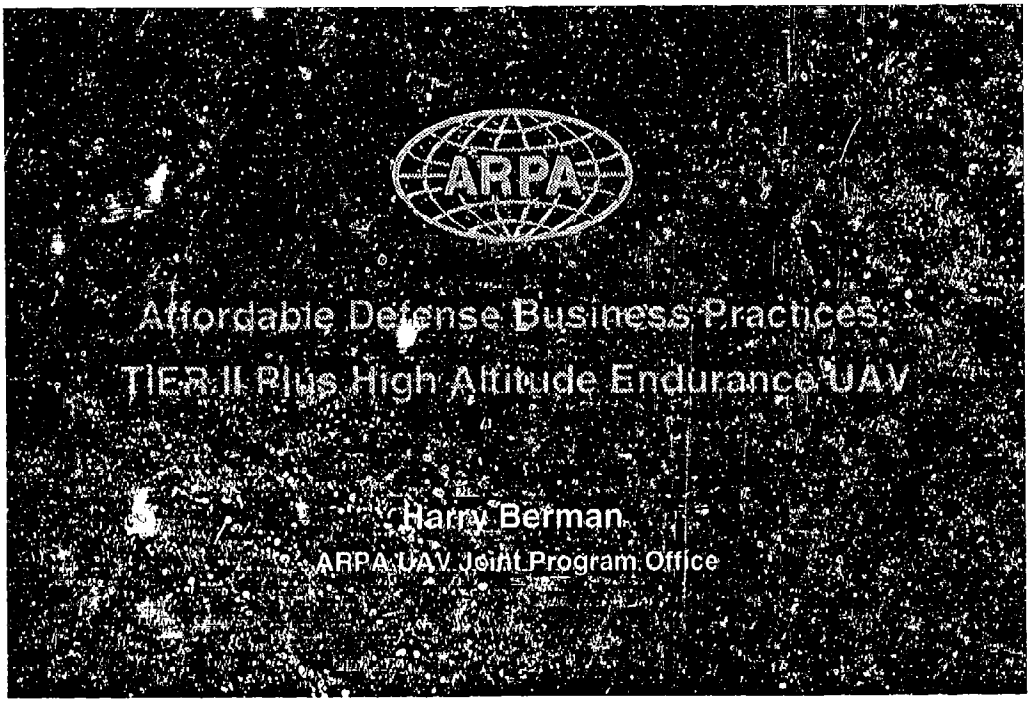
Progress will be reviewed by this steering group, with input from an industry review group that includes both defense and commercial contractor.

Month-to-month management of the program will be conducted by an multi-disciplinary management team that provides government representatives with skills across the full spectrum of technical and business areas proposed by the AM3 contractors. This team will engage with the AM3 IPPD process. Contract administration will be performed by Army, Navy and Air Force offices acting as ARPA's agents.

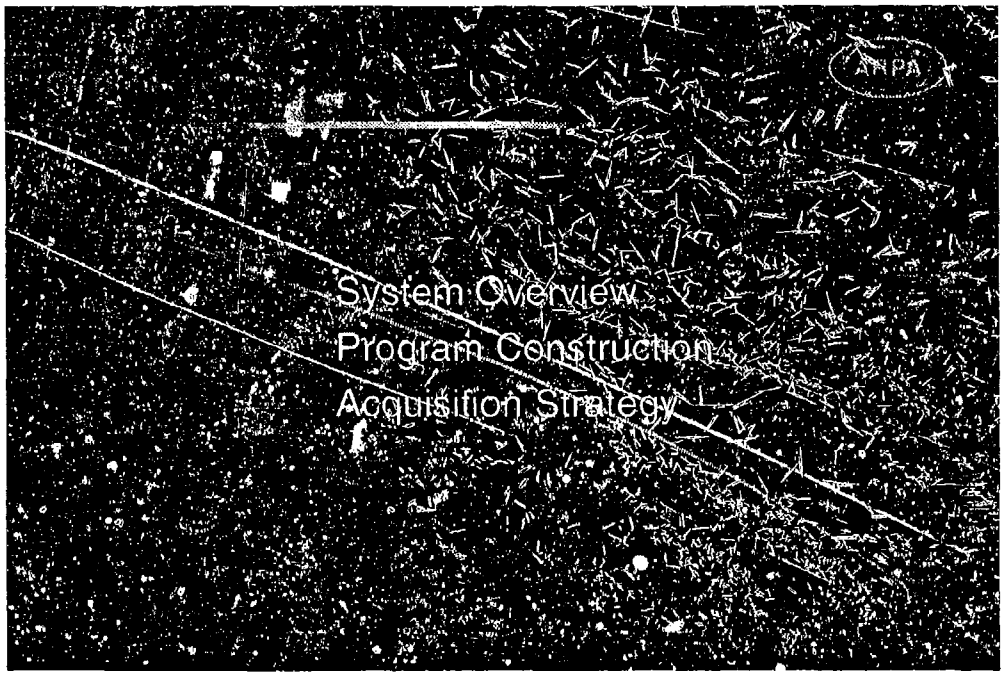


In summary, AM3 offers an important new opportunity for both DoD and industry. It has the potential to set the direction for the future of an entire industrial sector. To succeed, the program must have the participation of world class enterprise teams -- not just primes, but suppliers and subcontractors.

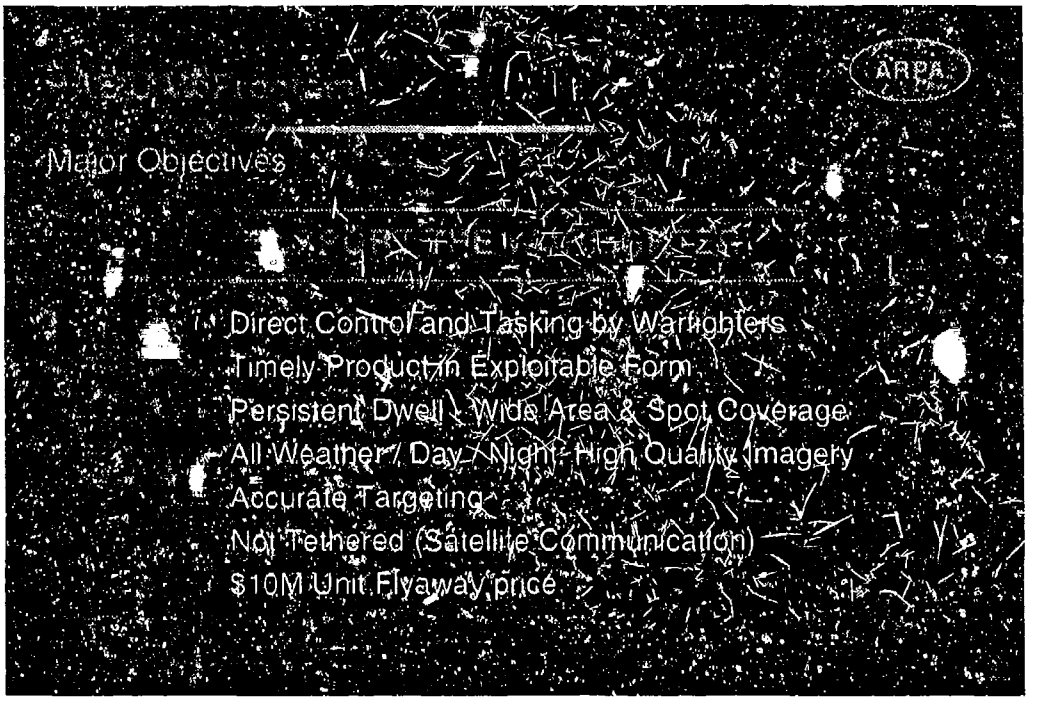
I encourage you to review the BAA and consider participating in this program. To get more information, send email to the address listed on this slide with the word "help" (no quotes) in the body of the message. You will receive instructions for getting info by email on AM3 and several other active ARPA soliciations.



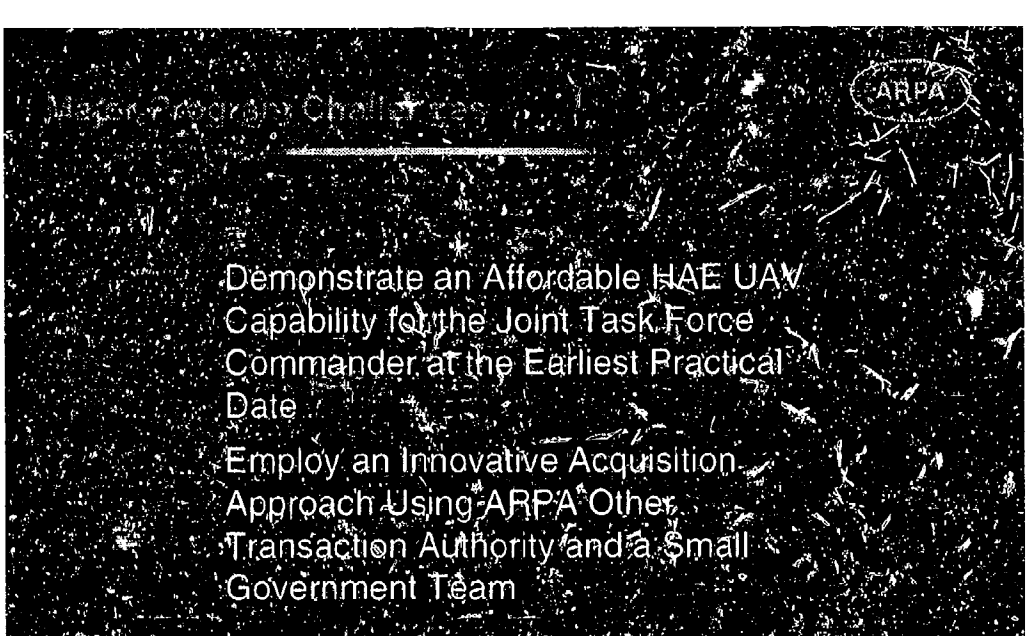
This briefing will cover the acquisition and business practices of the Tier II Plus High Alltitude Endurance Unmanned Aerial Vehicle Program. The High Altitude Endurance (HAE) Unmanned Aerial Vehicle (UAV) program is a Defense Airborne Reconnaissance Office (DARO) initiative to achieve significant military reconnaissance capbility for a fixed, pre determined, unit flyaway price (UFP) of $10M (in FY 94$).



The briefing outline is as shown. I will give a system overview to show what we are trying to do and then cover the program and acquisition strategy.



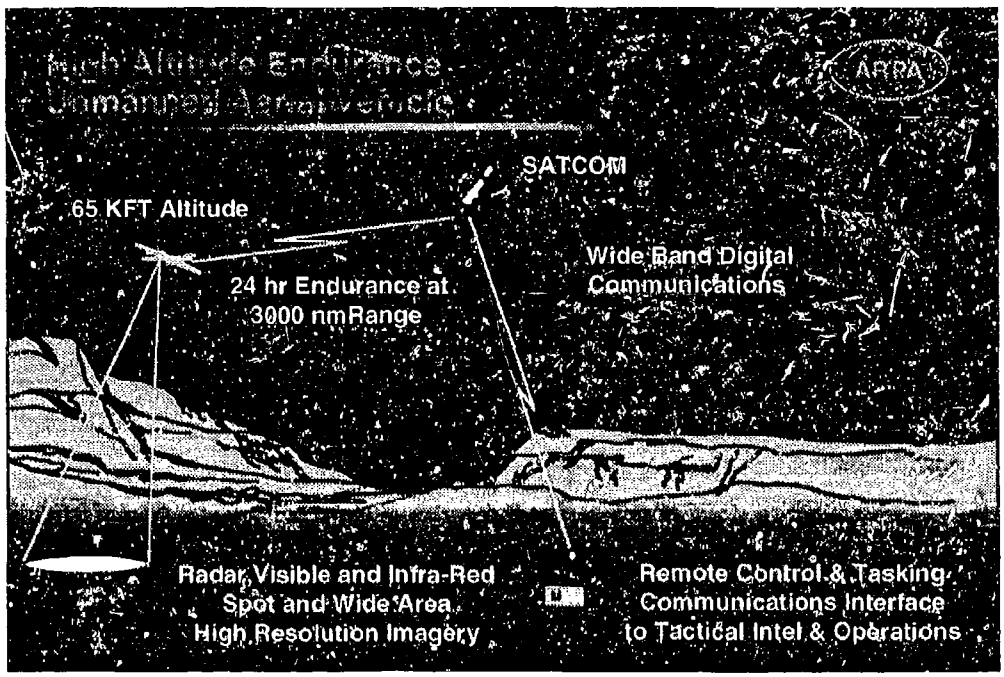
The HAE UAV system will provide rapid response, world wide reconnaissance coverage that is under the direct control and tasking of the Joint Forces Commander. The HAE UAV system will be capable of sustained, high altitude surveillance and reconnaissance under all weather conditions at up to a 3,000 nm radius of action. The system will provide near real-time all weather, day/night high resolution imagery to operational commanders. The radar and EO/IR data will be transmitted to current and planned image exploitation and dissemination equipment (i.e., JSIPS, CARS, Enhanced Tactical Radar Correlator (ETRAC), etc.) which will enhance battlefield situational awareness and provide near real-time intelligence and targeting information. These capabilities will provide JTF Commanders with accurate targeting, timely data on enemy terrain, infrastructure, force concentrations, enemy offensive and defensive positions, deception postures and combat assessment necessary for planning theater campaigns and major operations. At a cost of $10 Million unit flyaway price, which includes air vehicle and sensors, this represents an economical, unmanned reconnaissance asset which can stand the risk of being sent into enemy airspace.



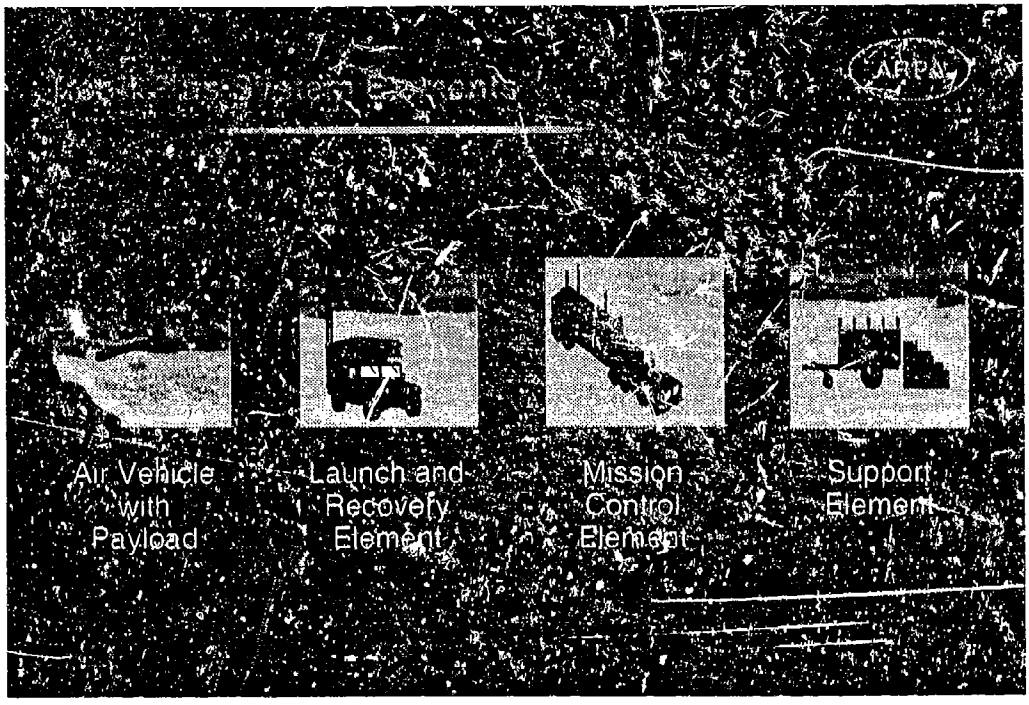
We have two primary objective: To demonstrate an affordable reconnaissance capability for the Joint Force Commander (JFC) that will provide the JFC with timely high quality imagery intelligence products in exploitable form.

In addition, the HAE UAV business strategy represents a radical departure from the standard approach to acquisition. Using ARPA's recently granted "Other Agreement Authority", the HAE-UAV Program is streamlining development by maximizing the use of commerical practices and strandards, integrated government and contractor development terams as well as off-the-shelf components and having a firm design to cost requirement..

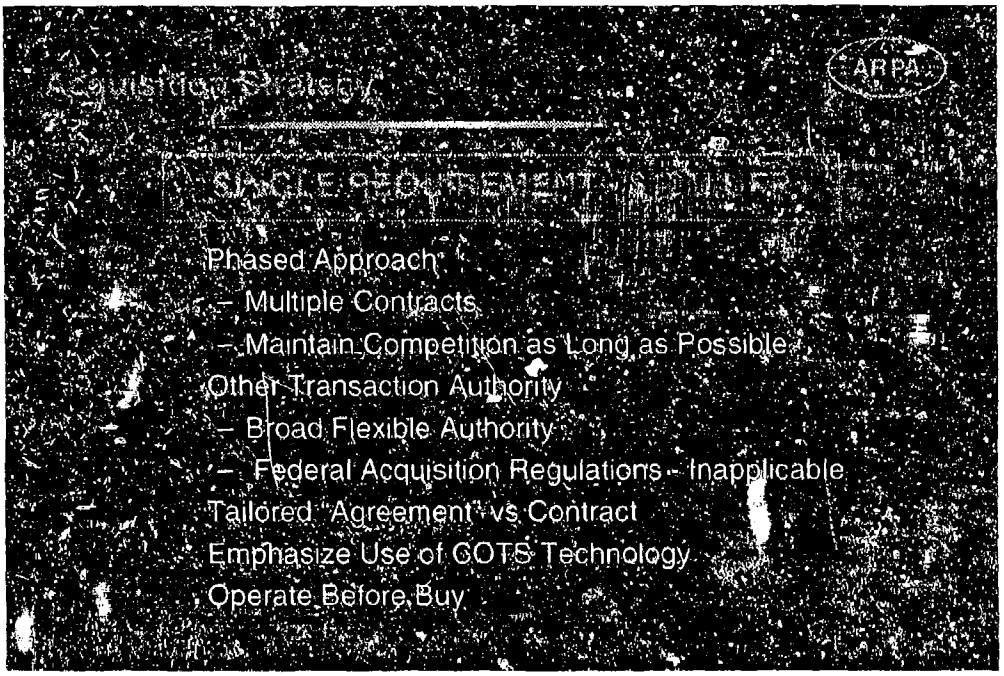
A primary management approach of the HAE-UAV ACTD MP is to introduce a paradigm shift in the advanced development process and to avoid excessive rigidity and formality in the process. The HAE UAV ACTD management approach is structured to: Foster an Environment of Teamwork and Trust Between Industry, the Program Office, and the Warfighter; Emphasize New and Innovative Ways of Doing Business; Focus on What We Want - Not How to Do It.; Use Commercial Business Practices; Maximize Use of Commercial Technology and Industrial Base; Make the User the Part of the Team from the Outset; Involve the User in Up Front Design and Development through Simulation and Analysis and Adopt Integrated Product Development.



The objective of the program is to develop a high altitude (65,000 ft) unmanned aerial vehicle capable of 24 hr endurance at long range (3000 nm). The primary reason for the high altitude is survivability but this also allows flight above most manned aircraft and weather and gives better sensor coverage range. The combination of long endurance, long range and reliable operation allows a fleet size of 4 vehicles to provide continuous coverage of a crises area from a reasonable number of world-wide bases. The UAV is an automatic reconnaissance platform whose initial payload is high resolution radar and electro-optical (visible and infra-red) imagery sensors which are processed and communicated in real time via satcom wideband communications to a ground station. The ground station plans and controls the vehicle and sensors, interfaces with theater military operational forces for tasking instructions, formats the imagery and disseminates it in real time to imagery analysis and exploitation systems. Through the ground station, the theater commander has direct control of the system and first look at the product.



Each HAE UAV system will be comprised of an Airborne Element (air vehicles with sensors, avionics, Line of Sight (LOS) and Satellite Communications (SATCOM) data links, and data storage), a ground system consisting of a Launch and Recovery Element (LRE) and a Mission Control Element (MCE), and a Support Element. The LRE will be designed to prepare, launch and recover the air vehicles while the MCE will be designed to mission plan, dynamically retask the air vehicles, and process, store and/or disseminate data as tasked. Processing and exploitation is to be accomplished by existing and planned DoD systems/installations such as the Joint Service Imagery Processing System (JSIPS), Contingency Airborne Reconnaissance System (CARS), Modern Intelligence Exploitation System (MIES), Joint Intelligence Centers (JICs), and Naval Processing Intelligence Centers (NPICs).



The Tier II + program is truly different in that we have only one requirement and that is a $10M Unit Flyaway Price. The focus of the entire program is to get as much reconnaissance capability as we can for a $10M air vehicle UFP.

In doing this, we have taken a phased approach to the entire acquisition. In phase 1 of the program, three to five contractors will perform studies and analysis to refine designs which we will take into engineering development and flight test in Phase II. At the completion of Phase II a single contractor will build a number of prototype demonstration vehicles and 2 ground systems and conduct a two year operational demonstration. After that a final production decision would be made.

We are attempting to maintain competition for as long as possible. The contractors from Phase I will be paired down to two contractors for Phase II. This gives us a look at the system in operation in a competitive environment well before a production decision is made.

Broad contracting authority has been granted to ARPA by the Congress to modify our business practices with what is termed "other transactions authority" under Section 845 of the 1993 Defense Authorization Act. This authority permits us to deviate from the Federal Acquisition Regulations, create new and innovative ways of doing business and make our programs more attractive to commercial suppliers. Consequently, we have structured an agreement with the industry instead of a classical DoD contract.

This authority has also allowed us to place a strong emphasis on the use of commercial off the shelf technology (COTS) and equipment. We are trying to encourage industry at every turn in the program to use commercial practices and bring commercial equipment into the DoD sector. We will look at this commercial equipment and the total system for several years of demonstration in the environment in which it will have to operate. This concept is what we term operate before buy.



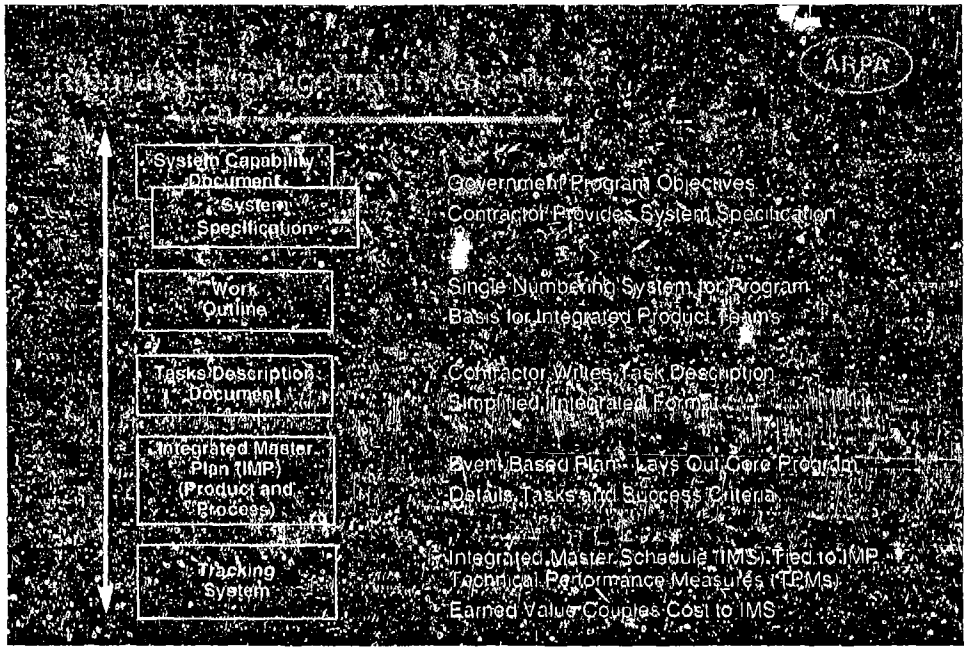
It may sound repetitious but I really want to emphasize this first point again, this program is dedicated to getting the most military utility that it can for $10M UFP. In doing this we are utilizing new simulation and modeling techniques which will guide the program. These new simulations are developed for the ARPA War Breaker program and will permit us and our users to better understand the systems that we have in development. I mention our users because they are a very active and integral part of the development of the Tier II+ system. Presently, the user are concentrating on prioritizing their requirements and developing our concepts of operation.

We put all of our objectives in a new form of RFP which we simply entitled a solicitation. This solicitation was very small and the proposal that accompanied it was extremely page limited. I'll discuss these in greater detail in just a minute. The point I'd like to make now is that we have focused the solicitation on the products of the program and so did the contractors with their proposals. We also concentrated our source selection on the agreement with which we will run the program.

We eliminated the classical CDRL and substituted in its place a tracking system which covers cost, schedule, and performance and interactively delivers data to the government and the contractor. Our objective here is to use the same data in the same format that our contractors are using. We are trying to develop insight into the efforts of our contractor associates rather than performing a classical oversight role.

We have also inserted into the agreement an irrevocable offer to buy the first 10 production air vehicles at the $10M UFP. This offer will take affect at the end of Phase II.

The key implementing feature or our acquisition strategy is the Integrated Management Framework which we have employed throughout all of our documentation. This framework allows us to link our technical objectives to our cost performance and organize the program around its products.

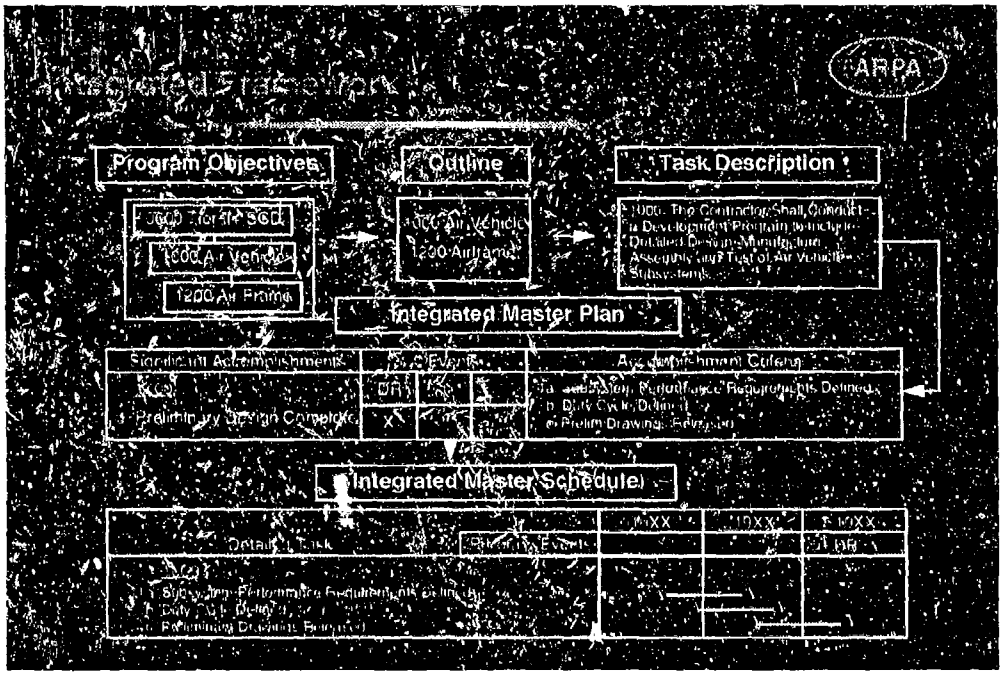


The System Capabilities Document (SCD) shows all of our contractors what the objectives of the government are. These are broken out and stratified across the products of the program such as the air vehicle, ground segment, etc. These are performance / functional objectives. We are not telling our contractors how to do things, we're telling them how we want our products to perform. Each one of the offerors responded to us with a preliminary system specification which shows how their system meets our program goals. Throughout the program we will refine this preliminary system specification until we select a single contractor and adopt their system specification as our own.

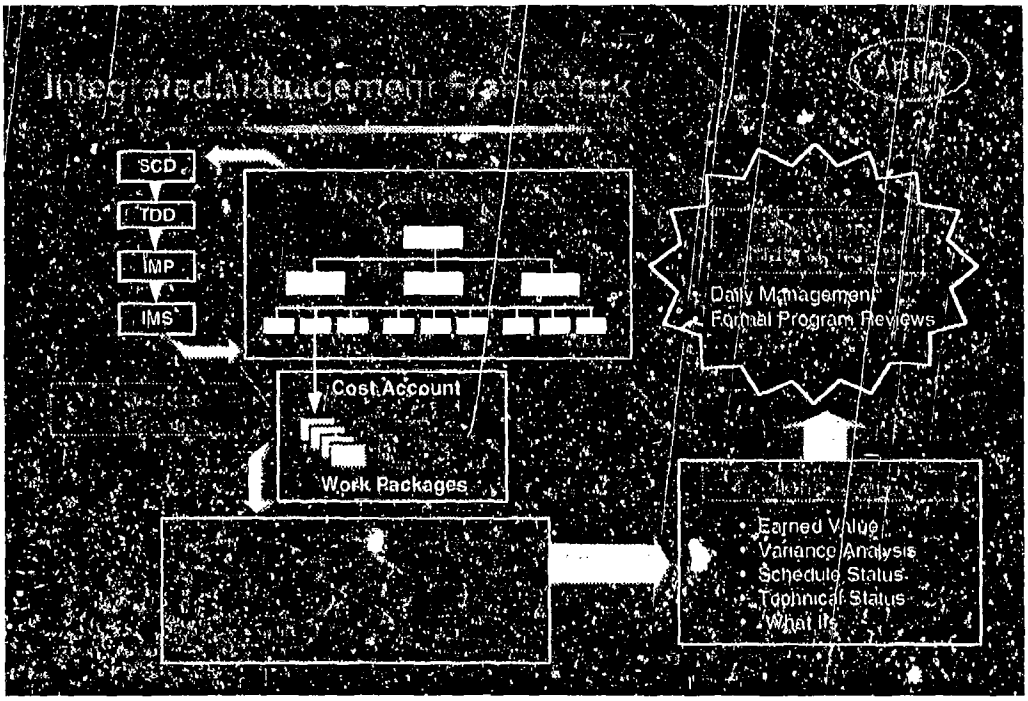
We also provided the contractors with our view of how the program should be organized. We did this through a work outline and asked them to put a single numbering system with it. This single numbering system (which traditionally is called a Work Breakdown Structure) simplifies tracking and lets us see the relationship of every element of the program. We will also organize around the products highlighted in the work outline. The Task Description Document (TDD) which is very similar to a statement of work, permits, for the first time, the contractors to tell the government what they are going to do to meet the goals contained with in the SCD. This is a greatly simplified level two document which alleviates many of the burdens classically found in a formal SOW.

The corner stone of our entire program is our Integrated Master Plan (IMP). This single integrated plan uses the numbering system from the work outline and is focused on the goals of the SCD. It is prepared by the contractors and lays out the process that will be used to produce the products of the program. Consequently the IMP is divided into product and process sections. The product plan is a simple event based plan designed to show us the critical path or core program. This product plan lays out the events, all of the tasks that must be done to reach that event and the criteria by which we will judge successful accomplishment of that task by the event. The process plan represents a fundamental and binding agreement on what processes will be used and how they will be applied to the program. The IMP is an attachment to the agreement and as such an integral part of it.

The last feature of our Integrated Management Framework has permitted us to eliminate the classical CDRL in our tracking system. Utilizing contractor formats we have called for a single Integrated Master Schedule (IMS) which is tied directly to the Integrated Master Plan. The Integrated Master Schedule assigns time to the tasks and criteria of the IMP and provides lower level program details. Tied to the schedule is a very robust set of Technical Performance Measures (TPM) which will show us how we stand in relation of the accomplishment of our performance goals. Also tied to the schedule will be an earned value system which will be developed during Phase I and will tie the cost to our schedule and our performance objectives.

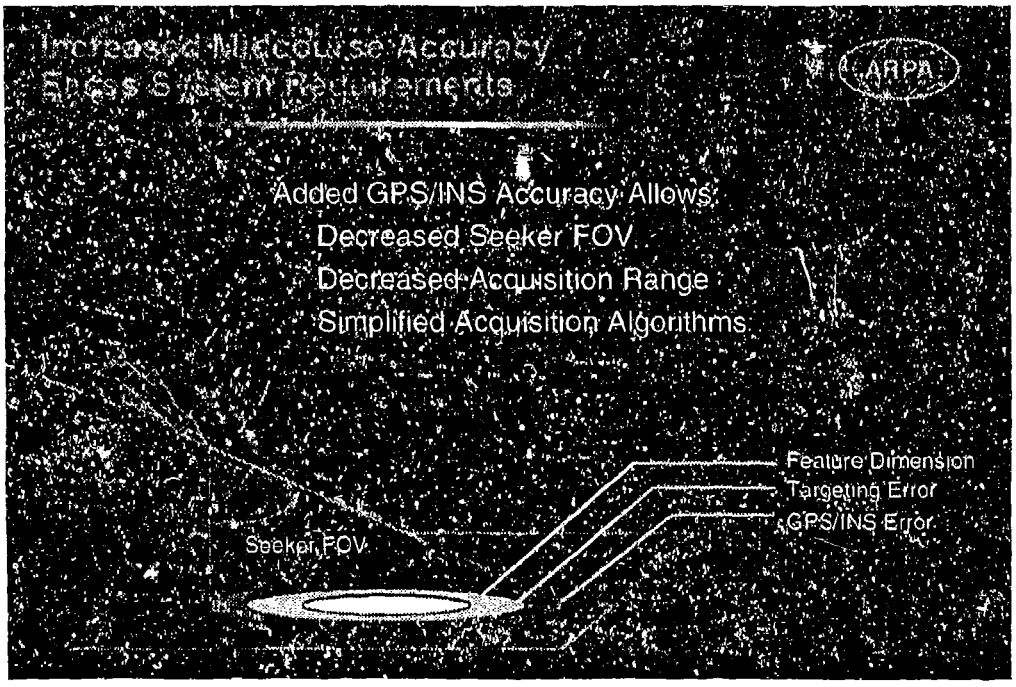


This slide illustrates the Integrated Management Framework that I've been discussing. As you can see our program objectives are specified in our SCD and utilize the same numbering system that we developed for our work outline. This allows the contractor to provide us with general tasking and then more detail in the IMP. All of this is then integrated into our master schedule and once time based permits us to develop an earned value management system, a technical performance management system, and other tools to track the program.



Integrated Management Framework

This chart illustrates the working relationships of the Integrated Management Framework. We have structured and related all of our documentation through the use of the single numbering system and a single work outline. Once we have time based this system we can look at our cost accounts and devise work packages, assign our budget and develop an earned value management system. All of this data will be contained within a common data base which both the government and the contractor will have access to. Together we will then perform our analysis of the program and develop a common understanding.



I previously explained the concept behind Common Grid. The question is, have we any quantification of the benefit?

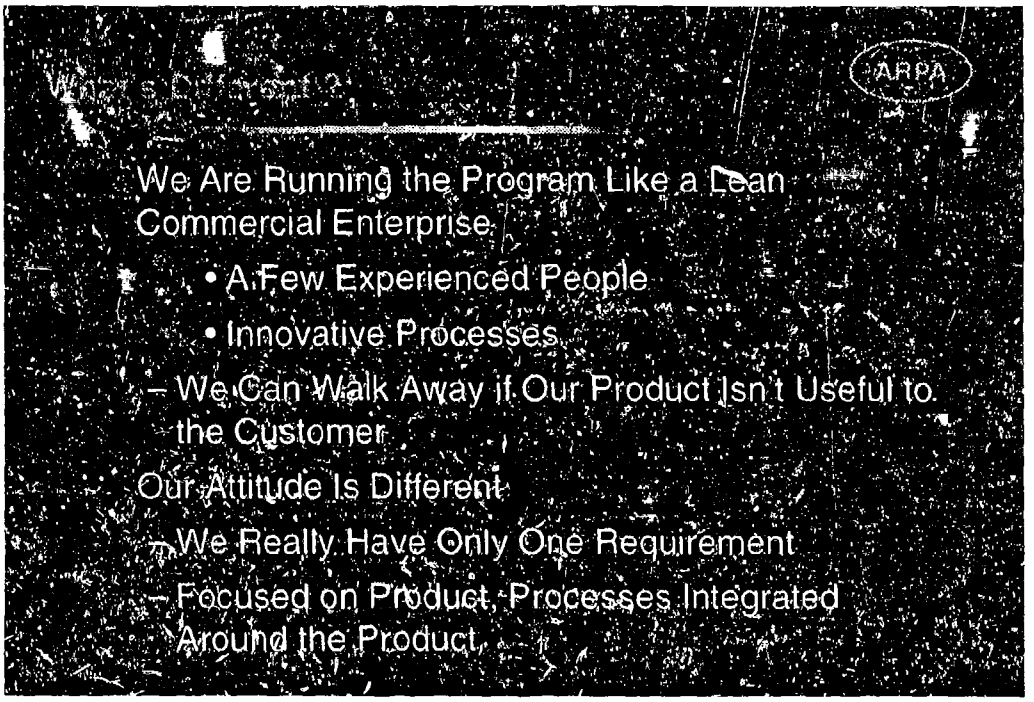
First, better target geolocation enabled by added GPS/INS accuracy allows less complex seeker and processing capabilities on a weapon. Examples:

–Decreased field of view

–Decreased range

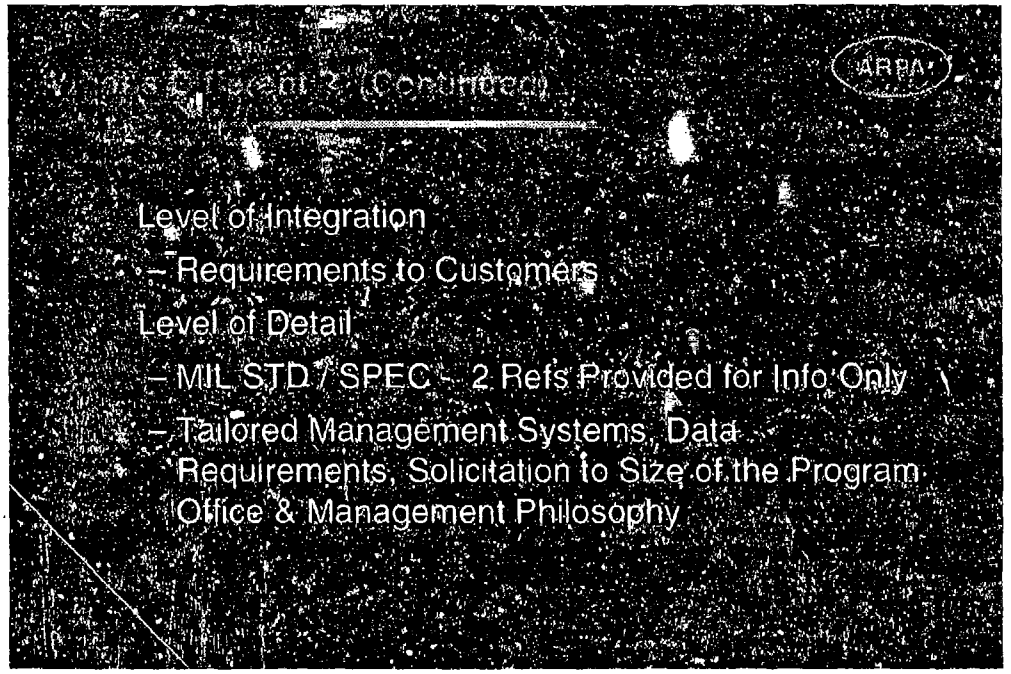
–Simplified signal processing algorithms

The benefits of reduced circular-error-probable numbers are shown on the next chart.

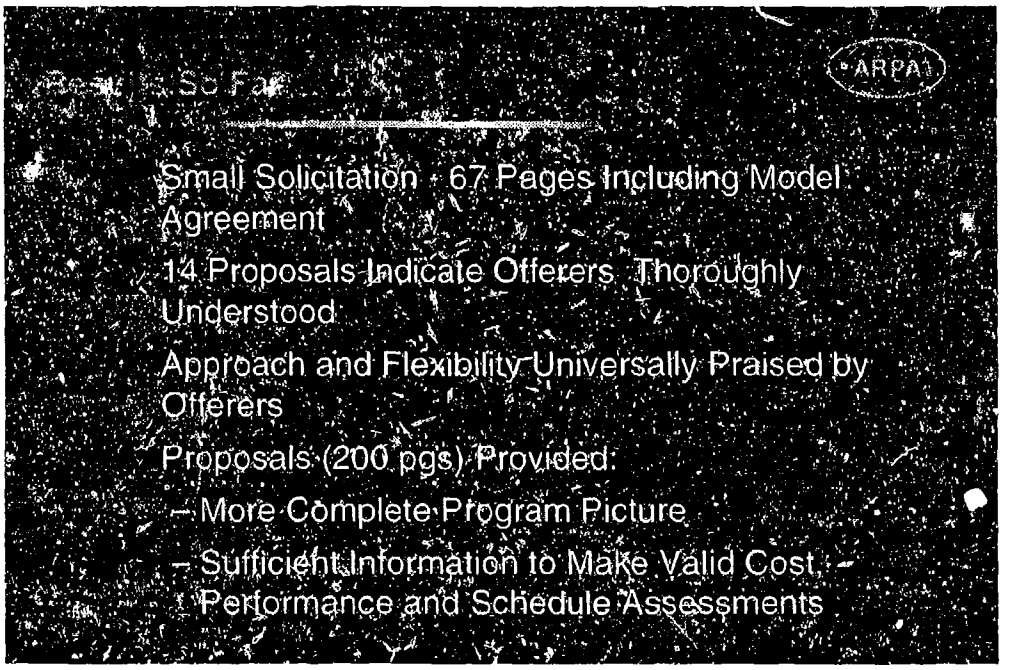


We are truly attempting to run this program in an entirely different paradigm. We want the Tier II+ to be like a lean commercial enterprise. This applies to our process and to our people. The government program office will be deliberately kept to a small and very experienced group of people who are capable of utilizing commercial products and translating them into the needs of other government agencies. We are truly encouraging innovation in all of our processes. There is virtually nothing "standard" about the Tier II+ program.

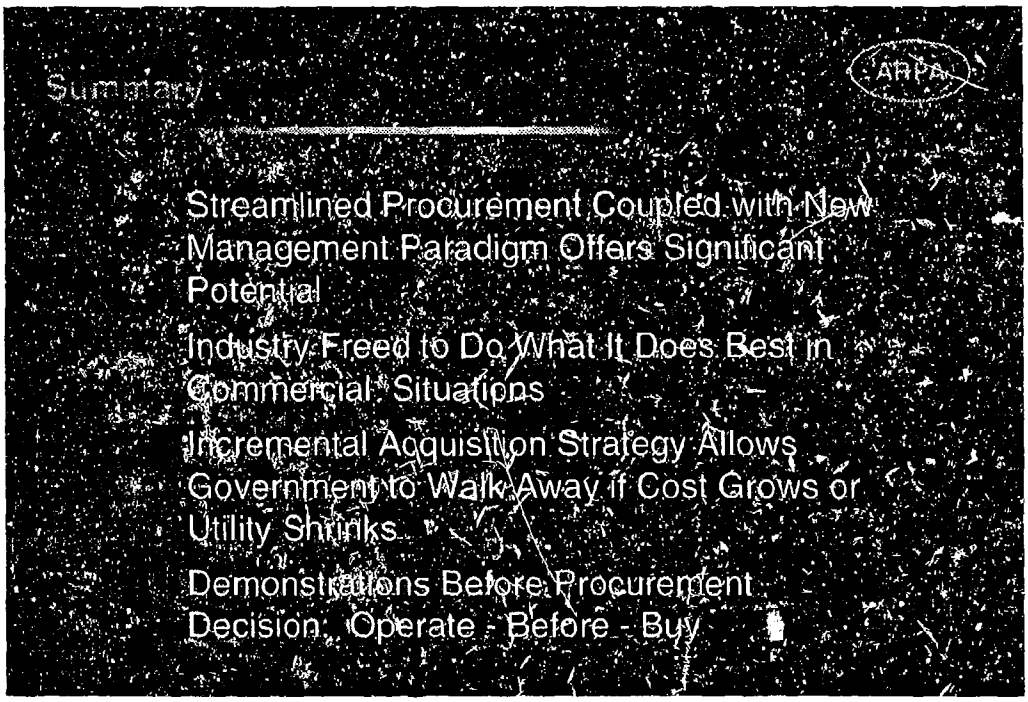
I think that you can see the attitude that we are pursuing in this program is truly different. We have but one requirement-$10M UFP. We have focused our program on our products and integrated our organization and documentation and in fact everything we do around these products. This has allowed us, through the Integrated Management Framework, to achieve a level of integration that is truly unprecedented. We can trace each one of our program goals directly to the people that work on the program. This fosters empowerment and a great deal of organizational loyalty and discipline.



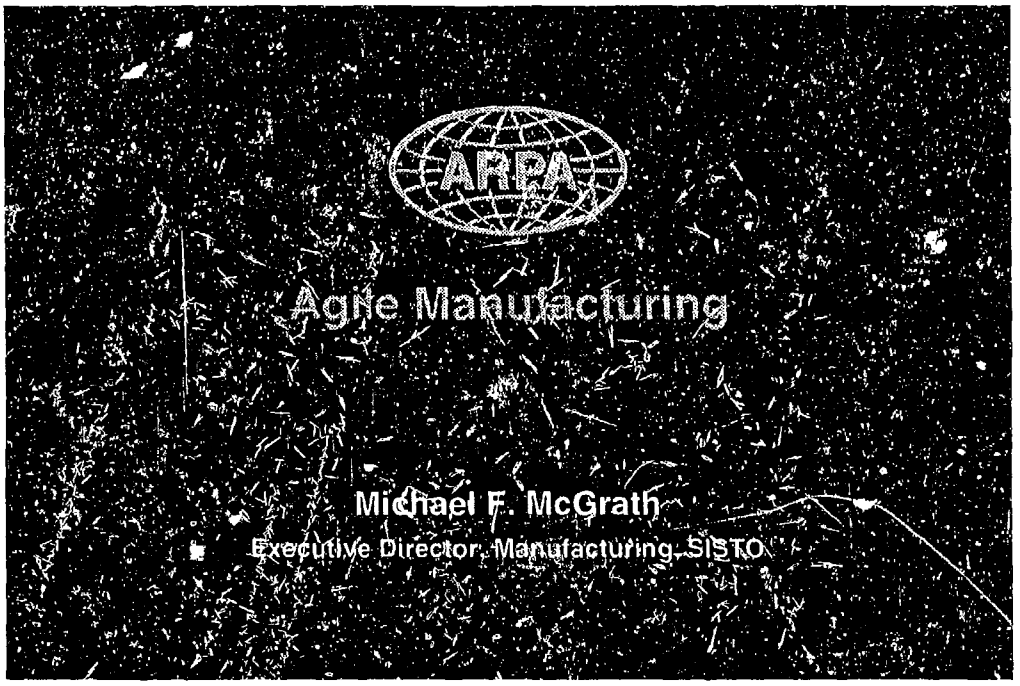
When you have a program that is as highly integrated as ours you can give industry more freedom. Consequently the level of detail at which we will operate will be much higher than in classical programs. For example, we have only provided 2 Mil Specs in the entire solicitation and these were done for reference only. We have tailored all of our management systems and data requirements to the Integrated Product Development philosophy and the lean small office that we wanted to maintain.

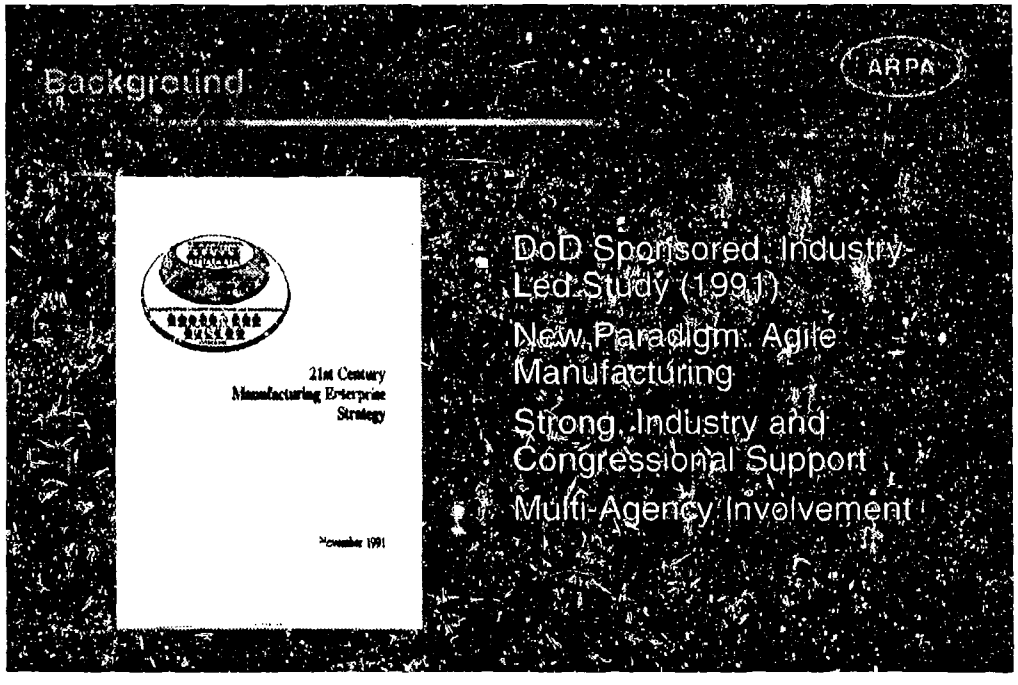


This is want we have accomplished so far. We have issued what we believe as the smallest RFP to come out of a DoD agency since the close of World War II. The solicitation is 67 pages long and includes our model agreement. In response to that, we received 14 excellent proposals. Discussions on our draft solicitation all indicated that our offerers understood what we wanted and were encouraged by our approach. The proposals were limited to 200 pages and the government evaluators universally responded that the IMP and the Integrated Management Framework provided a better integrated and more complete picture of the entire program than they have been able to achieve in previous source selections.

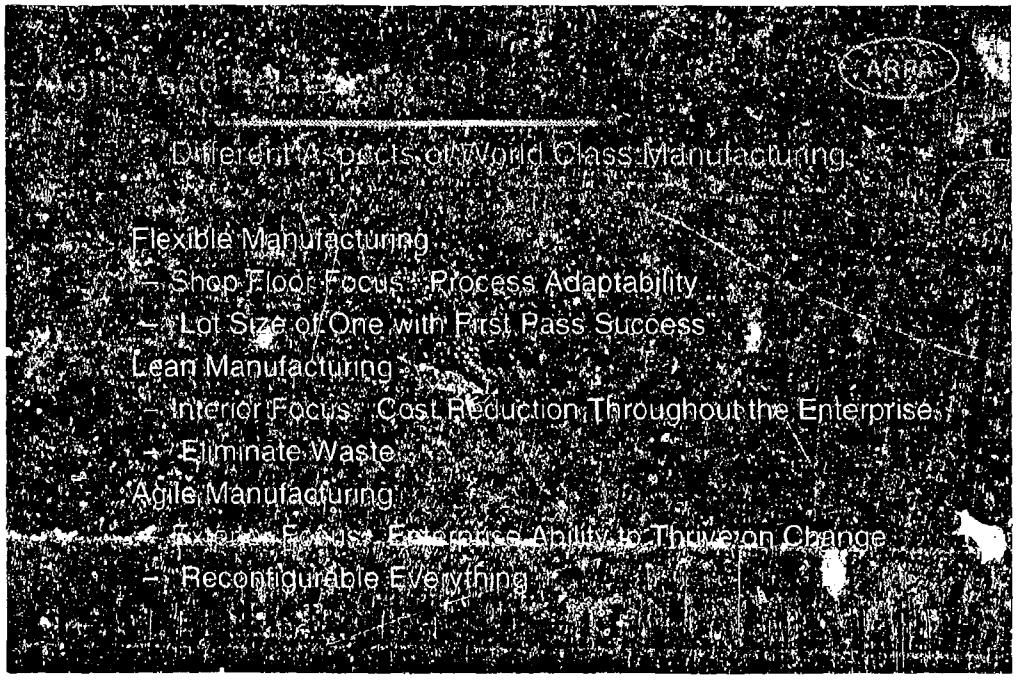


In summary, we believe that through our "Other Transaction" Authority and our Integrated Product Development implementation that we are pursuing a new acquisition management paradigm which holds great potential for the Department. We are truly freeing industry to provide us their good ideas in a commercial environment. Our incremental acquisition strategy allows us to carefully examine our requirements and to cancel the program if it either begins to cost too much or shows marginal utility to our users. Our operate before buy philosophy allows us to truly examine this system before we make any final production decisions.


ARPA
Agile Manufacturing
Michael F. McGrath
Executive Director, Manufacturing, SISTO

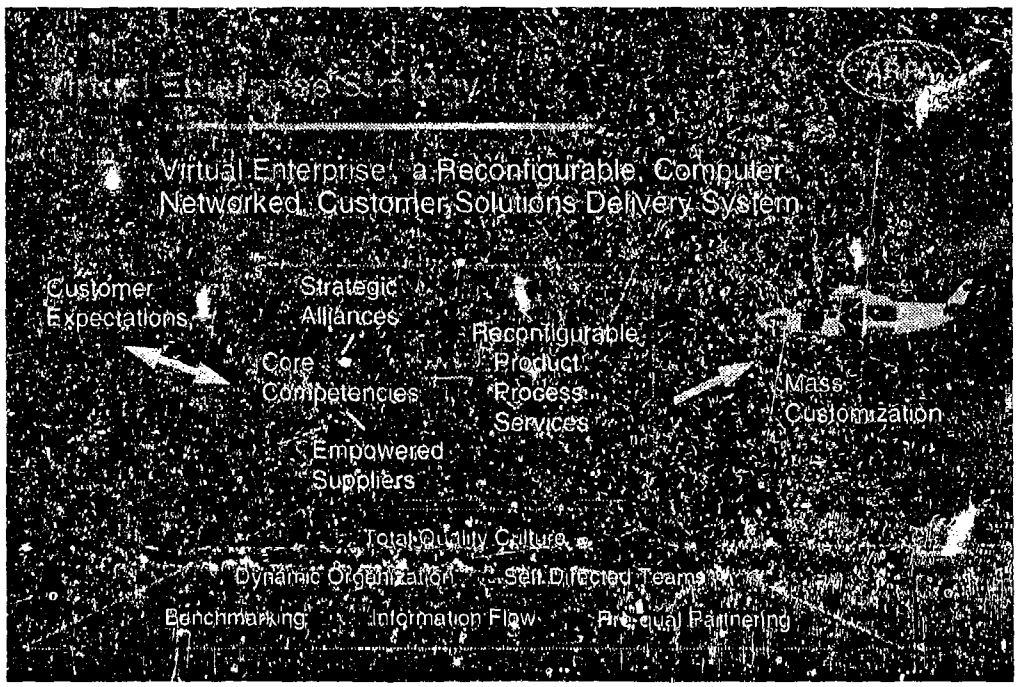


In 1991, the DoD ManTech program sponsored an industry-led study to develop a vision for 21st Century Manufacturing. The group forecasted an environment where competitive advantage is won by manufacturing enterprises that are able to thrive in an environment of continuous, unanticipated change. The group coined the term "Agile Manufacturing" to describe this new paradigm. The study report was widely circulated . gained strong support in industry and in the Congress, and became the basis for ARPA's Agile Manufacturing program and related efforts in National Science Foundation, Department of Energy and other agencies.

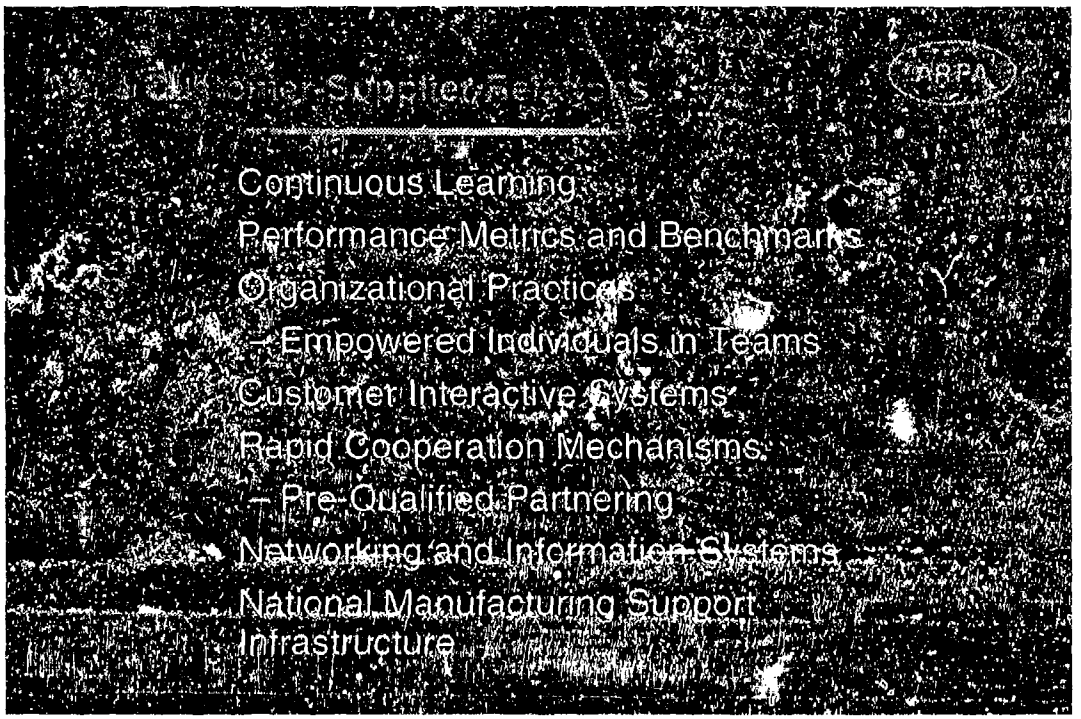


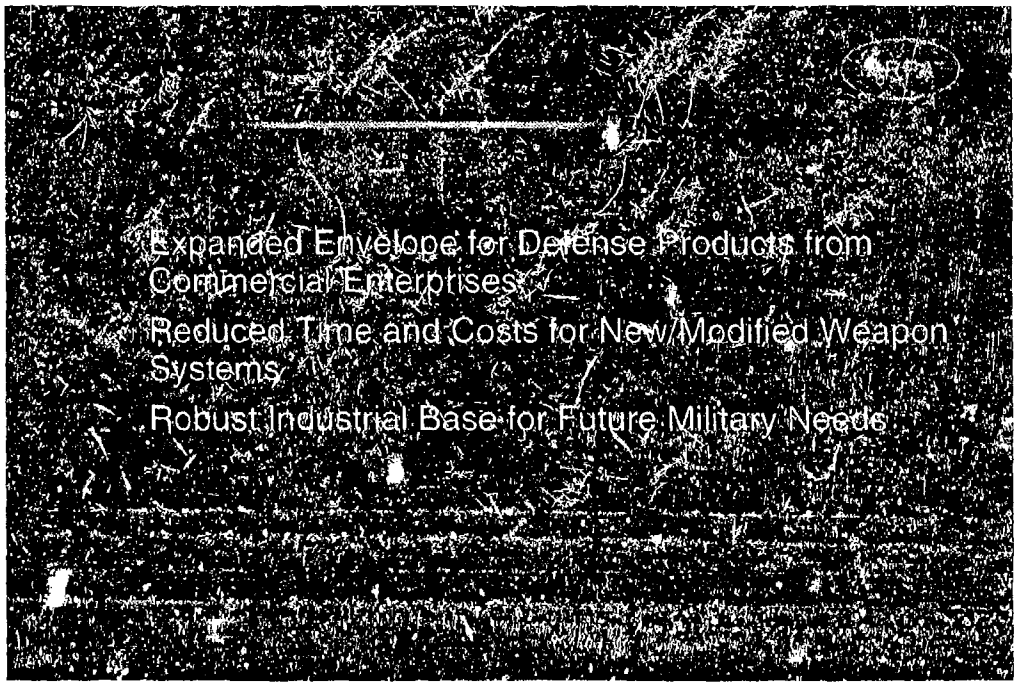
The concept of "agility" tends to be confused with "flexible manufacturing" or "lean manufacturing". Rather than drawing sharp semantic distinctions, it is most useful to consider all three terms to be descriptive of world class manufacturing enterprises. The aspects emphasized by "lean", as defined in the MIT study of the automotive industry*, are primarily connected with eliminating waste and reducing costs. Some of the same enterprise characteristics affect not only cost, but also adaptability to change as emphasized by "agility". Hence there is considerable common ground between lean and agile paradigms.

*The Machine that Changed the World (Womack, Jones and Roos, 1990)

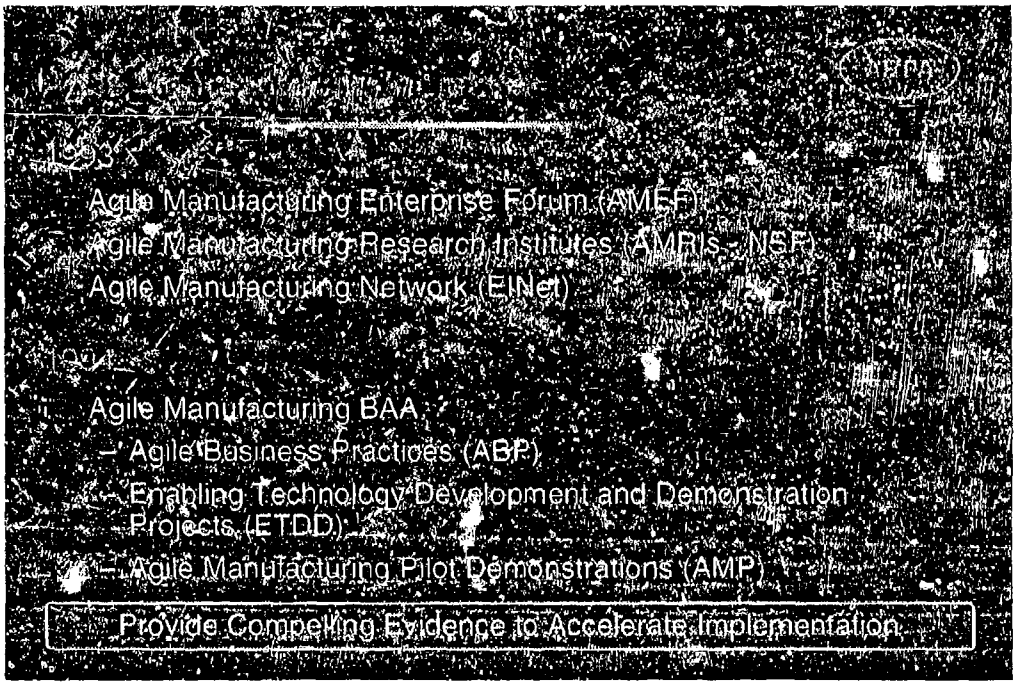


A key concept in the vision of agile manufacturing is the "virtual enterprise". This is a business enterprise whose operating units are chosen to fit a particular market opportunity, linked by computer networks and capable of functioning as an integrated whole to respond rapidly to meet customer needs.


Customer-Supplier Relations
DARPA
Continuous Learning
Performance Metrics and Benchmarks
Organizational Practices
– Empowered Individuals in Teams
Customer Interactive Systems
Rapid Cooperation Mechanisms
– Pre-Qualified Partnering
Networking and Information Systems
National Manufacturing Support Infrastructure



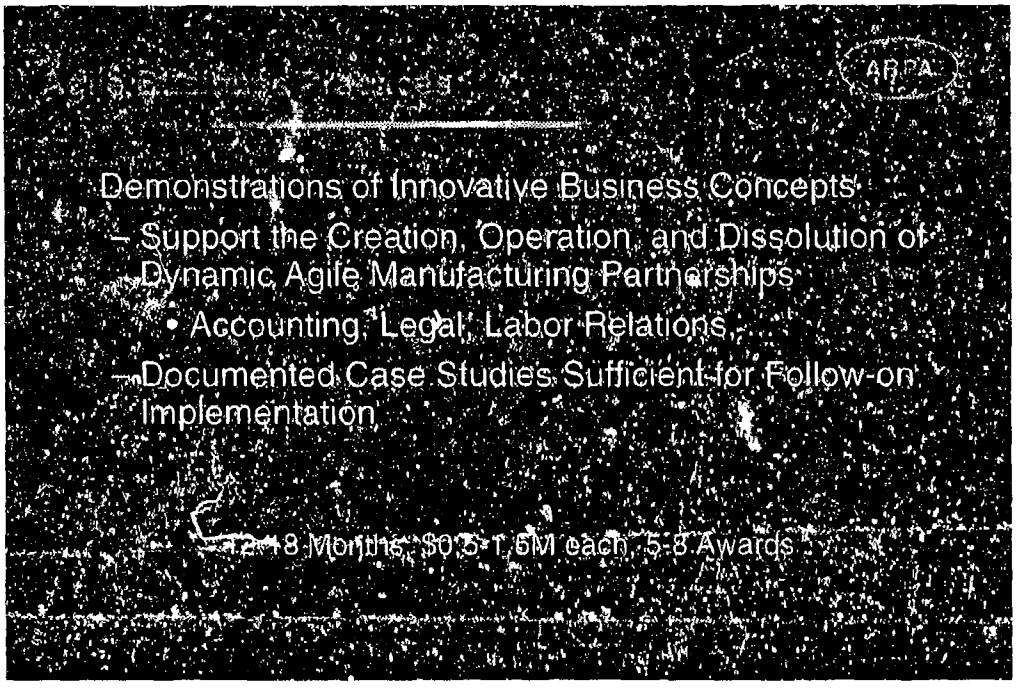
DoD will benefit as Agile Manufacturing concepts are implemented in both government and industry. Agile firms in the industrial base will be able to respond to market demands for both defense and commercial items. As a result, weapon system components will become more affordable, will be available in a shorter period of time and will have "world class" quality . The ability to thrive on unanticipated change is an important characteristic for the future robust industrial base that can meet military contingencies.



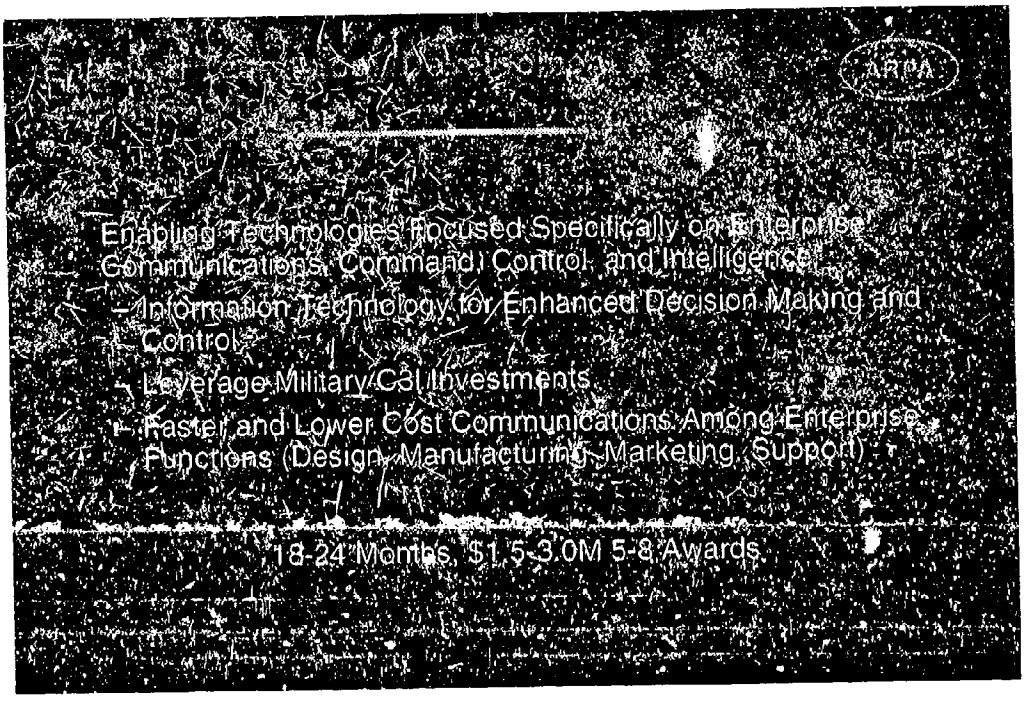
The Agile Manufacturing program was launched as a joint NSF and ARPA initiative in 1993. The initial elements of the program included (1) an industry forum (the AMEF) to continue development of agile manufacturing concepts, best practices and benchmarks, (2) university/industry research institutes in key industrial sectors (electronics, aerospace, and machine tools), and (3) an enterprise integration network to prototype agile manufacturing applications on the information highway.

In 1994, the program was expanded to include demonstrations and pilot programs in the three areas shown on this chart.

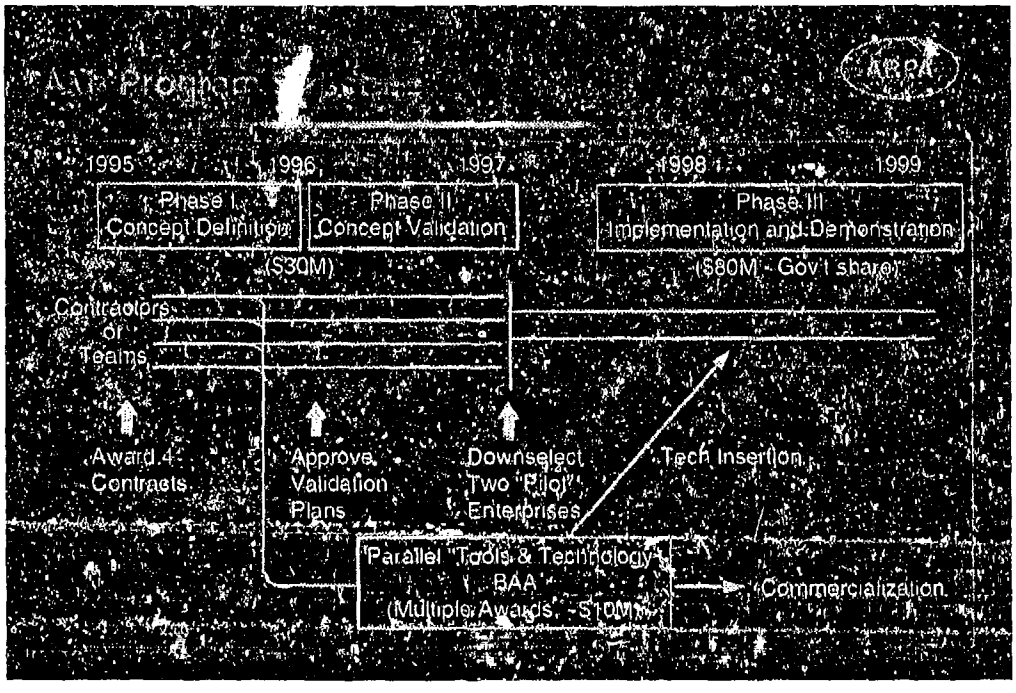
Each of these components of the Agile Manufacturing program is described in the next few charts.



This defines the goals and objectives of agile business practices, one of the areas for which proposals were requested in the Agile Manufacturing BAA 94-31.



The second technical area in the Agile Manufacturing BAA is Enabling Technology. ARPA focused specifically on applying in the business environment technology of the sort used for battlefield C3I.



The program structure for AM3 starts with a 1995 concept definition phase. Four awards are anticipated to companies or teams of companies. Awards will be based on innovative proposals for reducing the cost of a target mix of missiles that constitutes an important subset of the total DoD portfolio. This phase will result in studies that refine the concepts proposed for reducing costs, design the enterprise processes and systems to support the new concepts, and design validation experiments for Phase 2. The concept definition phase will also identify gaps in tools and technology that become the candidates for a parallel solicitation in 1996.

Phase 2, Concept Validation, will demonstrate the AM3 concepts in design exercises, manufacturing of components, simulations and business process experiments. Empirical data from these validation exercises will be used to support estimates of the effect on the cost of the target missile mix, and will be the basis for down selecting to two pilot multi-missile manufacturing enterprises.

Phase 3 will implement the new concepts, systems and technology within two "pilot enterprises", each comprised of the prime contractor and suppliers involved in the target missile mix. This phase will be cost shared. The pilot enterprises will implement the new concepts in actual missile development/ product improvement and production. Innovative acquisition approaches will be implemented using ARPA's "Other Agreement" authority as required.



Ironically, the oldest large manufacturing industry in the united states is in jeopardy.

With the cold war over and the resulting military downsizing, navy ship construction is not enough to sustain the shipbuilding segment of the defense industrial base. This means that the shipbuilding industry must be maintained through a combination of military and commercial construction.

The difficulty with this strategy is that the united states has been out of the international commercial market for a generation—and has no market share in international commercial shipbuilding.

Further, because u.S. Shipyards have been focused on the navy and protected domestic markets, u.S. Yards are out of touch with potential international customers and their international competition.

The U.S. shipbuilding industry must relearn how to build and sell commercial ships—competitively—in the international market.

This situation has been viewed with some alarm by the shipbuilding industry, as well as president clinton and members of the congress—and last year, they determined that action on a national scale was required.

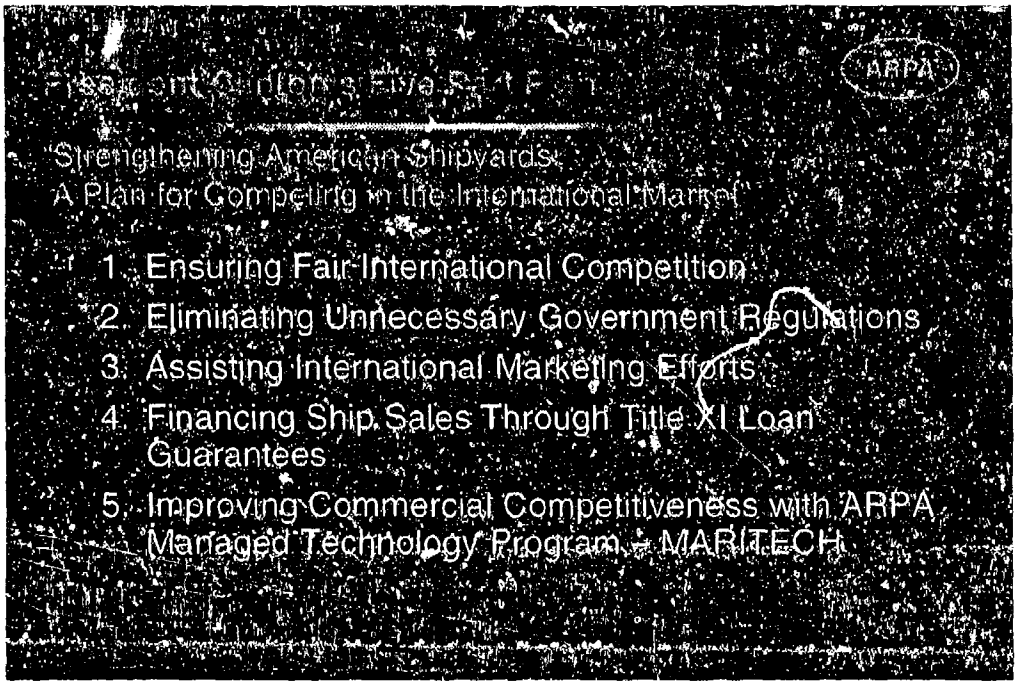
Shipbuilding is a key element of the defense industrial base . . . Its success benefits the economy as well as national security.

Without a strong shipbuilding industry, the industrial base is jeopardized, as is our status as a maritime nation.

Fortunately, there are projections for an international market that U.S. shipbuilders can participate in—if they can become more competitive.

On October 1, 1993, the President submitted a plan to Congress, entitled "Strengthening America's Shipyards: a Plan for Competing in the International Market."

His plan consists of five parts:



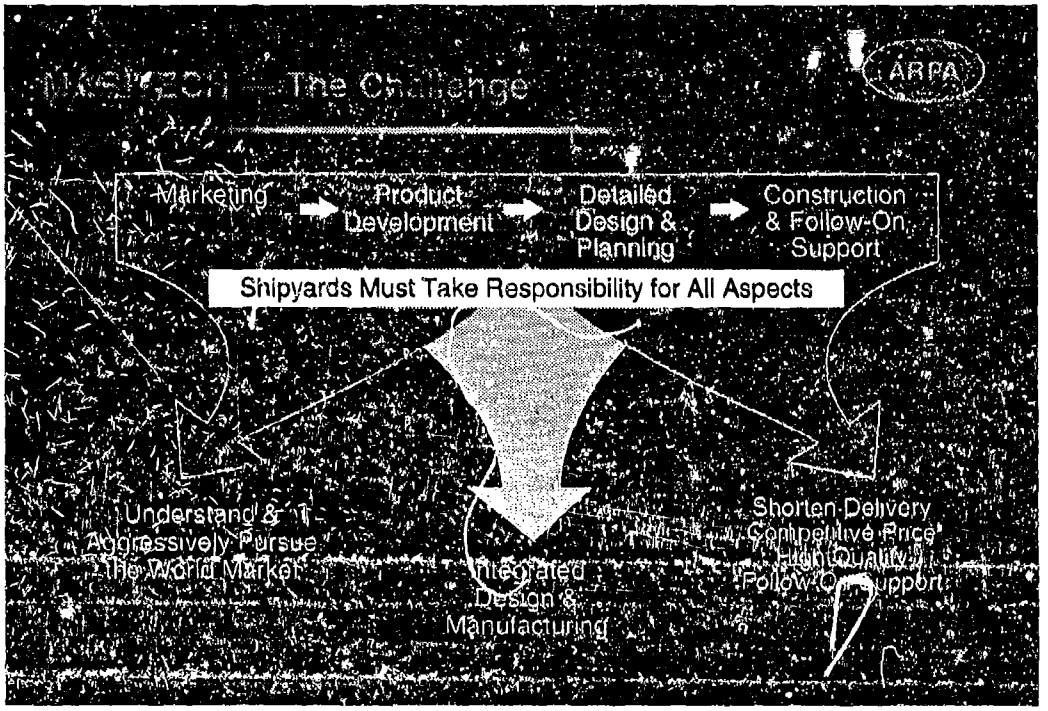
The first is ensuring fair international competition—in this regard, the u.S. Government has participated in the oecd negotiations to level the international playing field by eliminating foreign subsidies. These talks were completed in paris this summer. The agreement will most likely be ratified this fall.

The second is eliminating unnecessary regulations—all u.S. Government agencies are reviewing regulations that impose unnecessary burdens on the u.S. Shipbuilding industry. Major activities include acquisition reform within the department of defense, adoption of international construction standards by the u.S. Coast guard, and updating the regulations of the occupational safety and health administration.

Tthe third is assisting international marketing efforts—-the departments of commerce, transportation, and state have all begun coordination of activities among their departments to promote the sale of u.S.-Built ships around the world.

The fourth part is financing ship sales through government-backed loan guarantees—the maritime administration has recently published regulations permitting government backed loan guarantees for shipyard modernization and, very significantly, for export sales of ships. This is very important as shipyards try to transition to focus on commercial customers. Because U.S. shipyards have not been in commercial ship construction, they do not have a proven track record, and banks have been most reluctant to finance their construction efforts. The government backing with title xi loan guarantees will make it easier for the yards to attract financing. I want to clarify that these funds are not grants, but represent u.S. Government guarantees of commercial bank loans.

Lastly—the fifth piece of the president's plan and the program i will now speak about—is maritech—-a $220 million, 5–year technology development program for improving u.S. Shipbuilding commercial competitiveness. We hope that, by applying advanced technologies and processes, maritech will help develop and improve the nation's commercial shipbuilding and repair capabilities and thereby help maintain and improve military ship repair and construction capabilities. If successful, we will have helped to create a self-sustained commercial shipbuilding infrastructure which will be available for defense mobilization contingencies and capable of building military ships more efficiently and cost effectively.



With the Navy as their primary customer over the past 15 years, U.S. shipyards were typically only involved in the detailed design and construction aspects of shipbuilding. They had little or no involvement in the development of the ship in the early design stages. The U.S. Navy was in charge of defining ship requirements, and the emphasis was on ship performance, not ship producibility and cost effective production.

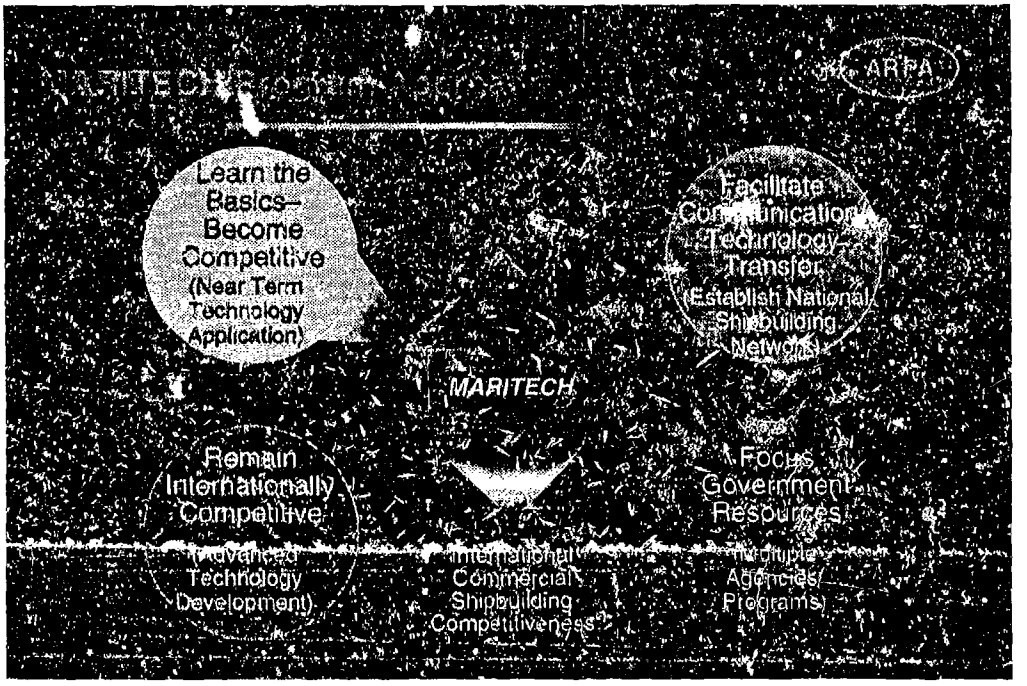
To be competitive in a commercial market, american shipyards must accept responsibility for all aspects of the shipbuilding process: marketing—product development—detailed design and planning—and construction and follow-on support. The development and integration of ship and shipbuilding technologies planned in this program will address the entire shipbuilding process—and will assist shipyards to make the required fundamental changes in each process step.

Maritech technology development will occur in two integrated phases. The initial phase will be to master the basics of commercial shipbuilding by developing competitive products and processes to enter the international market in the near term. The second phase is to provide a national infrastructure dedicated to continuous shipbuilding product and process improvement over the long term.

While U.S. shipyards have been out of the commercial shipbuilding business, their foreign competition has not stood still. Foreign yards around the world have built thousands of commercial ships in the last dozen years—and they have continued to develop and evolve hundreds of state-of-the-art designs for many classes of ships, specified for many different markets.

Coincident with their product development, foreign yards have continued to improve and perfect their marketing, design, and production processes. The U.S. shipbuilding industry is not able to match this effort today. The administration's 5-part plan calls for 220 million dollars over five years for maritech to accelerate technology transfer and process change to assist u.S. Shipyards to first catch up and then surpass their foreign competition.

The funding, by law, must be cost shared by industry dollar for dollar—the cost-sharing will abide by the OECD guidelines when they are finally signed.



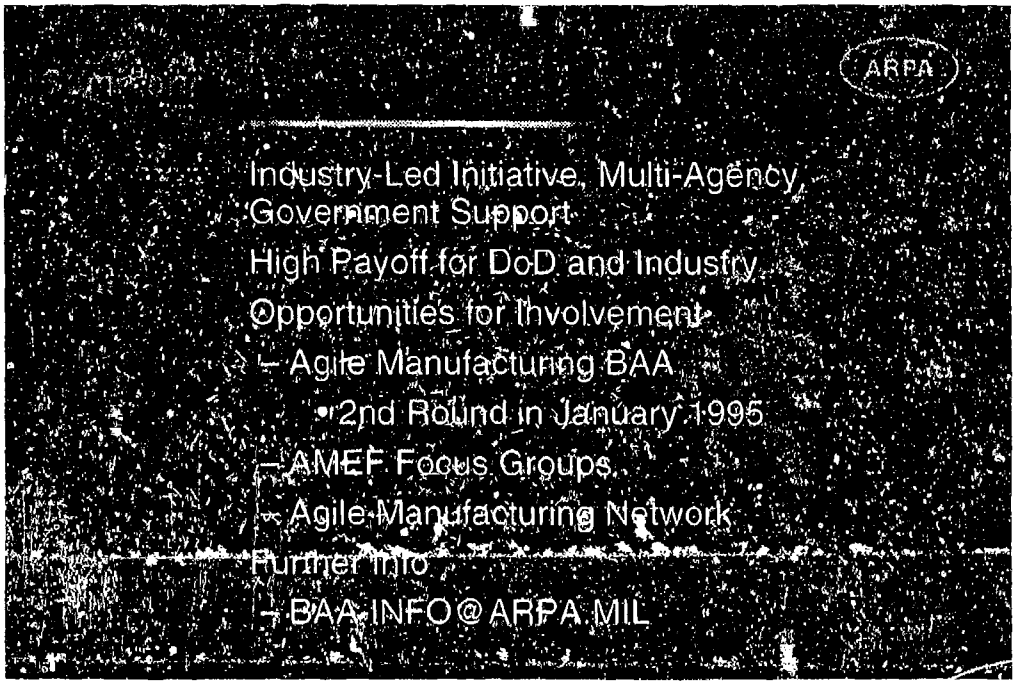
The Maritech program approach has four objectives:

The first objective is to apply existing technologies to develop new products and improve processes. Stated another way, to help U.S. yards learn the basics of international commercial shipbuilding. This effort will develop ship designs to be marketed internationally—and the improved build strategies and processes to build these ships competitively;

The second objective is to connect the shipbuilding community via a national computer network of shipyards— suppliers—shipowners/operators— financiers— technologists—and pertinent government agencies. The initial intent of this network is to facilitate communication and technology transfer;

The third objective is to focus government resources so that the various government programs among the multiple departments and agencies can be coordinated and leveraged to better support our goals.

And, finally, the fourth objective, to develop advanced technologies which will help us build better ships more efficiently than anybody in the world, and thereby help us stay competitive.



Implementing Agile Manufacturing will lead to a stronger, more competitive industrial base and reduced costs to DoD. There are continued opportunities for participation in this program in FY 1995. Further information is available by sending email to baa-info@arpa.mil.



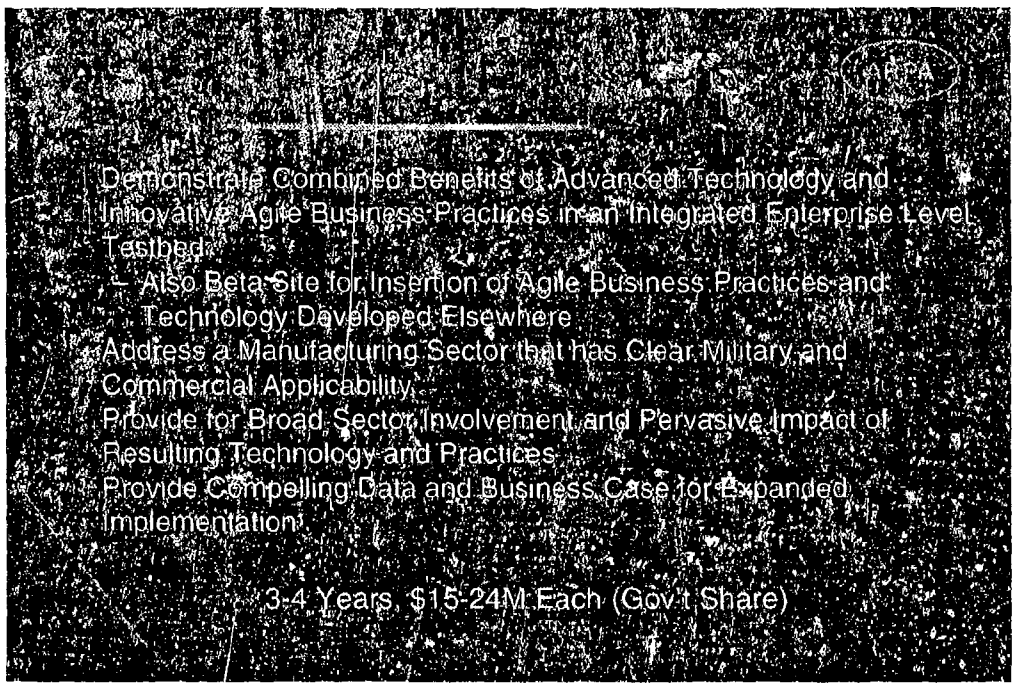
Good morning

My name is Bob Schaffran. I work in ARPA's maritime systems technology office, and I am the manager of ARPA's Maritech program.

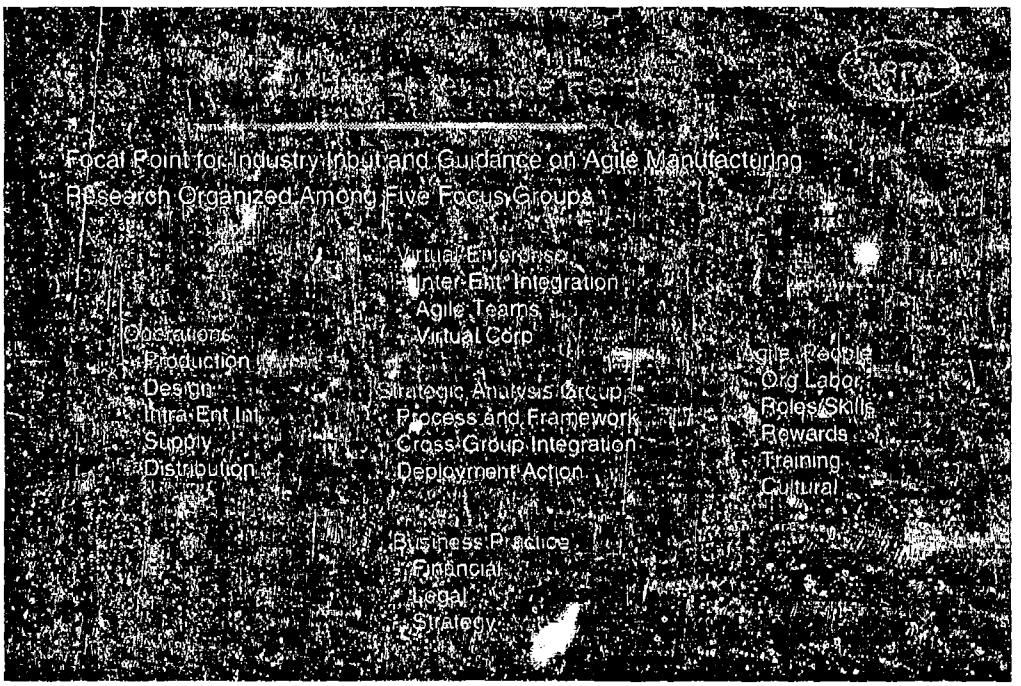
It is a pleasure to be here in San Francisco to participate in the ARPA Symposium. This is especially so, because it offers an opportunity to discuss Maritech—a program initiated by President Clinton, for applying technology to improve the international competitiveness of the U.S. shipbuilding industry.

Shipbuilding is significant—to the U.S. as it is to all maritime nations—and vital to our national security.

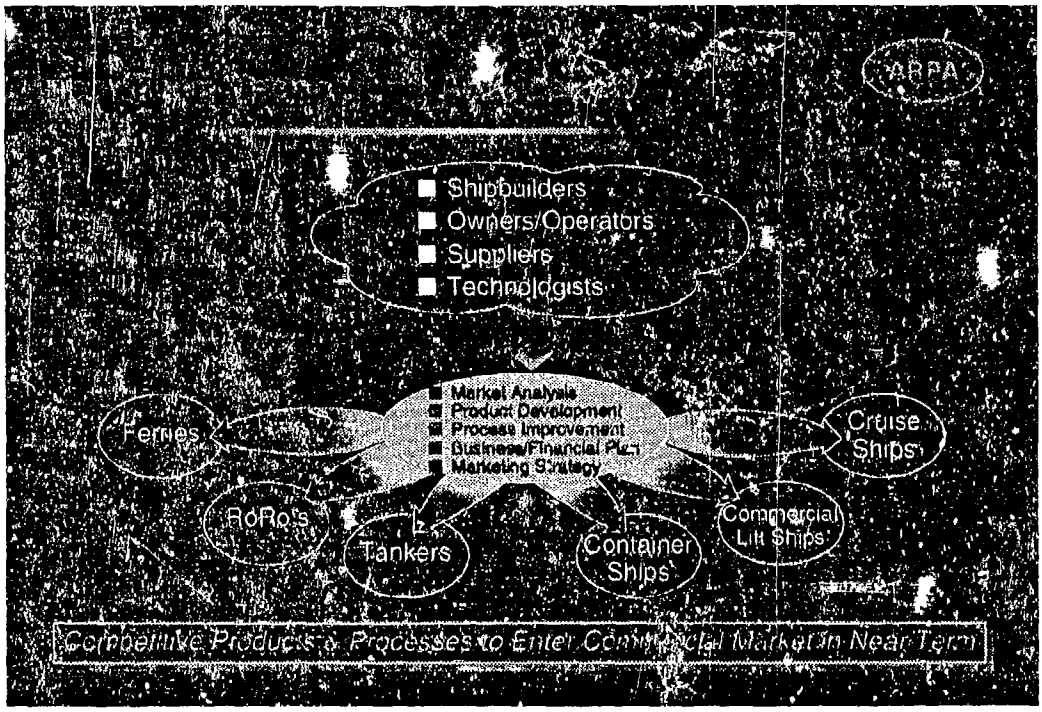
Our industry's roots date back to the dawn of the industrial revolution well over 200 years ago,



The last technical area in the BAA is Agile Manufacturing Pilots. These programs will demonstrate the combined effects of advanced technology and advanced business practices in important industrial sectors. The pilots are dual use manufacturing demonstrations, and are cost shared using the same approach as the Technology Reinvestment Project. The pilots are viewed as agents of shange for both DoD and industry.



The AMEF provides a forum for five groups of industry and academic participants to develop the intellectual underpinnings of agile manufacturing.



The primary thrust of the near-term program is commercial market penetration within the next three years. To sell ships on the international market, U.S. shipyards must be ready with products to sell at competitive prices. To achieve this, U.S. yards must be proactive in developing and marketing innovative, competitive designs that can be built quickly at a competitive cost.

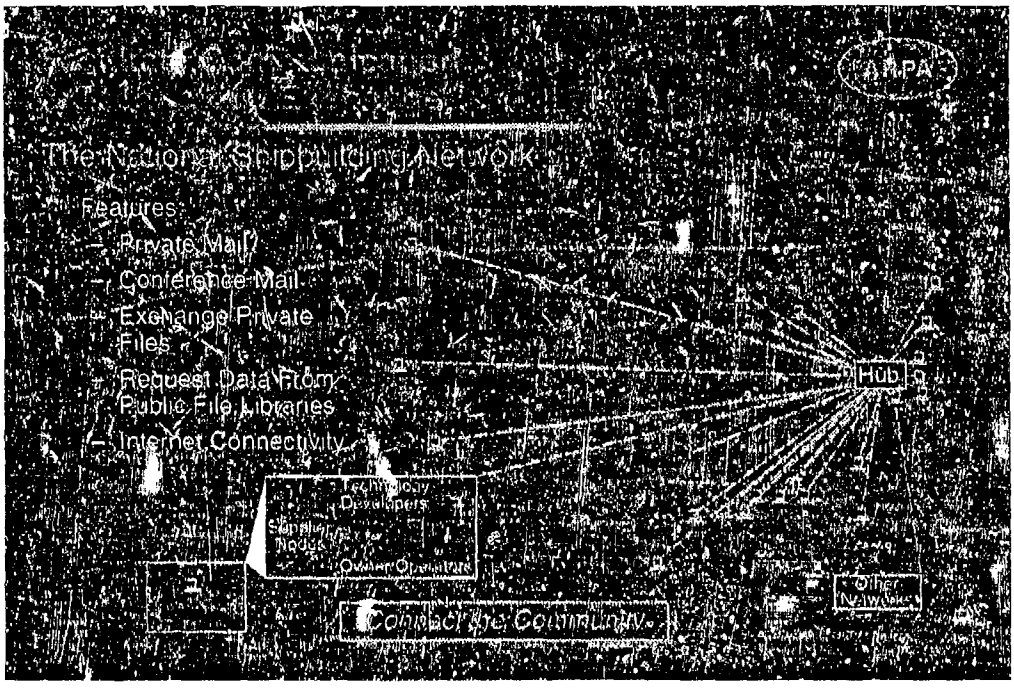
U.S. yards must analyze the markets—identify potential market niches—develop innovative, customer oriented ship designs—and develop design and construction processes for these products that will allow for competitive build cycles and competitive costs.

Since the U.S. Has l en out of the commercial market for so long, we expect some of the technology—particularly process technology—to be imported—and certainly some from japan and europe.

We have asked the shipbuilding industry to compete for maritech funds on a cost-share basis to assist in these development initiatives. We have also asked the yards to form teams with customers, suppliers, and technologists in order to develop a total systems approach.

Funds are being awarded to the teams most effective in identifying a real market need—an innovative design concept to service that market—and a competitive approach for the detailed design and construction process that could be implemented in the next 2 to 3 years. This year, 20 teams have been selected to develop new commercial ship designs and build strategies for the international market.

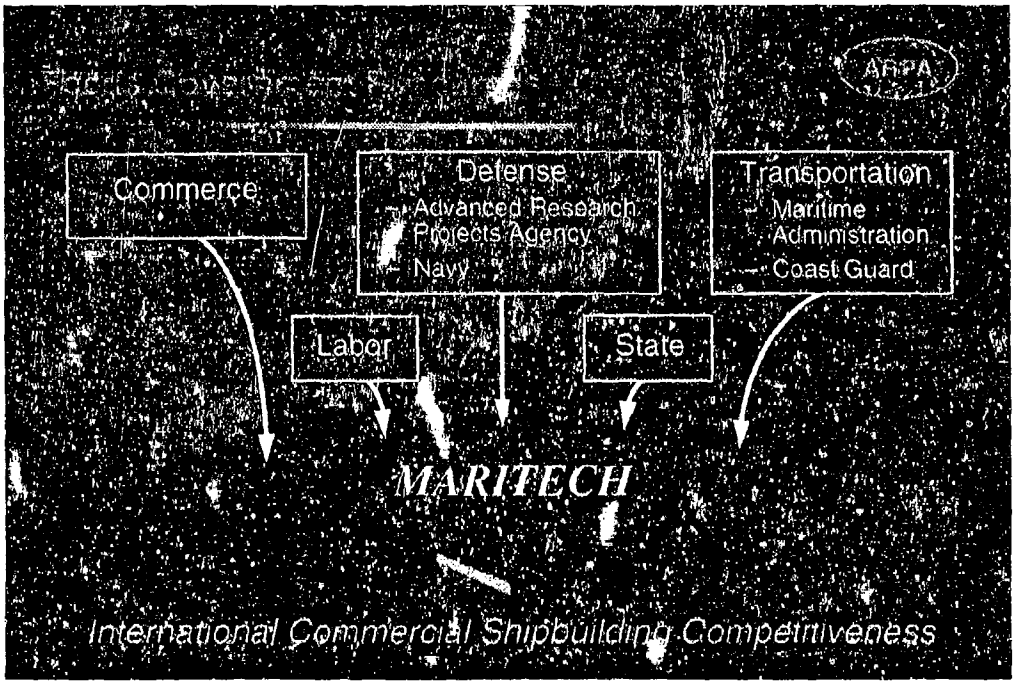
Although we were not aware of this when we initiated the project effort, i am told that japan took a similar approach with its shipbuilding industry in the early 1960s, and they went on to become the dominant shipbuilders in the world for the past 20 years.



Because U.S. yards have traditionally competed against each other for navy ship contracts or jones act ships, they have naturally built up walls to communications among themselves. One of the goals of maritech is to break down these walls and encourage cooperation and technology exchange.

ARPA has begun the facilitation of industry cooperation through development of a national communications network—the national shipbuilding net.

Nsnet will eventually electronically link shipyards, suppliers, prospective ship owners/operators, and technologists—including universities and trade schools—on a variety of shipbuilding subjects, ranging from marketing to financing to technology.



An important ingredient to the ultimate success of the industry, and something that has begun to happen—is coordination within the government.

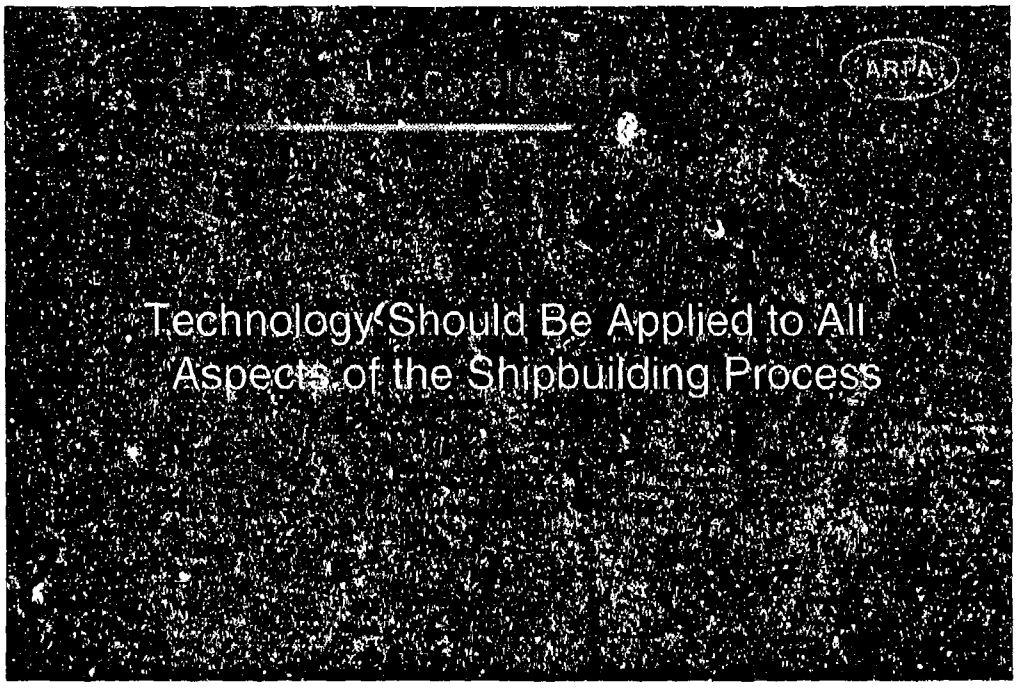
In that spirit, maritech will make a concerted effort to ensure that the government focuses its existing programs on shipbuilding in a complementary fashion.

The President identified numerous agencies that should assist the shipbuilding industry in its quest for international competitiveness. I have listed some of them here.

To facilitate coordination among these agencies, ARPA has established a maritech program office with facilities for a co-located interagency/industry staff.

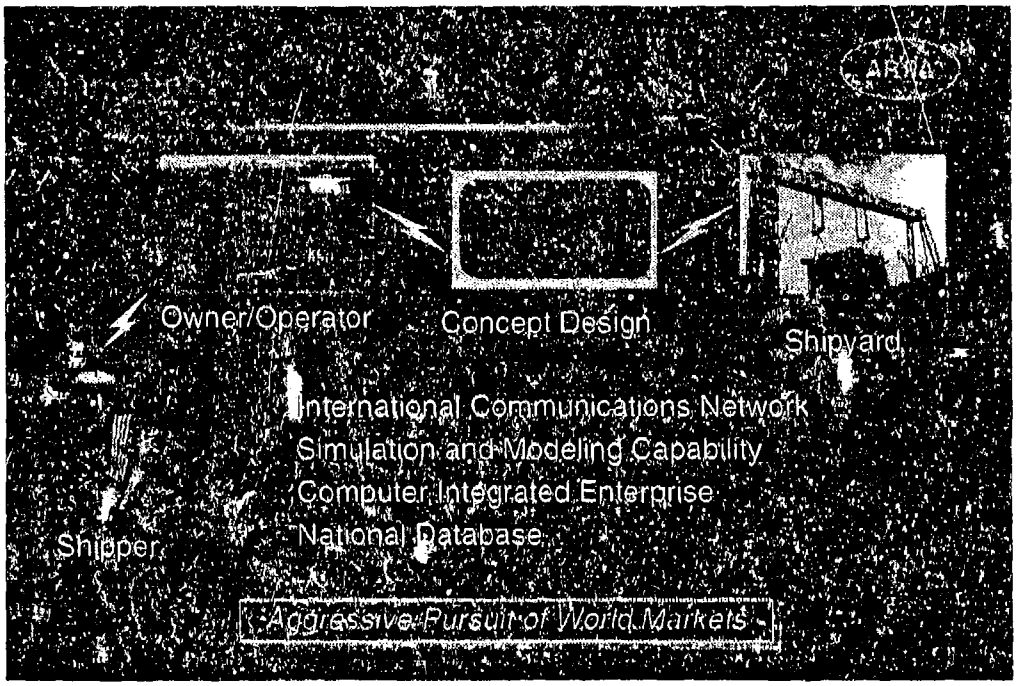
Government staff positions are currently filled by ARPA representatives and representatives from the maritime administration and the navy.

It is ARPA's intention that maritech be a catalyst among these agencies to apply their respective programs, facilities, and expertise in mutually productive ways for the benefit of U.S. shipbuilding.



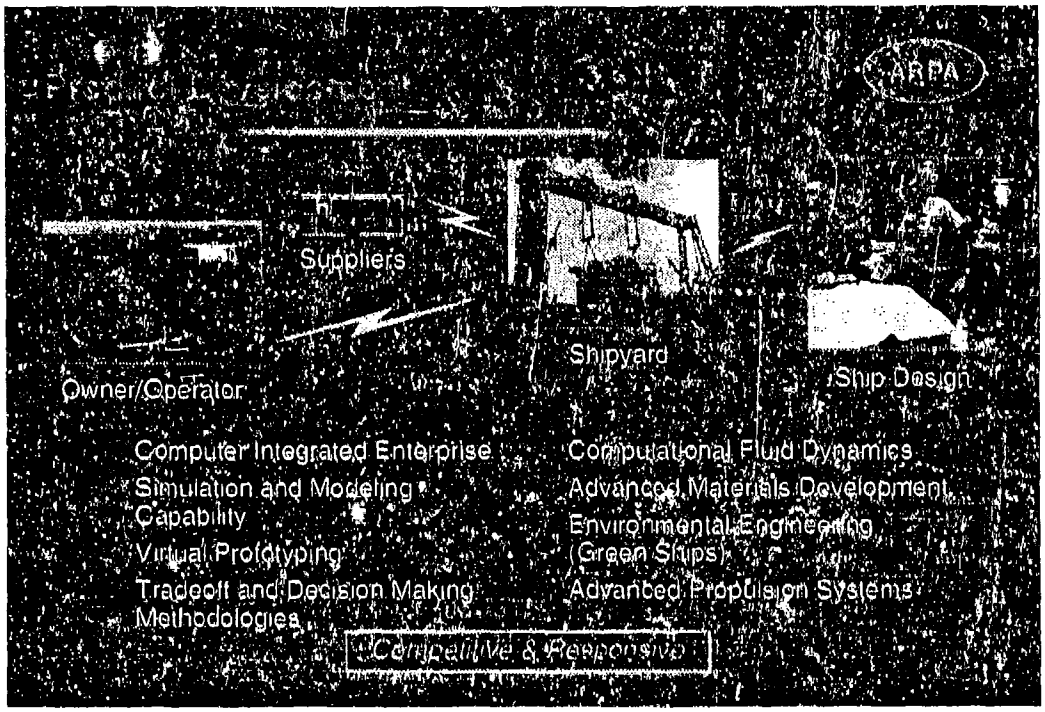
Lastly, for today's discussion, but foremost in our Maritech efforts, we are investigating and planning the development of advanced process and product technologies that will allow the U.S. shipbuilding industry to sustain a competitive position in international shipbuilding, conversion, and repair into the next century.

Let me discuss some of the technologies that we plan to pursue that will help us achieve our vision at each step in the process.



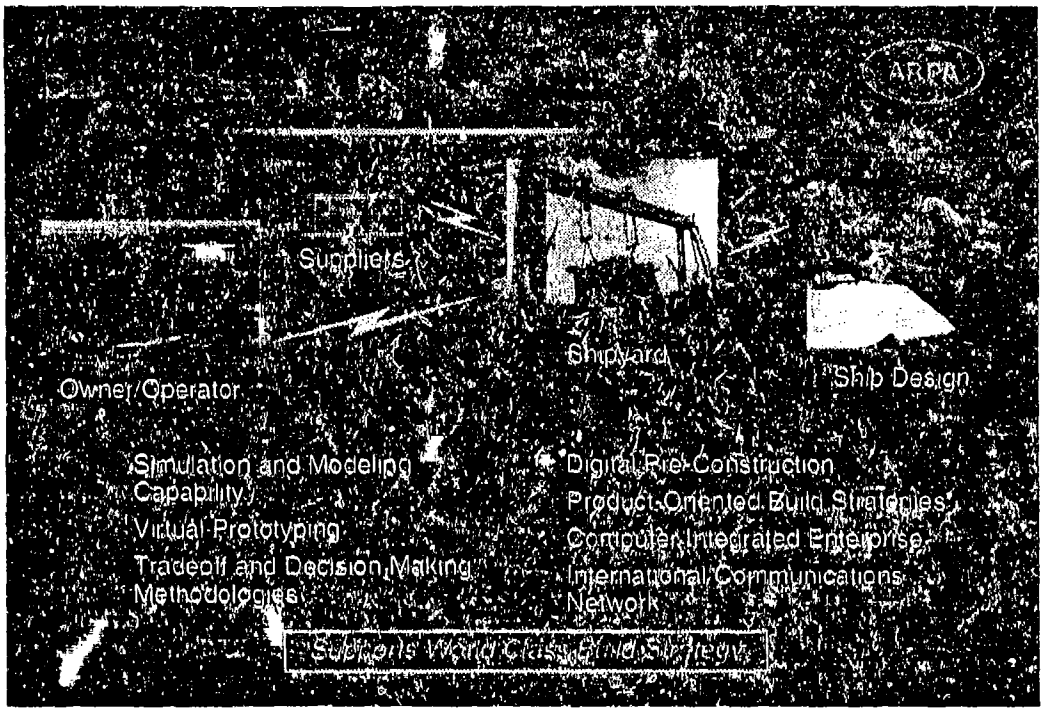
All yards must be aggressive in their pursuit of markets. They must proactively pursue domestic and international opportunities with continuous market analysis to understand customer needs and then capitalize on their knowledge with customer responsive product lines.

Our goal is that these product lines must be conveyable to customers with rapid or real-time ship model simulation and visualization technology through on-line customer communication links. Our current thoughts are to establish an international communications network fed from a national database of designs that would allow customers to have their requirements fed into the product development process in real time.



In the product development area we must be able to develop conceptual ship designs in rapid response to customer requirements or for pursuit of anticipated markets. In order to do this, we must be able to quickly retrieve data from previous products, designs, and construction strategies and quickly make trade-off decisions for improved operating efficiency, safety, producibility, affordability, etc.

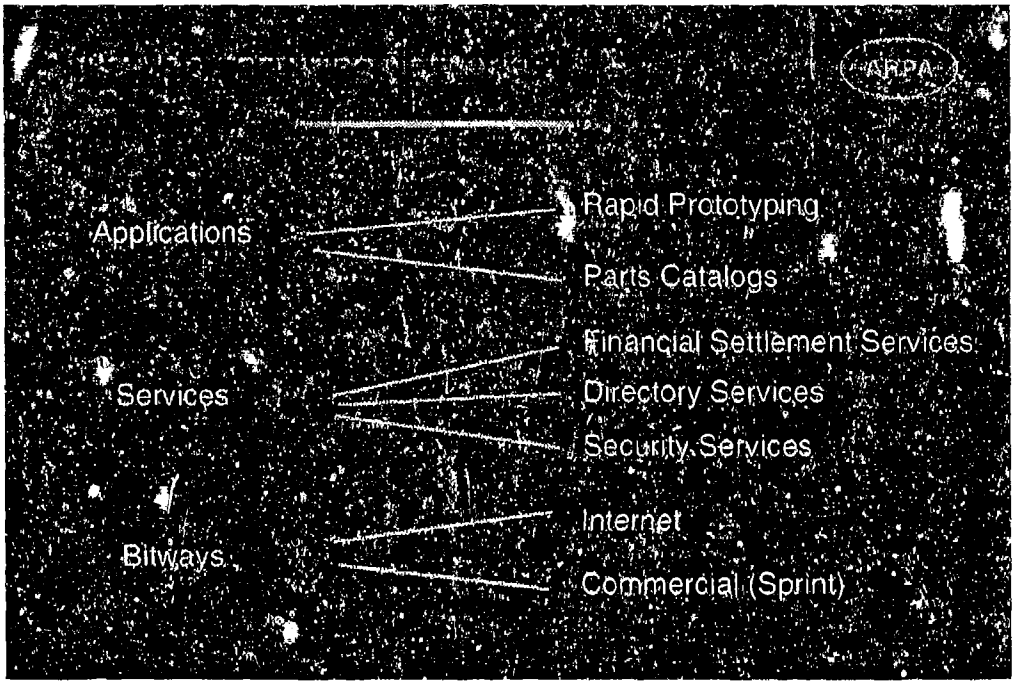
We plan to work closely with other ARPA initiatives to develop an advanced simulation-based design system that will incorporate all operational characteristics of the product, from computational fluid dynamics of the hull form to the detailed design and production planning functions of the shipyard. Customer requirements should be able to be incorporated in a ship product model under development in real time with the participation of the customer. Digital data will be accumulated from a pre-approved suppliers' database, and the production-oriented build strategies of the shipyard will be incorporated in the database to support design and production tradeoffs and decision making.



If successful, the majority of the production planning will be completed during the product development process. However, the simulation-based design system will include the ability to simulate the construction process——in essence, provide the capability to preconstruct the ship on the computer and thereby allow us to continually optimize the process during the detail design and construction planning phase. On-line communication with pre-approved suppliers will assure rapid cost analysis and reduced inventory. The goal is to dramatically shorten the time from contract award to start of construction and minimize, if not eliminate design changes after the contract is signed.



Our goal for construction is to build the ship as quickly and as cost effectively as anybody in the world. We must develop designs and production processes which facilitate the fabrication, assembly, installation, and test of repetitive structures, systems, and equipments. This, in turn, would facilitate a high degree of automation, pre-erection testing of fully outfitted ship sections, and dramatic increases in throughput. Development of a national computer integrated enterprise to accommodate agile manufacturing as well as advanced technologies in measurement, cutting, welding, painting, and process analysis underpinned with product-oriented build strategies will lead to efficient one-of-a-kind production of ships with construction times significantly under 12 months.



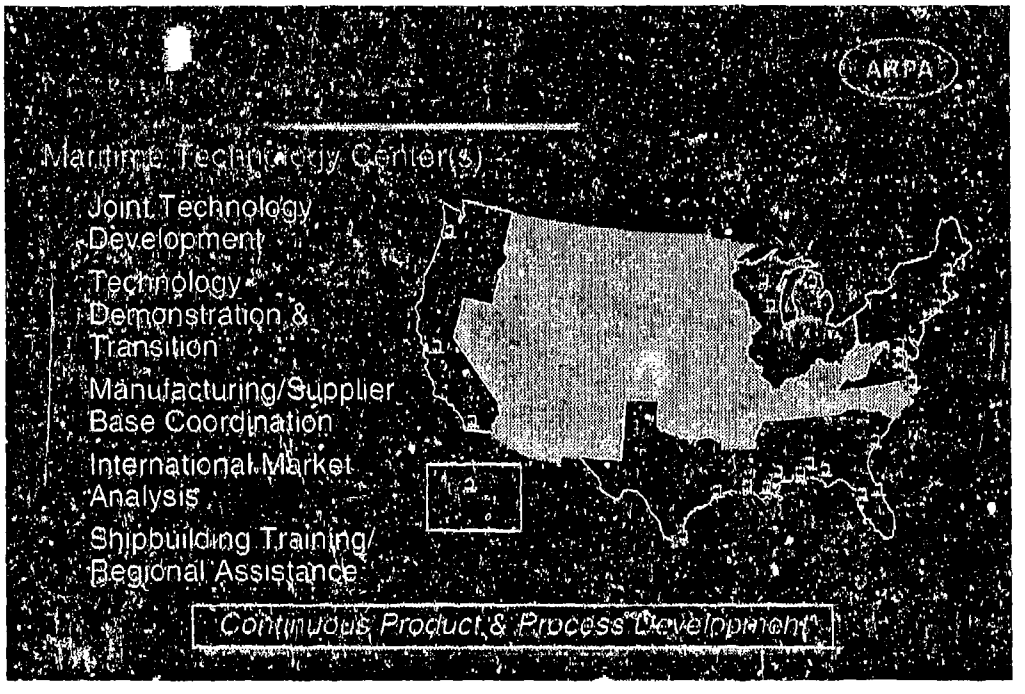
The Agile Manufacturing Network creates virtual factories, companies, etc. through electronic information in the areas of applications, services and bitways . Shop floors linked by the manufacturing network can share parts and engineering designs and rapidly build a new unit or modify an old system at reduced cost and less time.



Much of our efforts in product design and construction would be for naught if the shipbuilding industry does not include cradle to grave product guarantees and maintenance agreements among shipbuilders, ship owners, and ship repairers.

Such guarantees should be planned by the construction yards and included in their marketing efforts. Shipboard maintenance monitoring systems should be enhanced with world-wide communications networks for maintenance and repair assistance. The ability to transmit video, audio, and data real-time in a maintenance or casualty scenario among the ship at sea, the repair yard, and guarantor would enhance ship operations and bring a significant dimension to a construction yard's sales package.

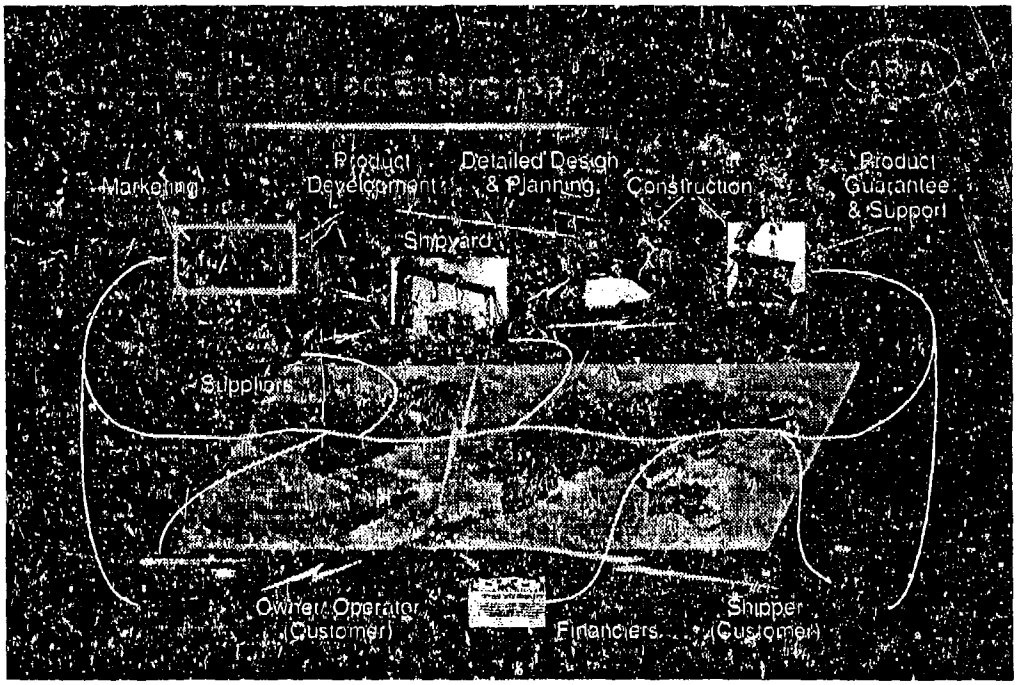
In addition, we must also nurture advanced ship repair technologies that preserve and protect the environment. Advances in blasting, painting, cutting, and welding that are safe to personnel and efficient to use with no impact to the atmosphere, ground, or water are essential and will be pursued.



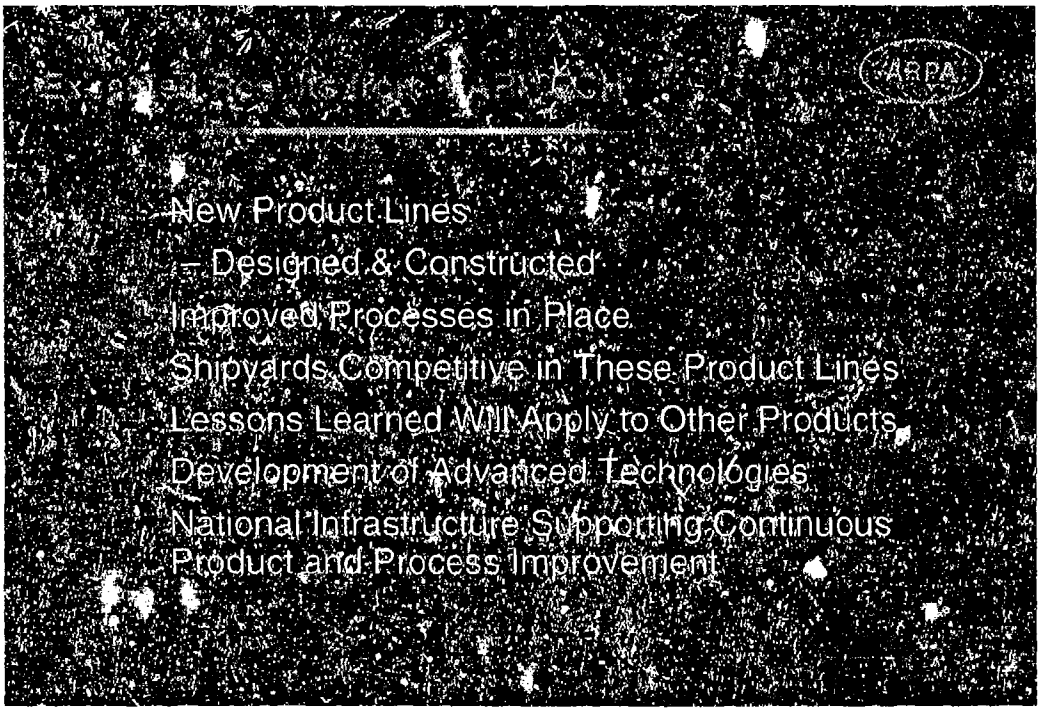
Another important objective of this long-term program is to put in place a national infrastructure that is focused on maritime technology development.

The objective is to ensure the long-term viability and growth of the industry through continuous product and process improvement in commercial and military ship design and construction.

One concept we are investigating is the establishment of a national or possibly several regional maritime technology centers where industry, government, and academia could collaborate and cooperate in a variety of areas from technology development to education & training.



I would like to conclude with our vision of an international computer integrated enterprise——a composite of a visualized global marketplace characterized by rapid, if not real-time, communication of information——voice, video, and actual product data among all aspects of the maritime industry. We should begin to make such a vision a reality for the shipbuilding industry.



If maritech is successful—and we believe we are off to a good start—we expect to have an improved u.S. Shipbuilding industry—one that is internationally competitive.

Within 3 to 5 years, we hopefully will have designed. built, and sold products competitively using improved, efficient shipbuilding processes.

We will have learned valuable lessons that can be applied to military vessel acquisition and construction processes and we will have a model for government and industry cooperation.

We will be well on our way in the development of advanced technologies that will result in dramatic improvements to the industry.

And, most importantly, we will have a national infrastructure in place to support continuous product and process improvement and maintain a key element of the defense industrial base.

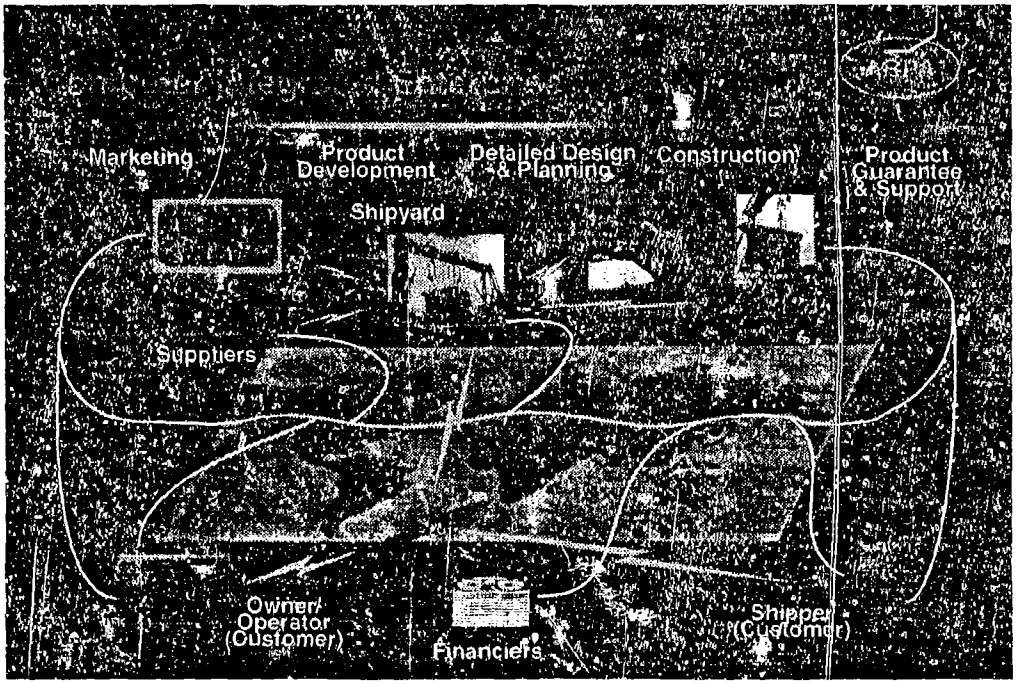


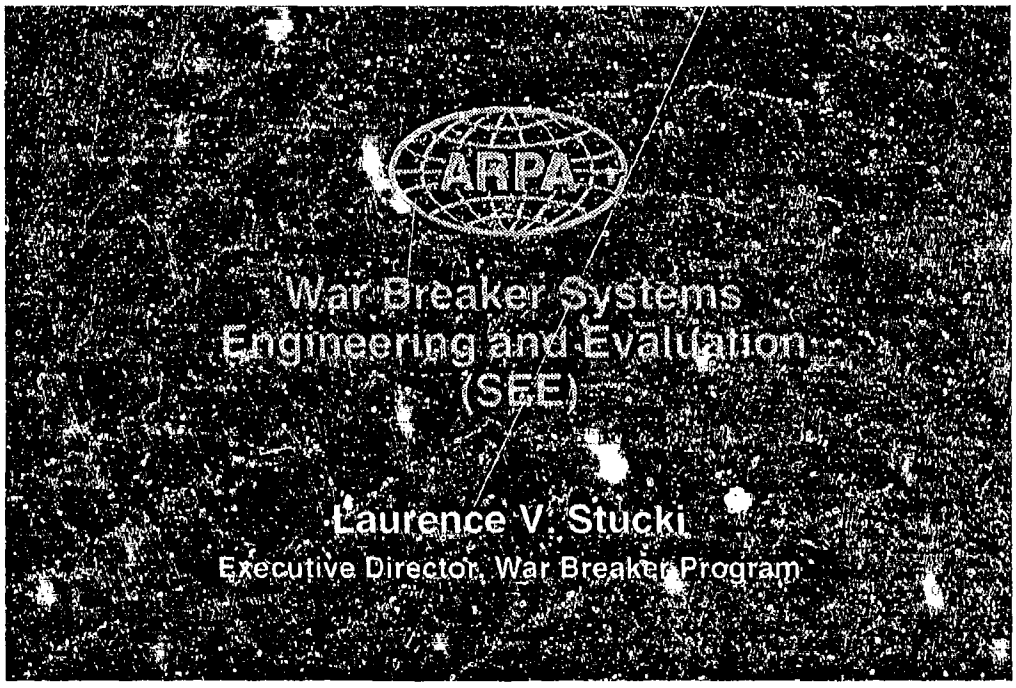
There are two maritech baas currently on the street which may be of interest to some of you.

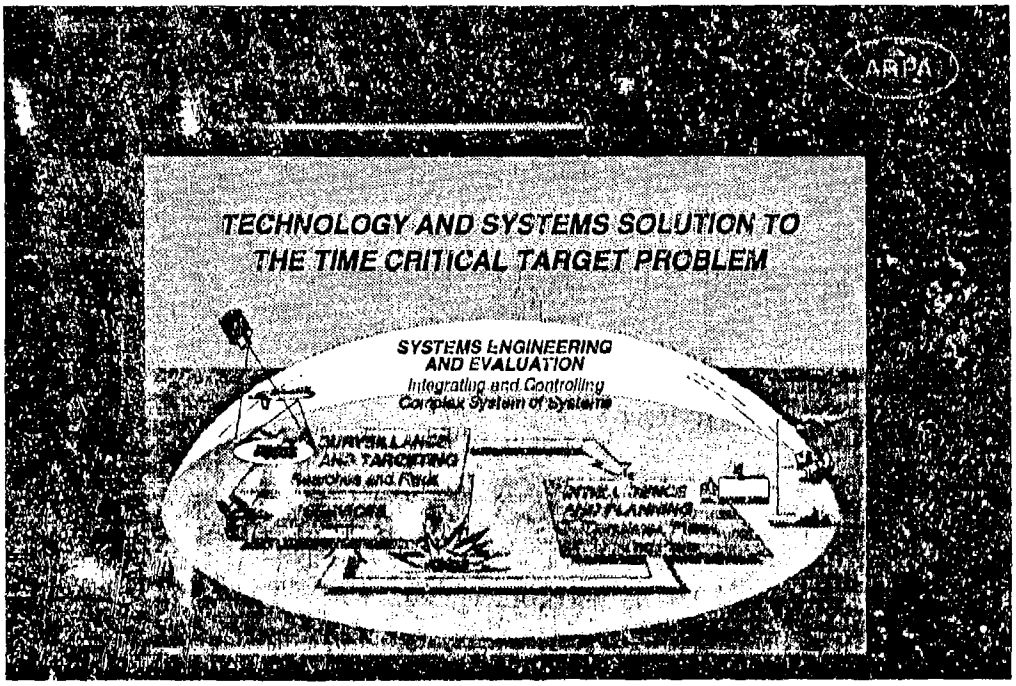
baa 94–44 (shipbuilding process and/or product technology development) was published in the cbd on september 14, 1994, requesting projects from discrete technology developments which could have wide application for improving either the process of designing and/or building a ship or the performance of the ship/product.

baa 95–02 (near term technology application) was published in the cbd on october 5, 1994, and is similar to last year's baa and asks for total ship design concepts which have potential for near-term entry into the international commercial marketplace.

That concludes my remarks. Thank you.


Marketing
Product Development
Detailed Design & Planning
Construction
Product Guarantee & Support
Shipyard
Suppliers
Owner/ Operator (Customer)
Financiers
Shipper (Customer)


ARPA
War Breaker Systems
Engineering and Evaluation
(SEE)
Laurence V. Stucki
Executive Director, War Breaker Program

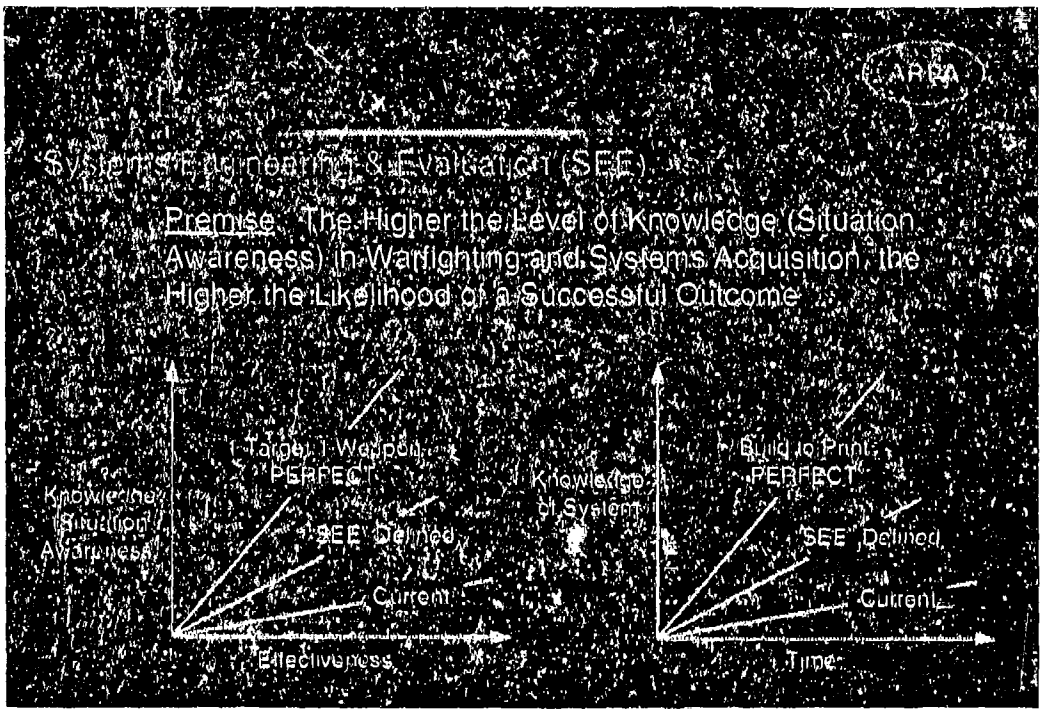


The War Breaker Program, conceived in 1992, was in response to the difficulty encountered during the Gulf War in combating the mobile missile threat. This threat was highly publicized in the press by accounts of the "Scud" missile shots from Iraq that prompted fear and consternation in Saudi Arabia and Israel during the conflict. Technology to combat such time critical targets (TCTs) prompted major attention in the research and development field, a field long driven by concerns of Global Cold War. However, time critical targets have since taken on new meanings in Bosnia and North Korea since the Gulf War. Artillery, tanks, rocket launchers, mobile command posts, and any other time critical targets can and do pose major concerns in conflicts, world wide.

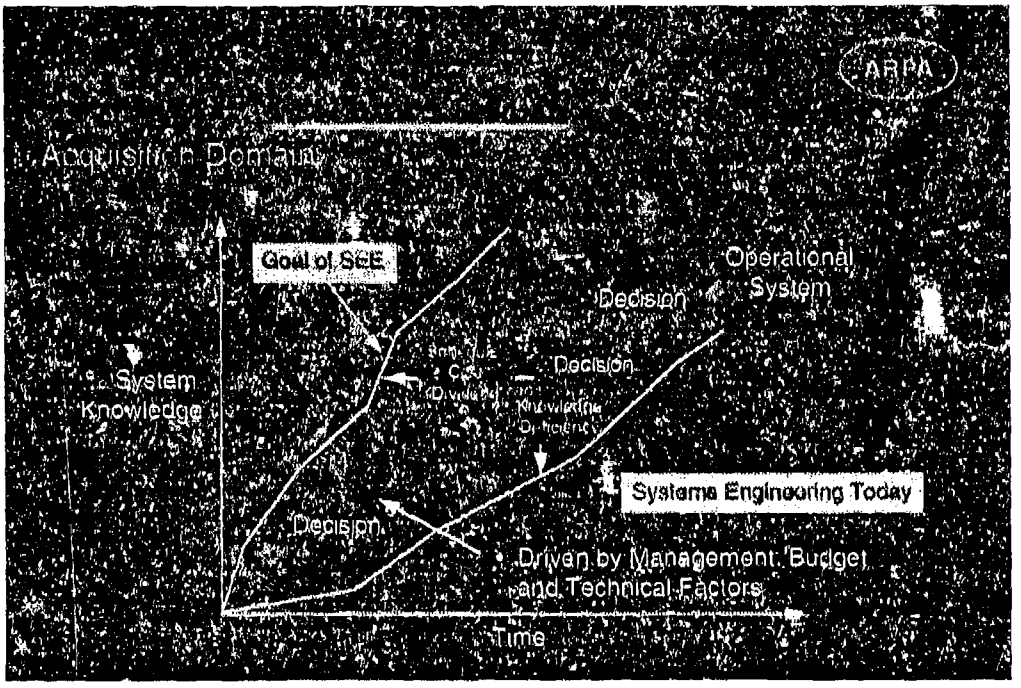
The Advanced Research Projects Agency (ARPA) initiated the War Breaker effort for two specific purposes: 1) to address the full cycle of sensor-to-shooter information control and management with heavy emphasis on providing the tactical commander necessary information to prosecute time-critical-targets; and 2) to make affordable systems by conducting systems trade analysis in the theater of battle domain. If technology insertion is considered at the individual system level, then each system is essentially defined as independent from other systems. In fact, multiple systems' dependencies do exist and judicious technology insertion in specific systems results in more overall "value added" to the full systems' capabilities at less overall cost. Domain scenarios include the Joint Chiefs of Staff sanctioned nearly simultaneous Major Regional Crises of North Korea invading South Korea and Iraq invading Kuwait; various counter proliferation situations, and other threats to national security.

The program, currently funded at a nominal $120 million per year, is partitioned into three major pieces for purposes of discussion and management. The Intelligence and Planning piece investigates the enabling technologies necessary to correlate and disseminate all-source intelligence information to the commander in a time constrained manner through automation and command/control processes. The Surveillance and Targeting piece investigates sensor technologies and automatic target detection/recognition algorithm application to detect and localize specific targets in "cluttered" environments. The Systems Engineering and Evaluation piece of the program acts as the "glue" or "heart" of the program by providing analytical determination of capability shortfalls and war fighting utility/advantages within the current war fighting posture, shortfalls requiring technology investment by ARPA for resolution.

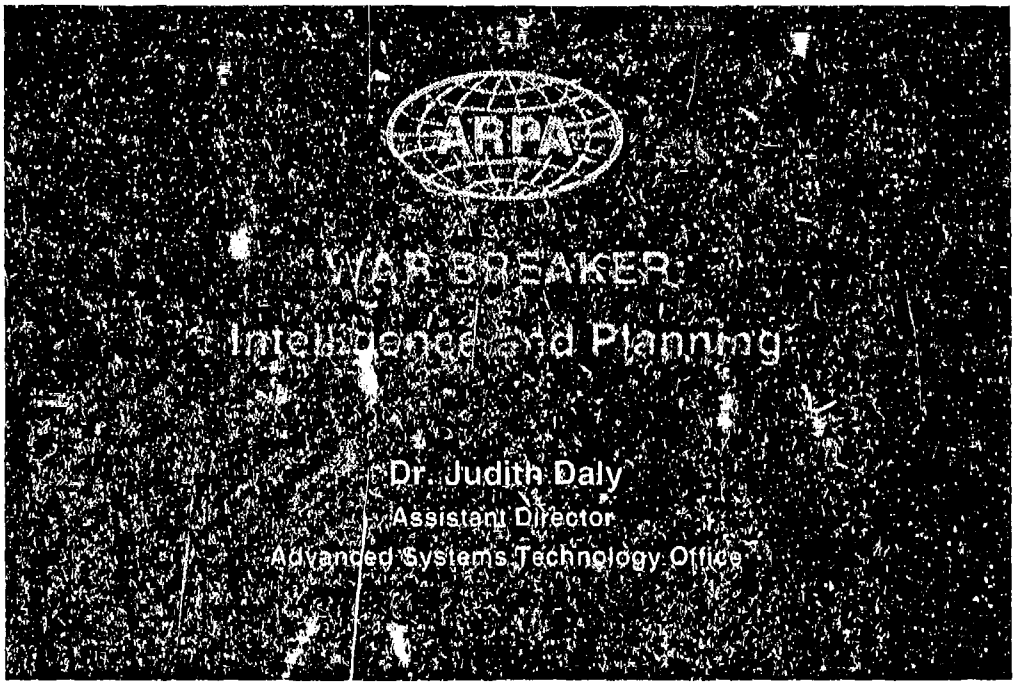
This portion of the three War Breaker presentations will dwell on the Systems Engineering and Evaluation Aspect of the program.

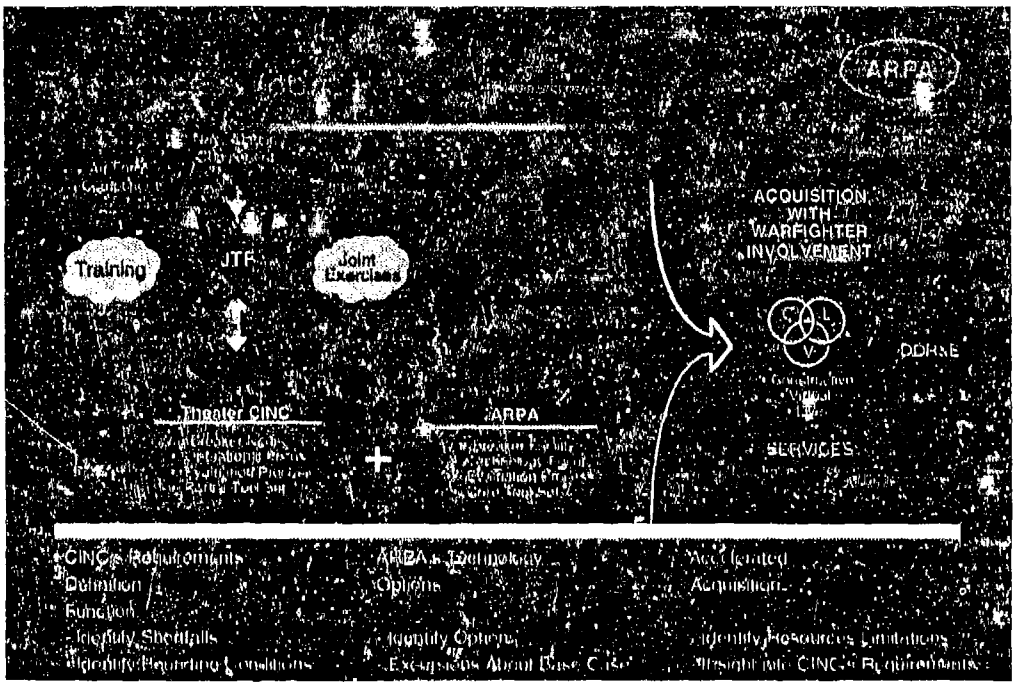


The level of knowledge that a tactical commander possesses of the battle field directly dictates his ability to be an effective commander and victor. Given that he uses his superior knowledge to the maximum, the theoretical optimal outcome could be the timely expenditure of only one weapon for each target of interest. This "cost efficient war concept", of course, is also dependent upon a cooperative enemy, technology superiority, or a host of other conditions. Similarly, the greater the level of systems' knowledge possessed by the Government program manager and manufacturer in the acquisition domain, the more likely the product will reflect a "build to print" approach, wherein the print correctly portrays the user-required system-of-systems design. The concept seems clear enough but the process and analytical tool set necessary to attain the knowledge, yet alone apply the knowledge has not been available in the past. The War Breaker Systems Engineering and Evaluation process and the analytical tool set are designed to bring this knowledge to the key players within each domain, knowledge based on man-in-the-loop service involvement throughout the entire evolution. Knowledge, in this context, means direct access to an affordable, effective, systems of systems capable of meeting the Service users' needs.



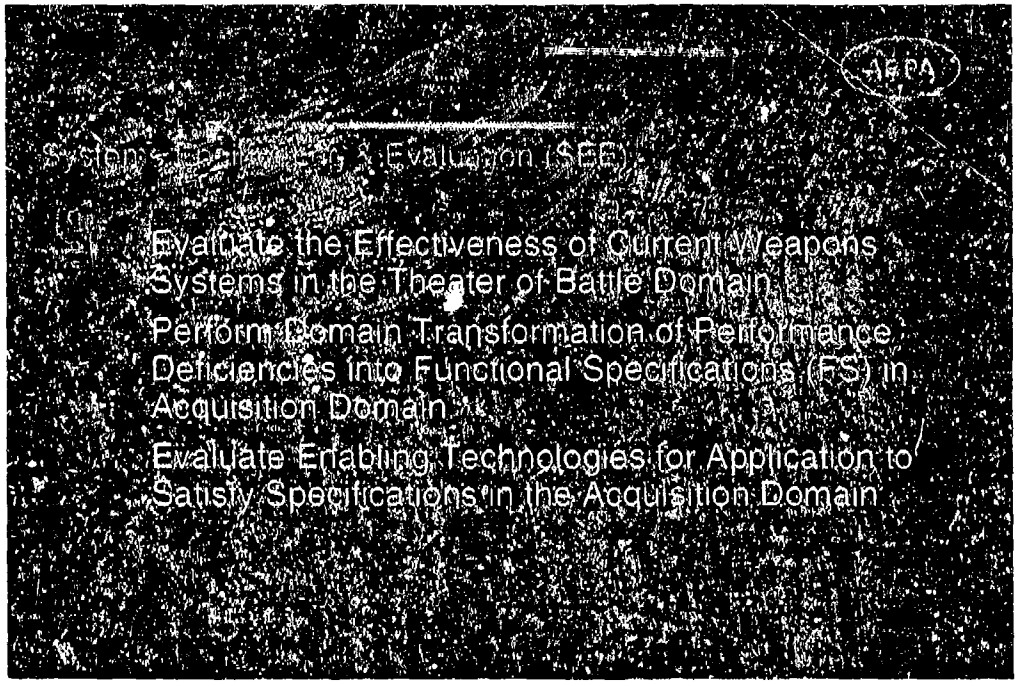
Let us zoom in on the acquisition domain for a moment. Each milestone decision made in the acquisition cycle is predicated upon management, budget, schedule, and technical factors. All of these factors should be based upon the war fighters' needs to be effective in the theater of battle. Affordability is knowledge driven and product schedule dependent. The laws of physics and economics do apply.


ARPA
WAR BREAKER:
Intelligence and Planning
Dr. Judith Daly
Assistant Director
Advanced Systems Technology Office



What's new in the process that distinguishes it from those in general use today? The analysis is conducted on the theater of battle level, not just at the individual system level. The measure of effectiveness is in terms of targets prosecuted, destroyed, or incapacitated. The analysis considers the tactical applications effect, the inter-dependencies of multiple systems in simultaneous use, and the effectiveness of man-in-the-loop decisions in winning wars.

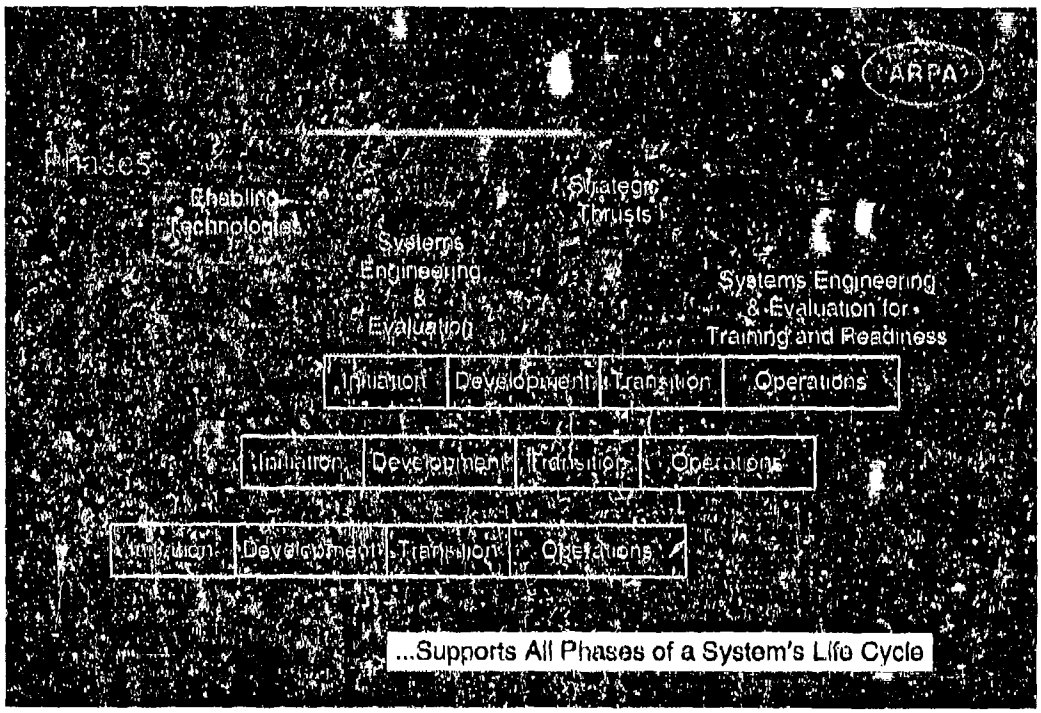
Anything other than actual war is a simulation of war. Live simulation involves actual war exercises and training evolutions. Virtual reality simulation is computer driven and involves men in the loop. Constructive simulation encompasses the rest of the simulation types. In order to gain the level of knowledge necessary, all levels of simulation conducted by the services should be evaluated to identify war fighting deficiencies. Application of the Distributed Interactive Simulation encapsulated analytical tools being developed by ARPA allows sensitivity analysis for systems performance, tactical application, and scenario excursions in order to better characterize the deficiencies. It also involves Service involvement by application of Services operators during man-in-the-loop evaluation.



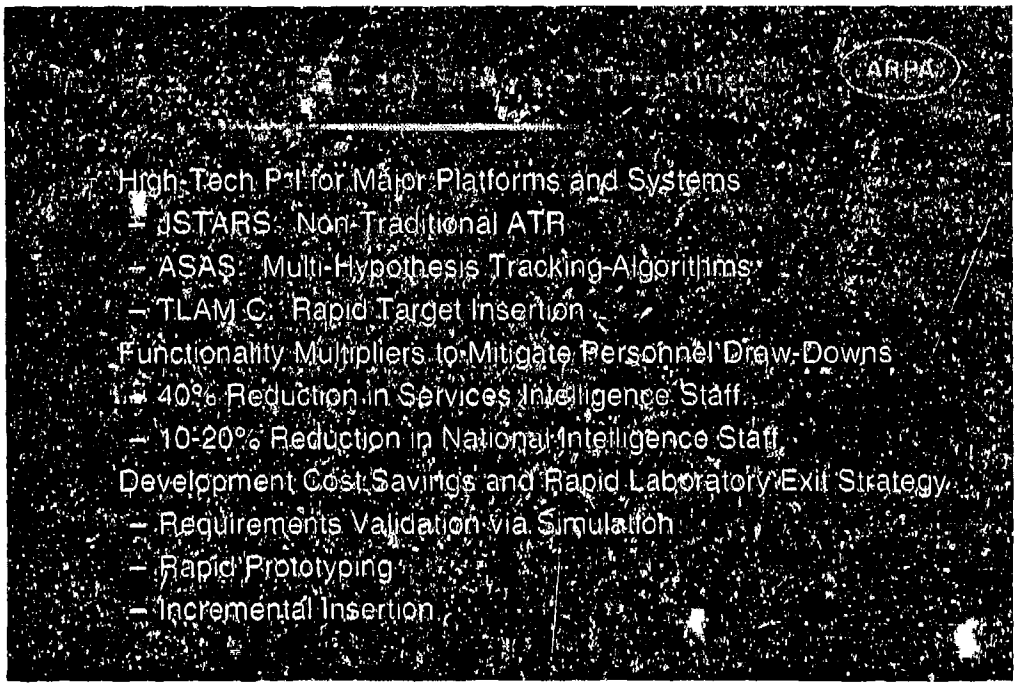
The process is broken down into three basic steps. The tactical commander's ability to perform his function revolves around the capabilities of the weapons systems available to him and the manner in which he tactically employs them. Evaluation of the effectiveness of the current weapon systems in the theater of battle domain captures the interdependencies of all the individual systems and the tactical application effects, if properly simulated and analyzed. Deficiencies in the war fighting capability are noted and functional requirements defined to correct same.

Domain transformation from the battle domain to the acquisition domain results in functional specifications being defined from functional requirements found.

A survey of enabling technologies which could be applied to satisfy the defined specifications is conducted and simulation based analysis is used to perform trade studies for determination of the best design solution.



Were we to take a simplified view of the acquisition cycle, we could categorize each program into four basic pieces. The first two pieces are where ARPA is heavily involved, the third piece is the transition of the system to the user Service or non-Service customer, and the fourth encompasses all of the remaining customer involvement. Application of the Systems Engineering and Evaluation process serves two broad purposes. The first is to directly support the development of systems, and the second is to explore and perfect tactical application of the system. Notice that a feed-back loop exists wherein application limitations of current systems act as requirements drivers for systems in early stages of development.



In keeping with the session theme of affordable defense, the War Breaker Intelligence and Planning (I&P) Thrust is focused on cost-effective targeting. Reconnaissance/strike technology is fast becoming a lynchpin of U.S. force projection, precision strike, and counter proliferation capabilities. WAR BREAKER I&P supports the development of this critical functionality in an environment of declining R&D and procurement dollars by utilizing three basic approaches.

1. Build on and enhance success: WAR BREAKER I&P technology is producing improvements in sensor product processing, information fusion, and mission planning by product improving deployed systems that are key to prosecuting time critical targets. For example:

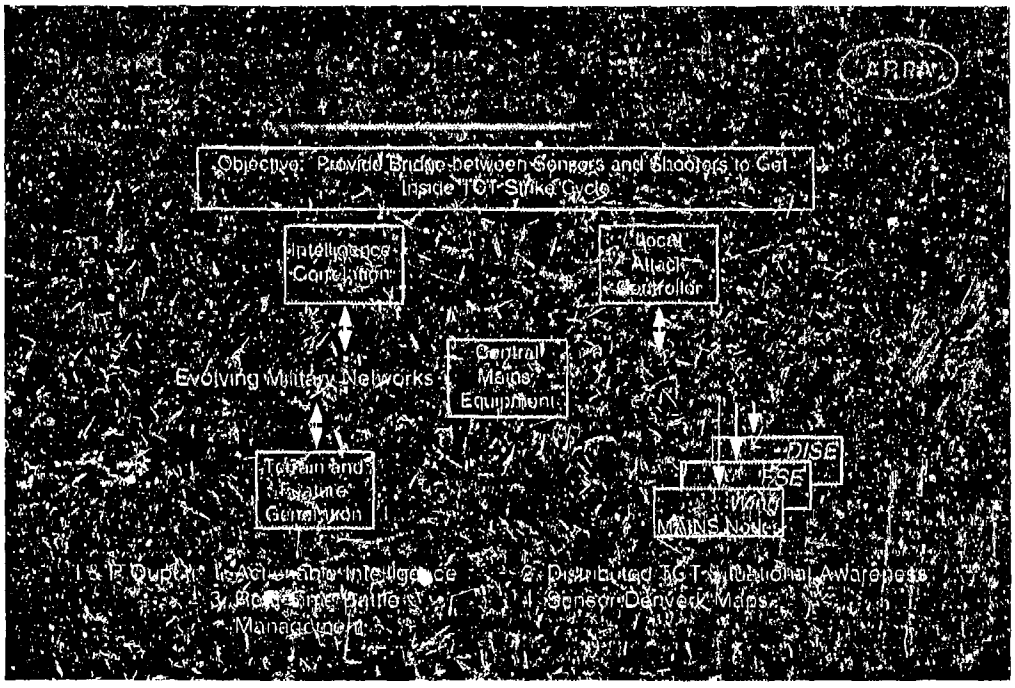
- JSTARS MTI radar is augmented by automated target recognition technology (ATR) focused on non-traditional applications such as discerning entire enemy units or activity patterns as opposed to individual vehicles.

- ASAS correlation routines are strengthened by tracking algorithms which greatly expand the recapture envelope for infrequently observed mobile targets.

- TLAM C's flexibility is increased using technology that supports the use of this highly accurate weapon against time sensitive and mobile targets.

2. Provide automated systems and tools that fill gaps left by personnel cuts. The draw down sparked by the end of the Cold War has stressed intelligence functions in general and targeting-related specialties in particular (e.g., imagery analysts, terrain analysts, order of battle specialists, etc.). WAR BREAKER I&P technology is being developed to replicate analytical functions that are amendable to automation, thus freeing ever scarcer human resources to pursue analytical functions rather than servicing the increasing ocean of data that confronts the shrinking ranks of intelligence and targeting specialists.

3. Finally, we hold down development cost via simulation and rapid prototyping designed to bring the user population into the process from the start, and we aggressively pursue opportunities for early insertion and transfer of technology as it matures at different rates within the WAR BREAKER system development context.



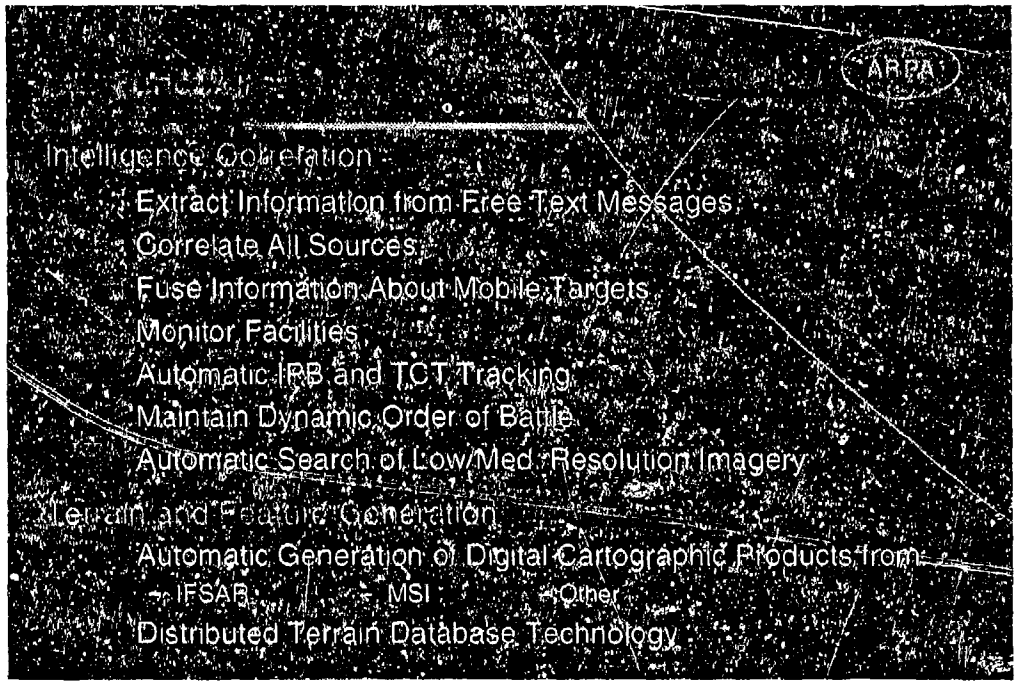
This is a developmental construct we employ to produce I&P technology. The graphic may look like the level of Dante's Inferno which houses the system engineers, but the object is quite straight forward and would be equally familiar to Ghengis Kahn or Norman Schwartzkopf: we want to do it to the bad guys before they do it to us. The outputs flow from this objective, and are matched to the subsystem boxes in the architecture.

1. Actionable Intelligence: Where is the enemy and what are the threats enroute to his location that endanger our strike systems? The Intelligence Correlation (IC) subsystem is being developed to answer this question by automatically ingesting message traffic and raw sensor product and producing a series of target location probabilities in near real-time.

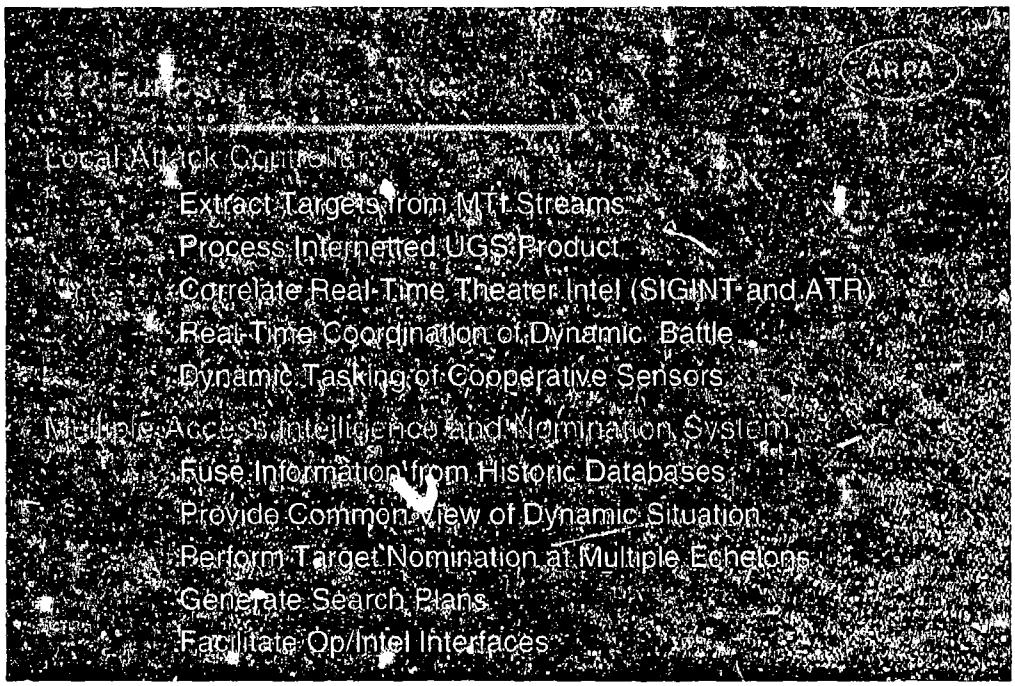
2. Distributed TCT Awareness: A target's location in space and time has different meaning and urgency for different missions and different echelons. The Multiple Access Intelligence and Nomination System (MAINS) supports a common picture of TCT population and status with resolution appropriate to level of command.

3. Real-Time Battle Management: Intelligence and operations functions blend during the prosecution of mobile targets with reconnaissance/strike technology. The Local Attack Controller (LAC) subsystem executes the endgame by enabling the rapid formation of cooperative hunter-killer teams, composed of sensor and attack platforms available to prosecute mobile targets at any given time.

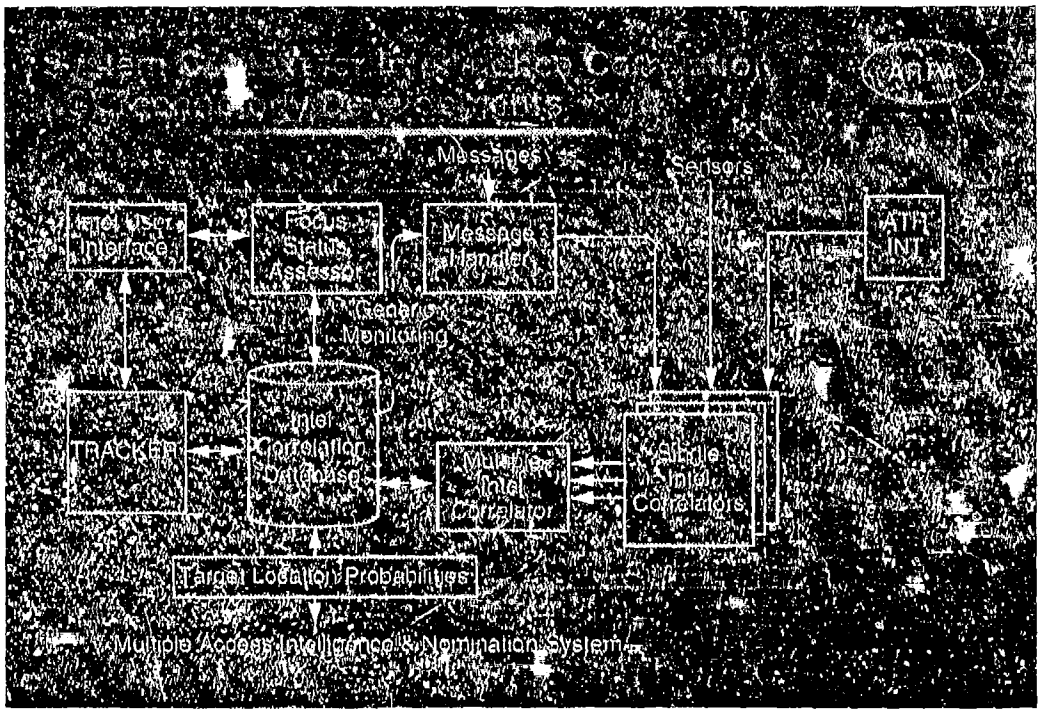
4. Sensor-Derived Maps: Current, detailed, and accurate digital terrain underpins all targeting efforts associated with land warfare. The Terrain and Feature Generation (TFG) subsystem is designed to rapidly produce large areas of digital terrain utilizing raw sensor data as input.



WAR BREAKER I&P technology is being developed in a dual contest: as an integrated system described on the previous graphic, and as a spin-off product factory for stand-alone applications that address serious military requirements shortfalls. The next two slides illustrate functionality modules that have been, or can be, productized in the near and mid-term for military customers and inserted into their intelligence and targeting ADP architectures. IC has deployed garrison monitoring technology into Joint Intelligence Center (JIC) environments, and conducted user technology assessments of imagery understanding systems at several sites. TFG will provide digital terrain of the Korean theater of operations as well as products to support CONUS exercises during FY95.



The LAC has fielded automated terrain analysis software in support of CONUS mobile ballistic missile targeting exercises, MAINS has provided targeting support tools to U.S. forces in Korea and Germany, and its data base mining technology is installed at several major U&S commands. In the next four graphics I will go down one level of detail on each of the major WAR BREAKER I&P subsystems.



Each component of the Intelligence Correlation subsystem is designed to address the automation of a key bottleneck in current targeting shortfalls.

1. Message Handling System (MHS): The translation of natural language into formal language enables machine processing of time critical target (TCT) observations based originally on sensor product but found in human-generated message traffic. MHS is a major advancement, based on the combination of natural language processing and pattern matching, that is currently not extant in deployed message routing software

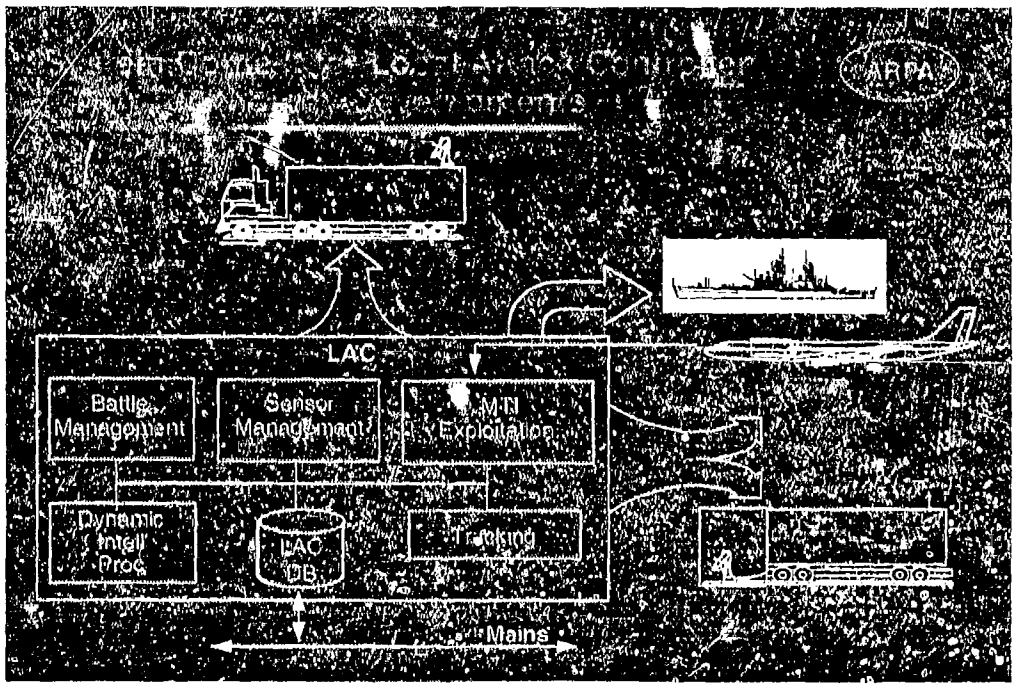
2. Single Intelligence Discipline Correlators (SICORs) ingest the product of MHS as well as parametric data and machine processed sensor product (e.g., ATR output from the WAR BREAKER Surveillance and Targeting Thrust) and reduce geographic and identification-related ambiguity. This technology is already quite mature in the area of electronic intelligence (ELINT) correlators, and we are integrating extant capability rather than developing another correlator. In areas such as automated imagery understanding, however, we are actively developing technology.

3. Multiple Intelligence Discipline Correlator (MICOR): SICOR product is subjected to further uncertainty reduction via correlation across disciplines. Together the SICORs and MICOR address the bottleneck caused by sensor product overloading a shrinking population of analysts.

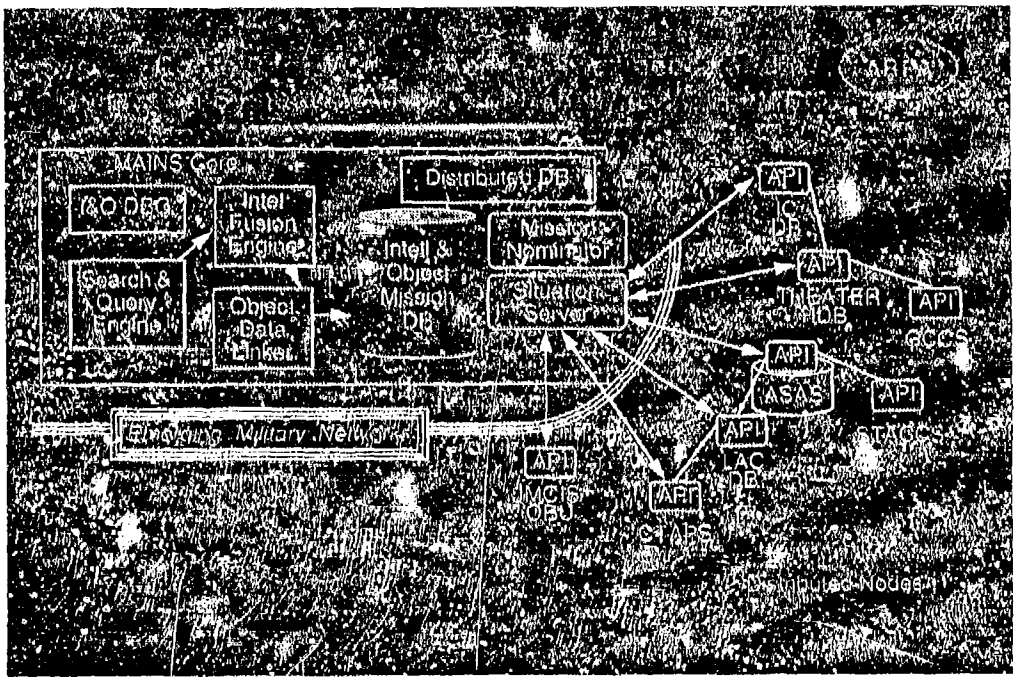
4. SICOR/MICOR product is archieved in the Intelligence Correlation Data Base (JCDB): Advanced data base technology is being developed to support a common model space, which will underpin all of the information fusion conducted in the various JC modules; as well as receive updates form and pass target location probabilities to other J&P subsystems via MAINS. This subsystem addresses the bottleneck created by multiple legacy system data bases which require special expertise to access, and none of which contain all the information necessary to support operations against TCTs.

5. Tracker: This module performs temporal and spatial correlation on SICOR/MICOR product. It connects discrete observations to TCTs in time and space, manages all of the hypotheses that result from noisy observations and false alarms, and predicts future locations.

6. Force Status Assessor (FSA): This module maintains the TCT order of battle by performing automated inference against observations of TCT and non-TCTs. It infers the existence of vehicles and units based on the presence of vehicles or equipment. The TCT order of battle forms the basis of battle damage assessment functionality, which also resides in the module. Together with Tracker, FSA addresses the bottleneck created by important, but repetitive and boring analytical functions that consume time and human analytical resources that should be focused on the nomination of fleeting targets.



The Local Attack Controller (LAC) combines and automates functionality that has traditionally been separated organizationally between intelligence and operations. In the LAC, IC functions are pared down to those associated with confined geography (e.g., a kill box or named area of attack) and near real-time and real-time feeds. These functions are combined with automated sensor and battle management modules so that extant assets can be rapidly generated and their interaction orchestrated within the broader planning parameters of force-level commanders. Thus LAC is not only technically challenging, but embodies the organizational challenges posed by the requirements to generate "operational intelligence" in order to operate within the strike cycle of enemy TCTs. This organizational challenge is being addressed by the services in a series of exercises designed to test new theater battle management architectures and procedures for locating and prosecuting tactical ballistic missiles. LAC technology is being demonstrated, tested, and evaluated in these exercises in accordance with MOUs between ARPA and the relevant service organizations.

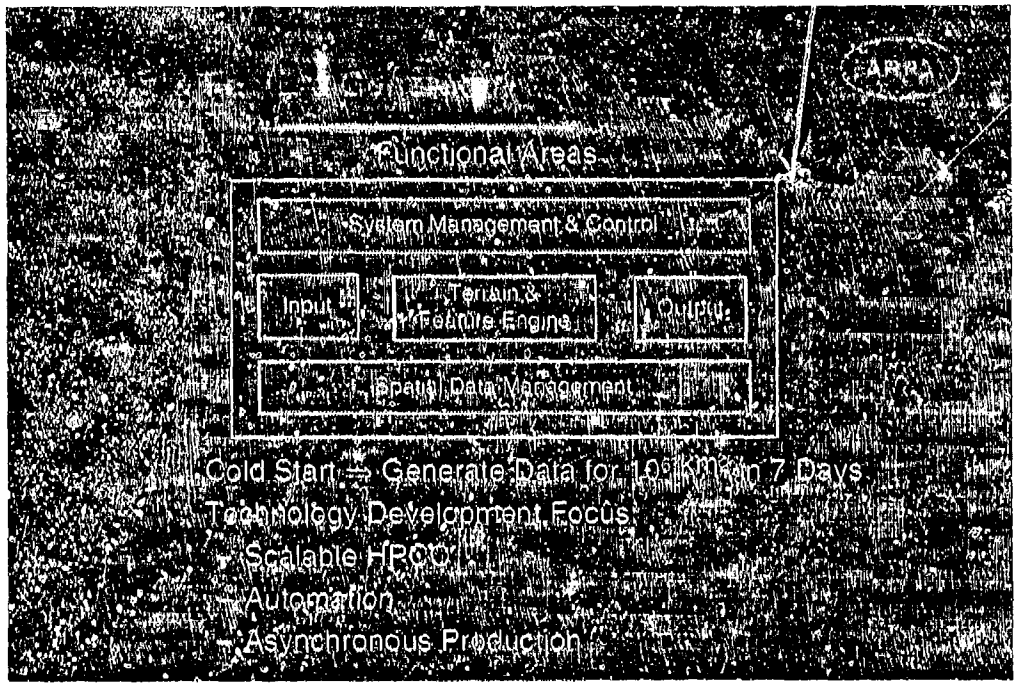


MAINS directly addresses a fundamental problem encounter in both the military and commercial words: data base technology has not kept pace with advances in network technology and bandwidth capacity. The ability to collect data has long outpaced human capacity to analyze it, but it now threatens to swamp the possibility to storing it effectively. Military and intelligence users are often faced with the ludicrous situation wherein data, collected and analyzed at great expense in time and resources, cannot be retrieved from a myriad of legacy data bases without an effort commensurate to that required for its creation.

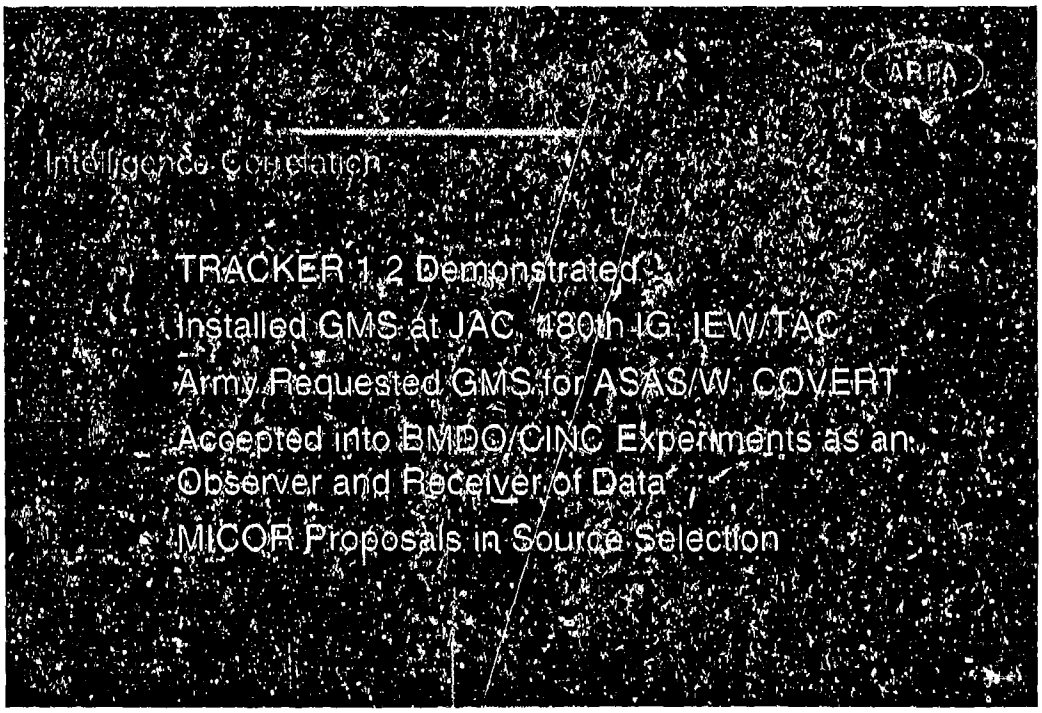
Without a common data picture, concepts such as "split basing" and "reach back", which underpin evolving intelligence doctrine, will not be possible. This is especially true in situations such as early entry, U.S. nationals evacuation operations, or peace keeping where intelligence data bases will be largely CONUS based and maintained. MAINS is developing two basic capabilities to address this key deficiency.

1. Data Base Generation (DDB): During Desert Storm some units maintained at least three separate data bases of the electronic order of battle: national, theater, and their own-each usually requiring a different data base management system. DBG technology is designed to merge the product or multiple data bases; eliminate redundancies, inconsistencies, and errors; and create a single baseline data picture for a theater of operations.

2. Distributed Database: The baseline data picture will be maintained and updated simultaneously at multiple levels of detail. This capability is vital to giving commanders at all levels a real-time view of their piece of the battlespace, and without it the digitization efforts underway will not fulfill their potential with respect to supporting targeting, damage assessment (BDA) and identification friend or foe (IFF).

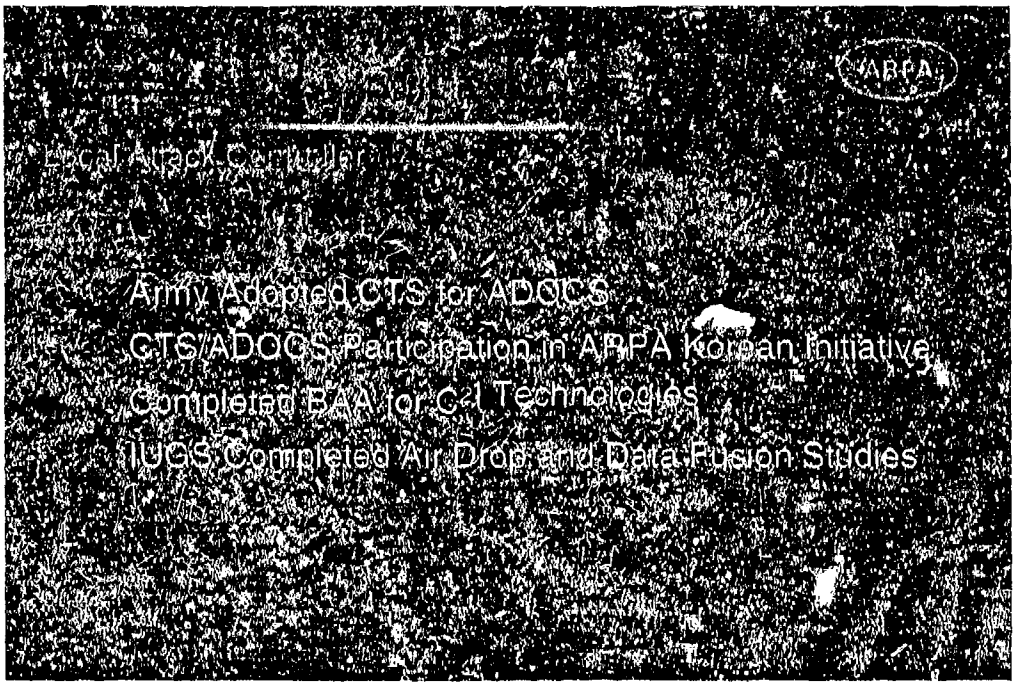


Terrain and Feature Generation is not a map production system. TFG is being designed to rapidly produce the digital terrain underlay for an entire theater of operation in a week. This product can certainly support traditional military mapping functions, but of more importance it will enable near real-time automated image processing, mobile target tracking, situation assessment, and timely, focused collection management. The processing will exploit a coarse-to-fine reasoning strategy whereby TFG will initially map an area at low resolution and then identify priority areas for detailed terrain and feature extraction. The technology anticipates programmed enhancements in sensors (such as S&T) that will provide frequent wide area coverage at resolutions once limited to small point targets. TFG will employ both literal and non-literal imagery in constructing a terrain product that will represent a continually evolving synoptic view of the battlespace rather than traditional hard copy cartographic products issued as a series of discrete updates.



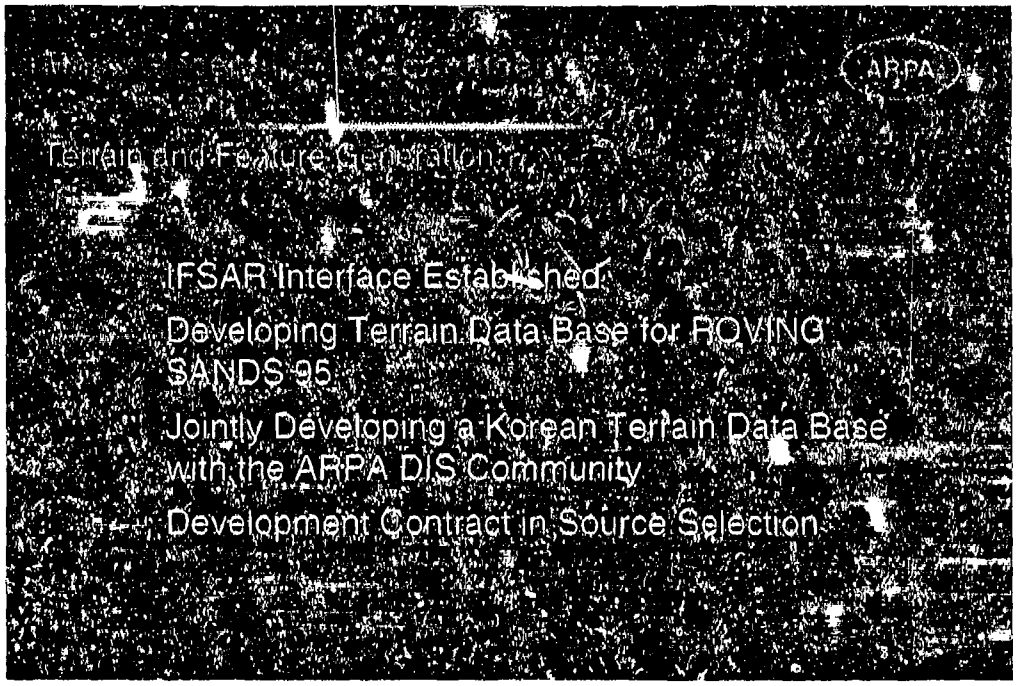
WAR BREAKER I&P has logged significant accomplishments in all of its subsystem development efforts during FY94. In the aggregate, these accomplishments indicate that we are successfully pursuing our dual objective of an integrated system and near-to-mid term productization and spin-off. Each subsystem has on-going insertion and/or product releases to the customer community. Each is also making major technical progress toward the overarching goal of shrinking our targeting timelines to within the enemy's strike cycles.

All the IC modules are currently under development, some as competitive efforts culminating in down selects in FY 95 and 96. The IC design informs all of the module development efforts and is driven by a uniform probability model underpinning all of the automated inference processing in each module. Insertion points for IC technology include deployments in USEUCOM and USACOM.

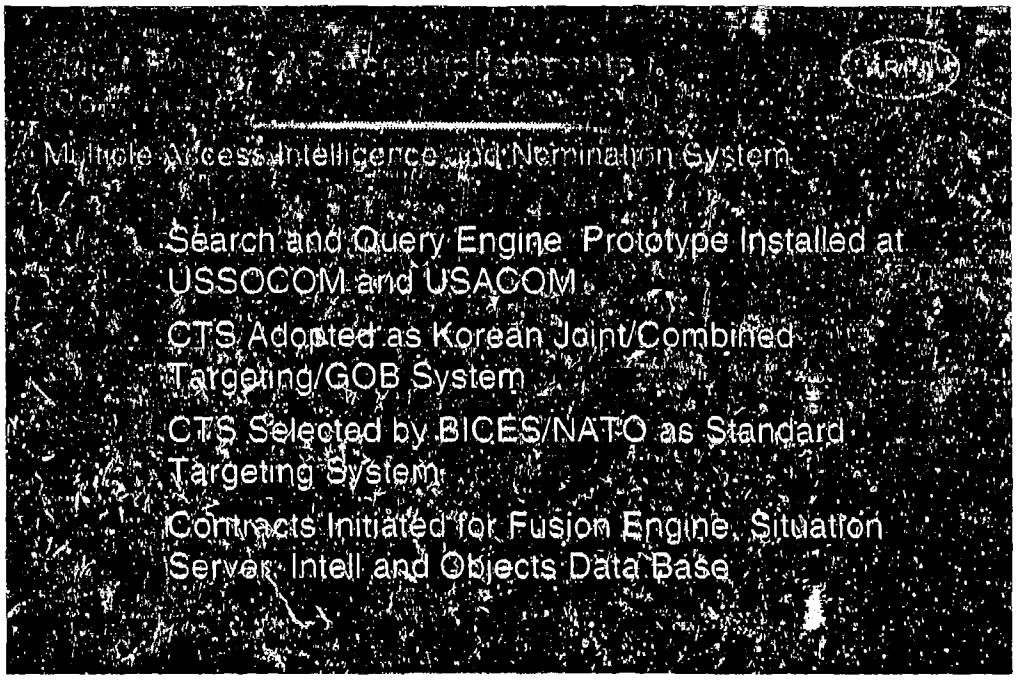


LAC technology has been a participant in several recent exercises during 1993 and 1994. During Operational Concept/Cross Bolt II, LAC area limitation software was used as a backdrop for JSTARS MTI displays, and facilitated rapid location of surrogate transporter erector launchers in hide and launch locations, and their prosecution by aircraft flying CAP. During Ulchi Focus Lens in Korea this summer, LAC battle management technology was utilized to link ATACMS launch units and fighter wings to targeting calls, greatly reducing targeting timelines. Finally, LAC targeting support tools were installed in every U.S. Army Corps fire support element during 1995, culminating in automated targeting support to a live ATACMS launch that significantly decreased sensor-to-launch timelines.

WAR BREAKER I&P has initiated a number of system design and integration efforts with the Air Force to aid in the transfer of LAC technology into the TBM Core System architecture. We are participating actively in product improvement meetings with the Electronic Systems Command (ESC), Air Combat Command (ACC), and Rome Laboratories to ensure that our technology developed in concert with the functional system requirements identified by the Air Force, and in a manner that supports practical insertion of I&P technology into the Air Force architecture. Insertion efforts are active with respect to the Air Operation Center (AOC), Control and Reporting Center (CRC), and the Joint Surveillance and Target Attack Radar System (JSTARS) Program.

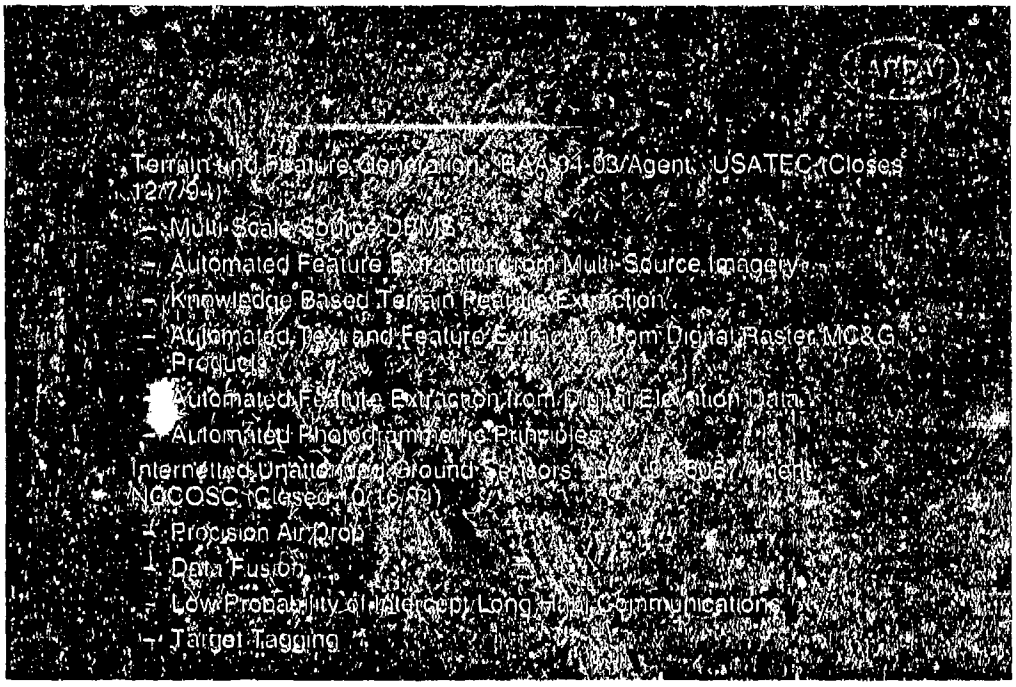


Initial MAINS DBG prototypes have been deployed at SOCOM and USACOM. Through a series of MOUs with the services, MAINS will insert distributed data base technology into evolving military intelligence and operations networks and data bases beginning in December 1994 with USACOM followed by USPACECOM in October 1995. MAINS technology is also being inserted into joint and combined environments in both NATO and Korea. MAINS technology was employed in Ulchi Focus Lens last summer utilizing both English and Hongul language versions. MAINS technology will provide the suite of targeting tools embedded in the NATO's evolving BICES architecture.



TFG is in a competitive design phase, with concurrent technology development under a recently announced BAA. This year TFG will supply digital terrain to the Roving Sands mobile missile targeting exercise and produce digital terrain of all of North Korea.

TFG's utilization of interferometric synthetic aperture radar (IFSAR) product is critical to achieving a rapid digital terrain production capability. A topical examples involve the use of IFSAR and moving target indicator (MTI) radar to create an initial terrain data base to support location and targeting of mobile ballistic missiles. For mobile missiles and other target types, the key discriminator as to launch and hide locations are slope, presence or absence of man-made structures, and road network. TFG algorithms can be employed to utilize IFSAR output to calculate elevation and slope to resolutions of less than a meter and with high accuracy utilizing global positioning system (GPS). The 3-D shape data from the IFSAR can also be employed to locate or update information relating to large structures suitable for hide locations or technical support bases. TFG can also employ MTI to create or update a road network, tying together regions of gentle slope with built-up areas for protection or support. Terrain analysis algorithms can be run against this "map primitive" of slope, roads, and buildings to highlight areas for high resolution collection to support targeting and mission planning.

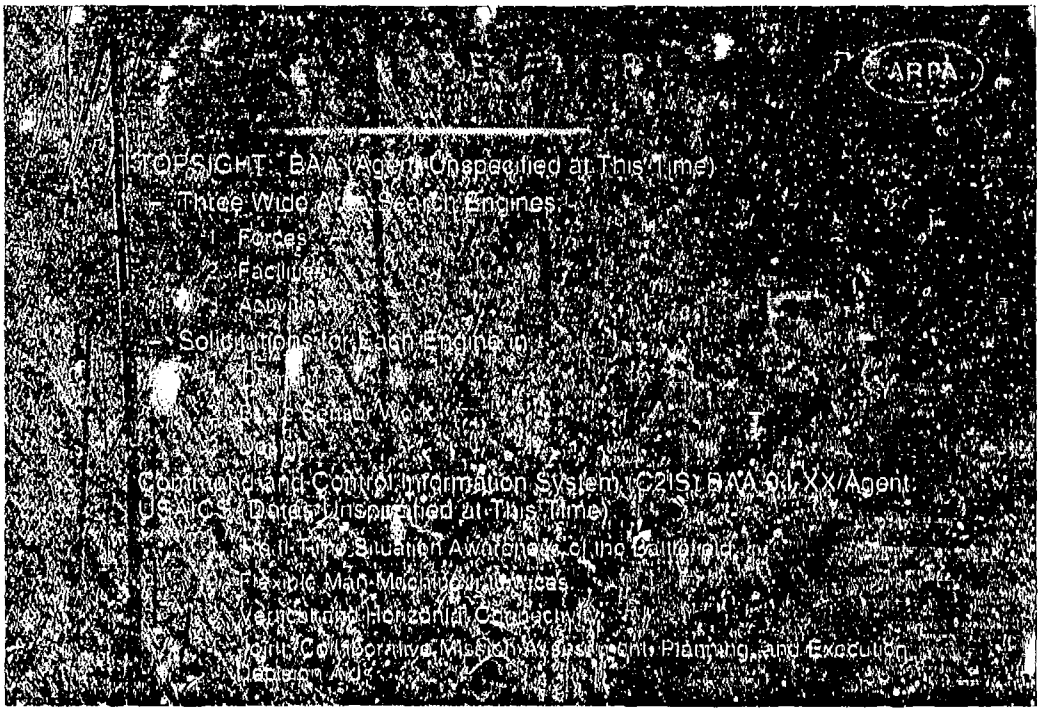


The TFG BAA focuses on six areas requiring innovative technological solutions encompassed by the TFG functional design.

1. Multi-Scale/Multi-Source Database Management Systems
   - Semantically Linked Raster and Vector Representations
2. Automated Feature Extraction from Multi-Source Imagery
   - National
   - Commercial
   - Landsat, Hyper-Spectral, Spot
3. Knowledge Based Terrain Feature Extraction
   - Utilization of Terrain Analysis Knowledge with Source and Compiled Date to Infer Features
4. Automated Test and Feature Extraction from Digital Raster MG&G Products
5. Automated Feature Extraction from Digital Elevation Data
   - Drainage Patterns
   - Ridge Lines
   - Natural Barriers
6. Automated Photogrammetric Principles

Selected efforts and developments will support the TFG Design, Development and Integration Contractor (Prime). To effect this support, the Government is specifying software Interfaces and development environments such as Khoros.

The IUGS BAA solicits technology to provide mid- to long-term solutions to enhance the capabilities of military forces to detect, classify, and identify TCTs with emphasis on specific TCT identification versus simply providing activity alerting. The IUGS program is an on-going program with efforts that already address sensors, advanced signal processing of sensor data, and short haul communications. The BAA is focused on four technical areas that are important to the IUGS Program but not currently under contract.



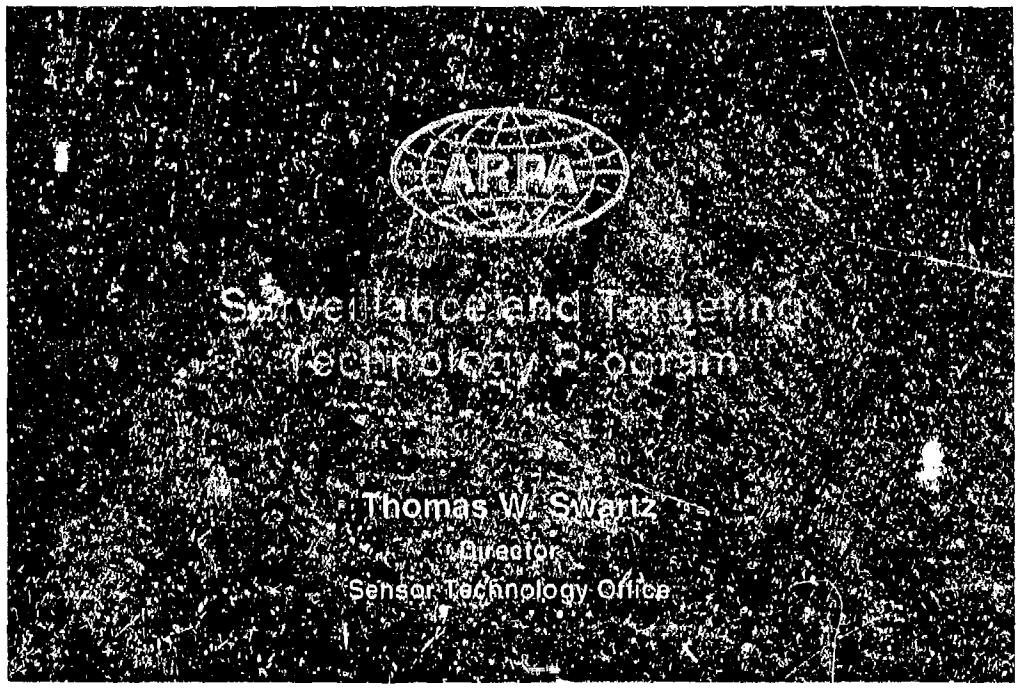
The TOPSIGHT BAA is decomposed into four primary systems, three WAS engines and a unifying control and inference. The three WAS engines are focused on:

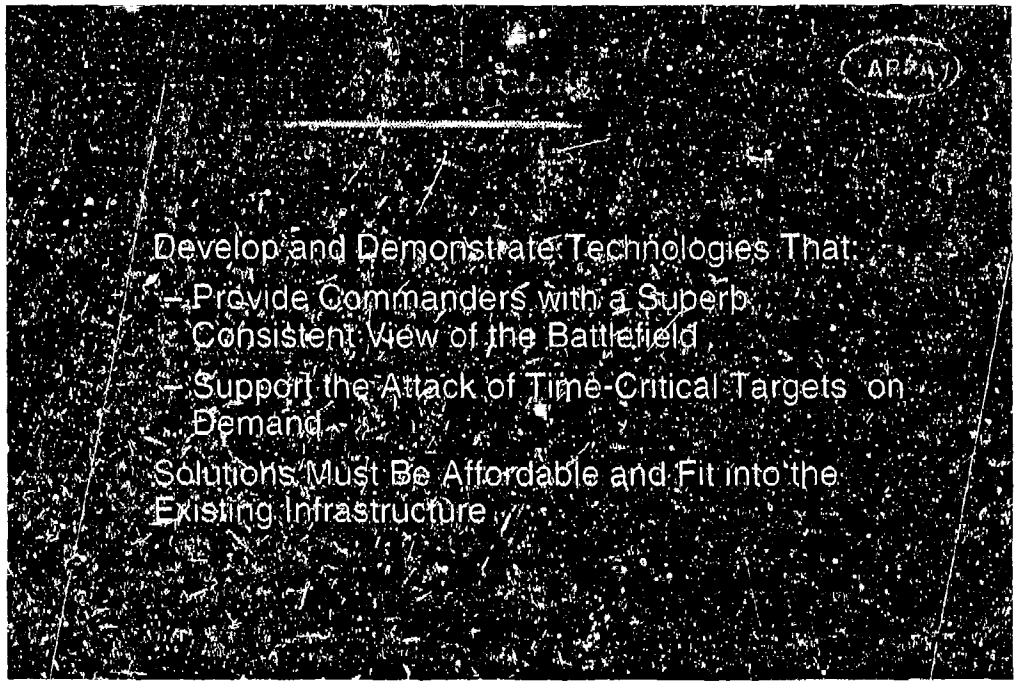
1. Forces
   - Maneuver and TCT/W/MD
2. Facilities
   - Existing Facilities and Manufacturing Nodes
   - New and Emerging Nodes
   - Underground Nodes
   - Environmental Indicators
3. Activities
   - Inter-node Traffic Identification and Analysis
   - Traffic identification and Analysis as an Indicator to other WAS Sensors

Each of the three WAS engines will solicit for:

- Domain
  - Observable(s) Analysis
  - Process Modeling
  - Inferential Design
- Basic Sensor Work
  - NTM, Commercial and MTI
- Design
  - Inferential
  - Decision Theoretic Control

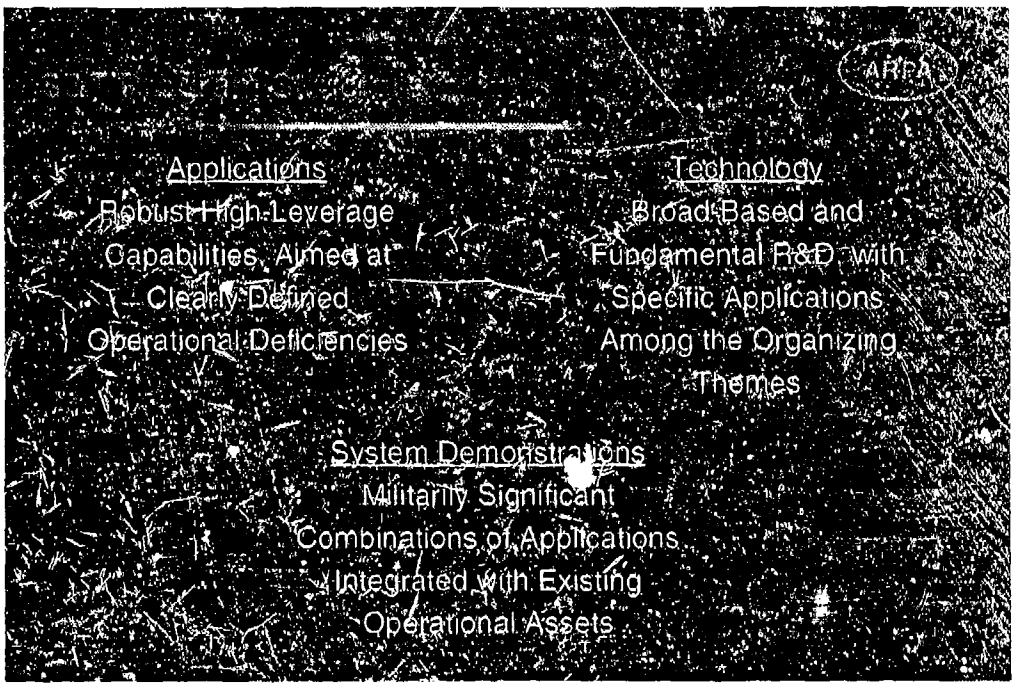
The objective of the C2IS BAA is to develop and demonstrate advanced technology that facilitates battlefield synchronization, supports Joint in-time Situation Awareness, decentralized battlefield execution, and flexible interfaces, particularly in early entry and subsequent sustained operations. While the focus of this effort is on ground operations, the early entry scenario involves key participants of multi-service and multi-national sea and air based operations.


DARPA
Surveillance and Targeting
Technology Program
Thomas W. Swartz
Director
Sensor Technology Office



Modern warfare demands that Commanders be able to visualize the battlefield and attack enemy capabilities at will. The view of the battlefield must be consistent so that different commanders (horizontally or vertically) obtain the same impressions. Different commanders vertically require different scales of information which still must be consistent. A major issue is to obtain surveillance and targeting data at the right place in a timely fashion for an appropriate, militarily viable response.

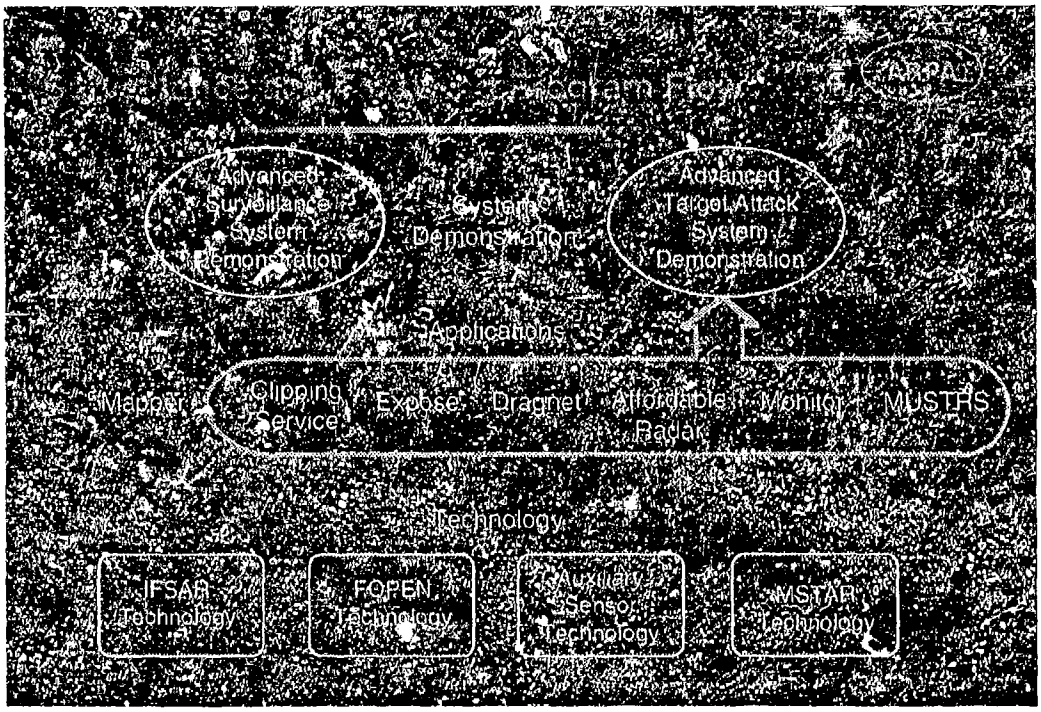
It is very important that surveillance and targeting systems be affordable and that the technologies contribute to improving affordability. New capabilities must complement rather than replace surveillance and targeting systems in existence. Currently, sensors and platforms are too expensive. We need system solutions to reduce the numbers required and technology to reduce the cost. The systems to be deployed must not impact the force structure andtherefore must be automatic to the maximum extent possible.



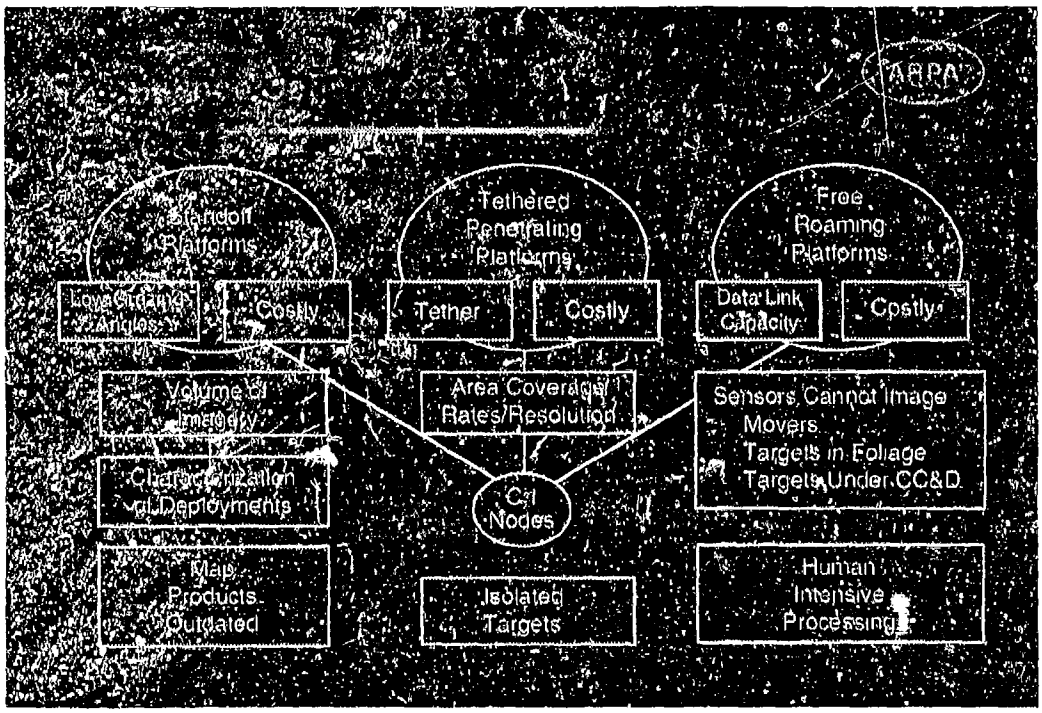
The ARPA program is structured along the three lines of: Specific Applications that are developed and demonstrated to deliver a solution to a critical portion of the problem that has been clearly defined. The solution is to 1) dramatically increase an inadequate, but critical, existing capability or 2) to fulfill a requirement not presently met in the force structure. The solutions supported must be based on critical needs.

Basic Technology is developed to support the needs of the Applications. Technological short falls, both short and long term are prioritized for support according to the criticality of the Application.

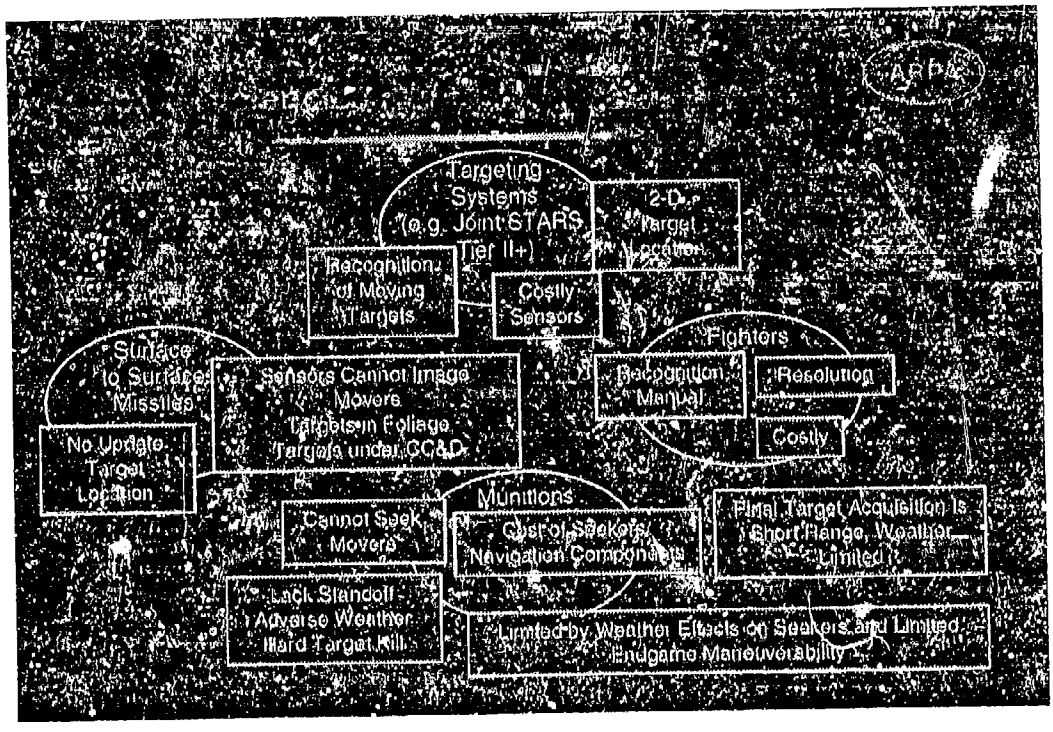
System-level Demonstrations will be conducted to demonstrate integrated capabilities.



The ARPA program consists of the specific elements listed here. Several of these are described in more detail later. This depicts the mapping of the program structure to specific Application areas (e.g. DRAGNET) and further shows the technology areas that support the total program. As the program matures, major System Demonstrations will be funded based on the application solutions.

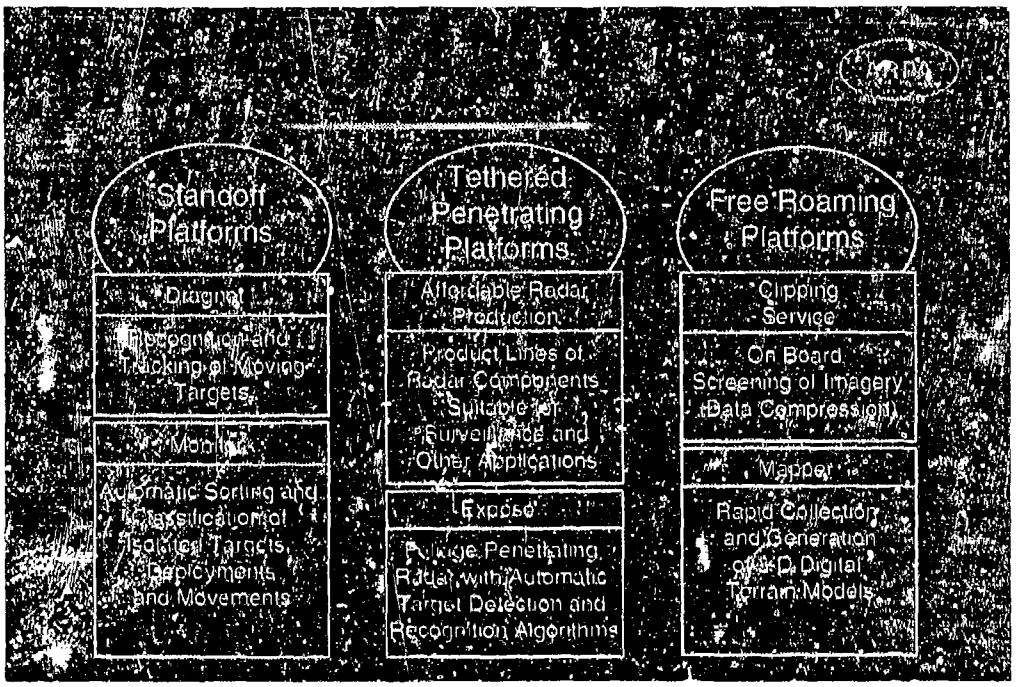


ARPA has analyzed current and near term projected surveillance system capabilities and identified the deficiencies shown here. In the case of platforms, it is seen that high cost is a major deficiency. This limits the total number of platforms that the services can obtain and limits the total area and/or timeliness of surveillance. There are many operational shortcomings in utilizing extant systems. These in general can be categorized as limiting our capability to find targets (area coverage, CC&D, resolution), or the timeliness of reporting and attacking targets (volume of imagery, communication nodes, human processing).

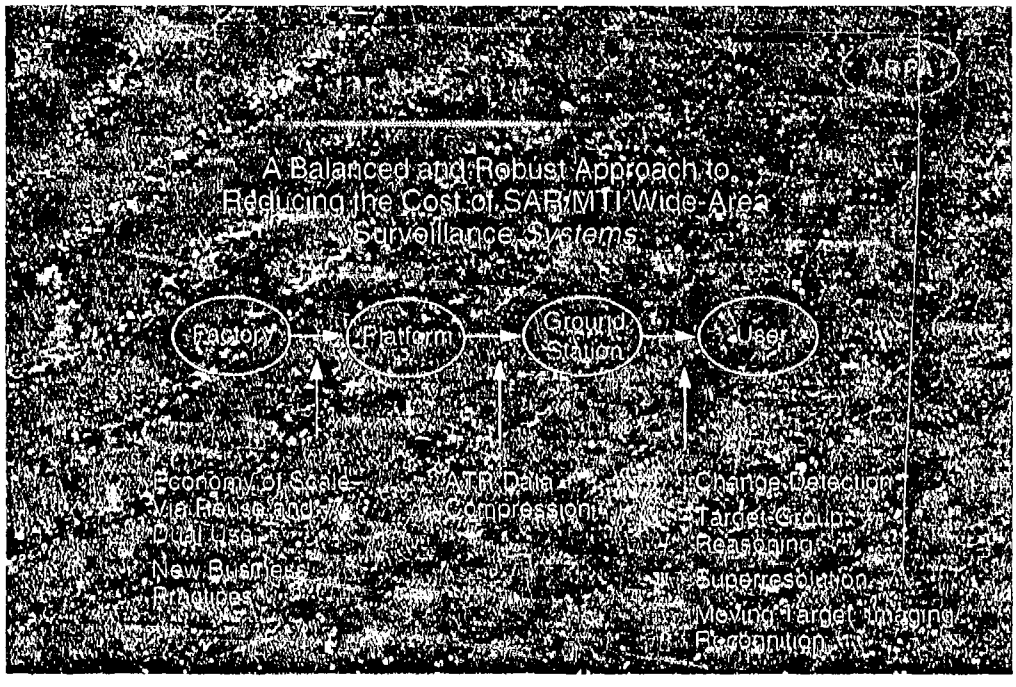


ARPA has analyzed current and near term projected attack system capabilities and identified the deficiencies shown here. Present target acquisition systems need high cost sensors that give limited capability to recognize specific targets. Because of these limitations, critical timeline issues develop.

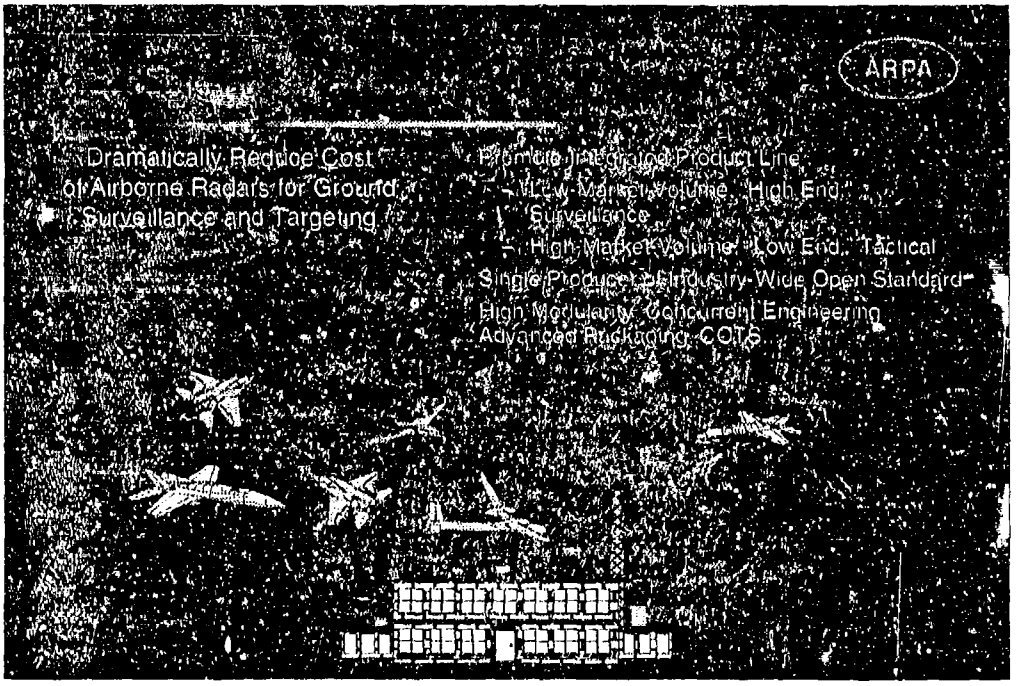
In the case of manned fighters, final target acquisition capabilities are short range and weather sensitive thus limiting capabilities to find and attack targets. This also makes the fighter more vulnerable. Present munitions also have sensor limitations that more advanced concepts will alleviate.



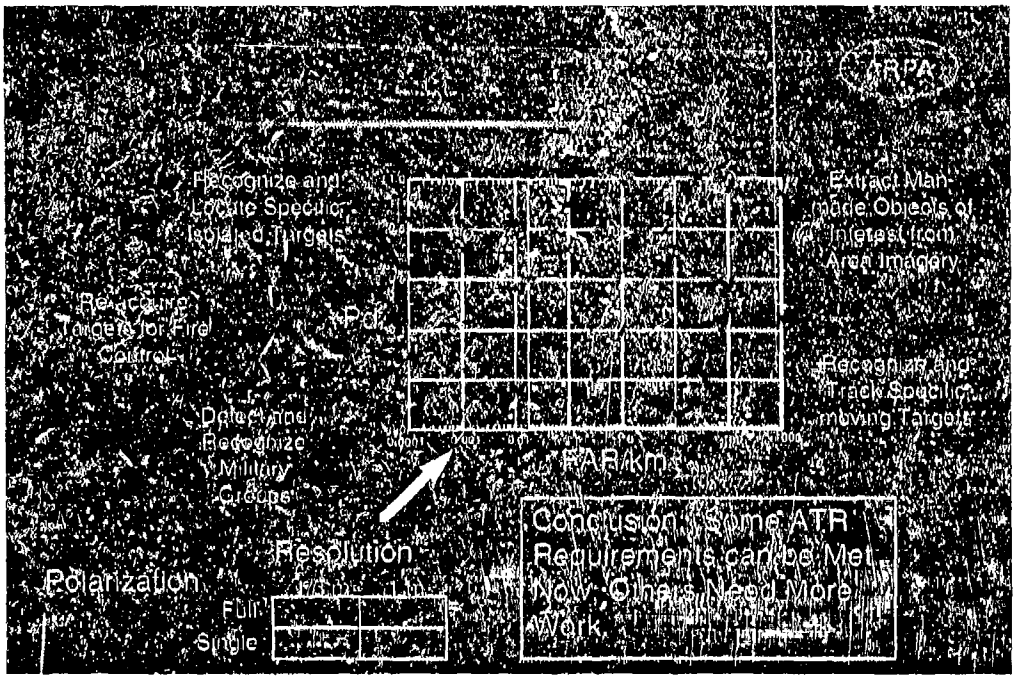
Based on the deficiencies, ARPA has defined specific applications to address each of the problem areas. As an example, of the broadness of applicability the affordable radar components would be utilized in all the platforms and would impact other radar systems directly or by example. Several of these areas will be outlined more fully in subsequent view graphs.



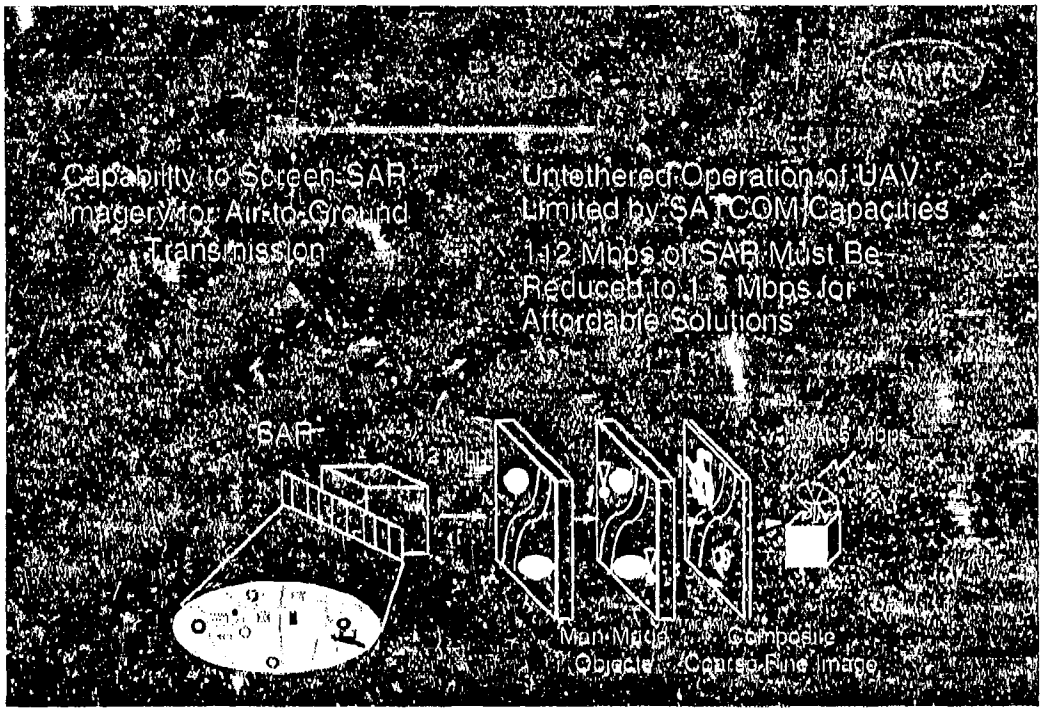
The ARPA radar cost reduction strategy is based on the three areas shown here. At the factory level, many special purpose components are built for each radar system, with an associated high cost. These systems are optimized mainly for performance. The new approach would add the constraint of cost to the optimization. This constraintrequires investigating the use of each radar component or some derivative in many other systems to obtain the benefits of large scale production. Platform to ground station down linking is a large system expense. By sorting the areas of interest on the platform, in real time, and only down linking these with enough surrounding information to retain context, large data compression ratios can be obtained. Down links to, transmit this amount of data are very affordable. This requires a capability to detect man-made-ness on the platform. Present Ground Stations use many analysts to exploit the data and to then plan missions. These activities are thus very time consuming and expensive in operation costs. Automating these processes will reduce the number of analysts required and at the same time increase the throughput of imagery exploited.



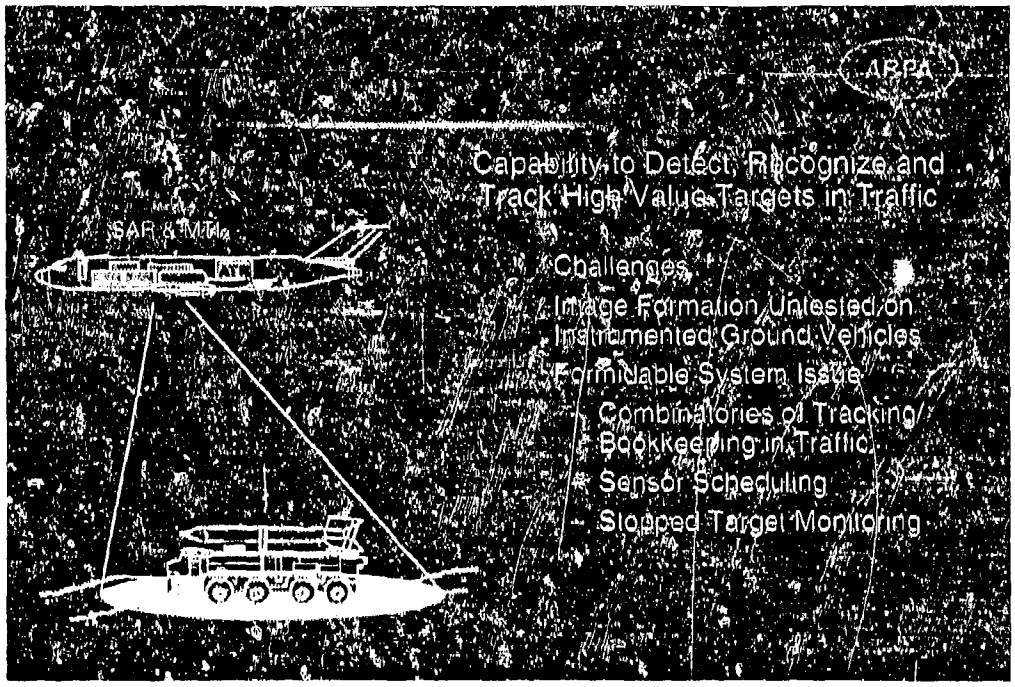
One program in Low Cost Radar involves the reduction of hardware components per se. This program approach is summarized here. The reduction in cost is based on obtaining an integrated product line of "common modules" that can be utilized in both the high production tactical systems and in the low production surveillance systems. The strategy includes the use of Commercial Of The Shelf (COTS) hardware and software.



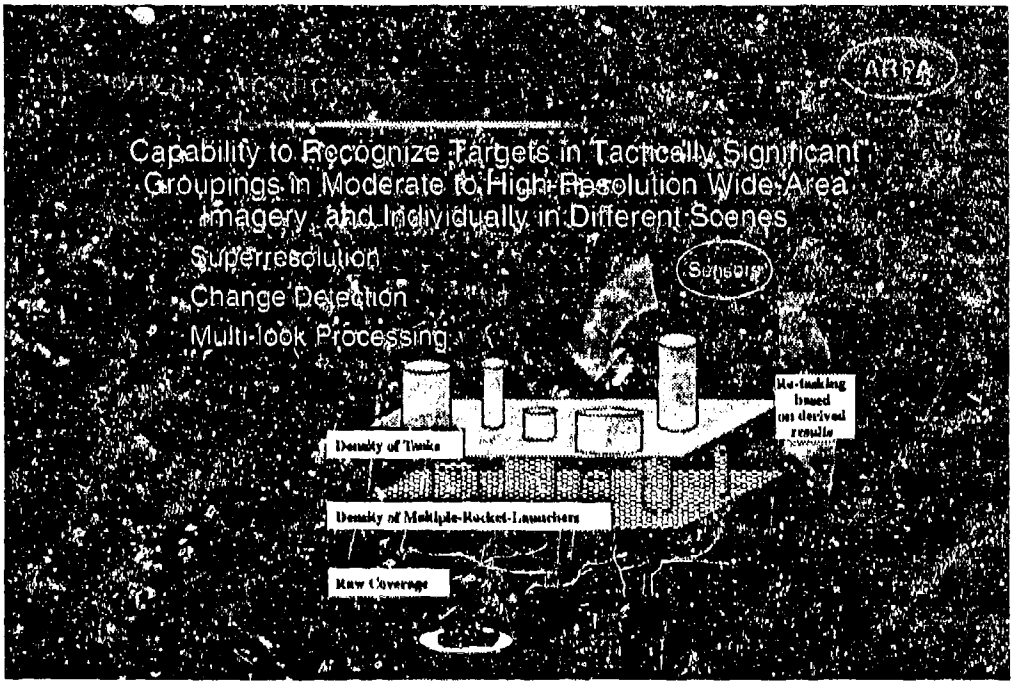
The state-of-the-art in sensor and ATR performance is summarized here. The best performance is achieved using a sensor with 1/3 meter spatial resolution and measurement of the full polarization matrix. Overlaid on the performance data are the requirements associated with conducting several military oriented tasks. The observation is made that the state-of-the-art in sensors and ATR actually supports the development of systems to perform some of the listed functions, while additional progress is necessary to reach all of the requirements.



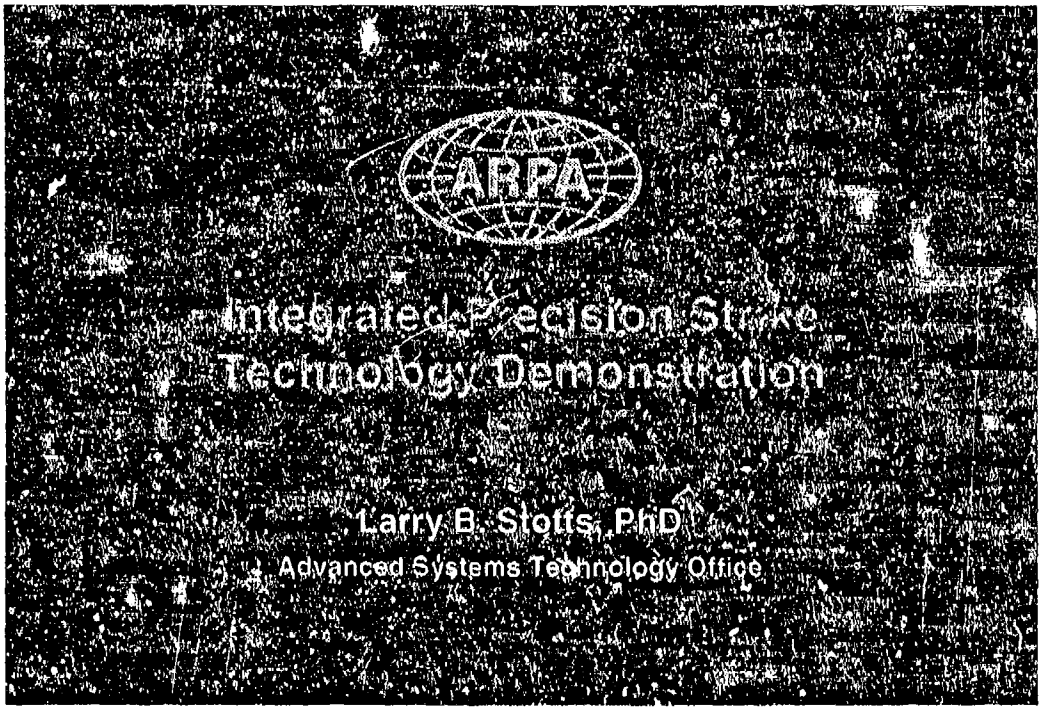
The automatic screening of imagery is can be performed using state-of-the-art sensors and ATR. The specific application being addressed by ARPA is the reduction in the imagery which must be passed over a data link from a UAV (specifically the TIER 2+ system). It is shown here that a compression ratio of approximately 100:1 is the goal of the system. Between the ATR function and a modest compression algorithm this goal is conservative. There are many approaches being investigated in both industry and academia.



The detection, recognition and tracking of moving time-critical targets is deemed to be an application which can be addressed by state-of-the-art sensors and ATR. The DRAGNET program will develop and demonstrate the capability described here by exploiting target characteristics during movement. The ability to predictably detect and recognize targets using motion as a cue is inhanced since the aspect of the target is defined by the motion and the target signature is better characterized since doors, auxiliary equipment or camouflage are not a factor.



Future SAR sensor systems (e.g., TIER 2+) will produce prodigious amounts of imagery of the battlefield on a regular basis. Summarizing and assimilating the information available from this data is a new and unique problem. MONITOR will apply the enabling technologies shown to effect a capability for synoptic situation description.

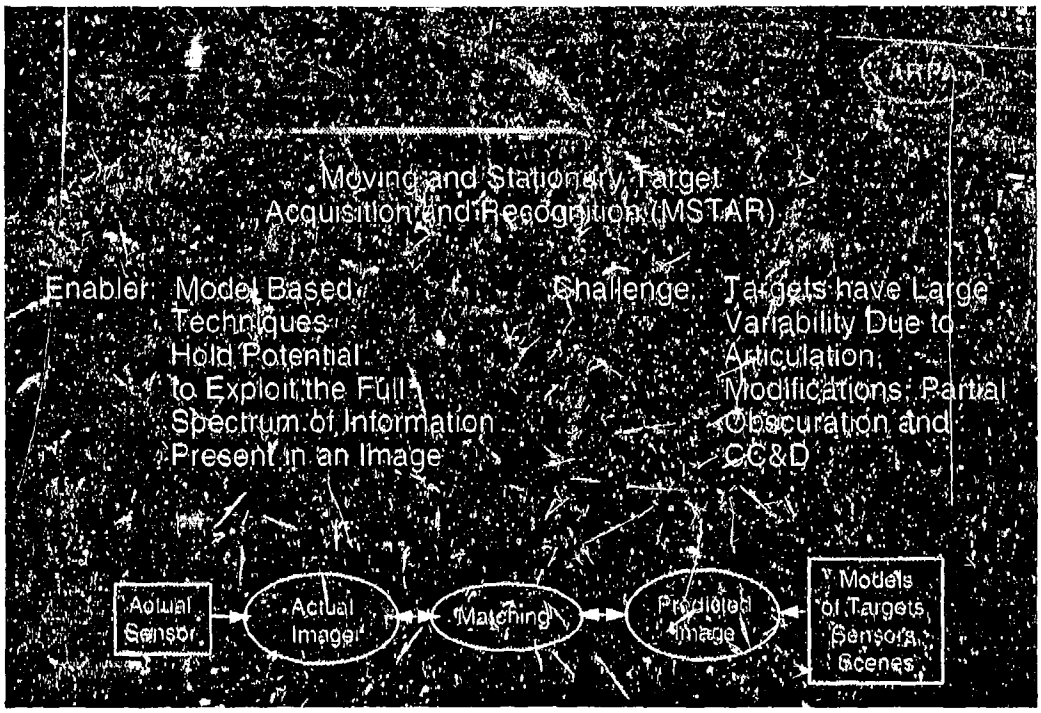


Good afternoon, I'm Larry Stotts and I'm going to describe for you an Integrated Precision Strike Technology Demonstration.

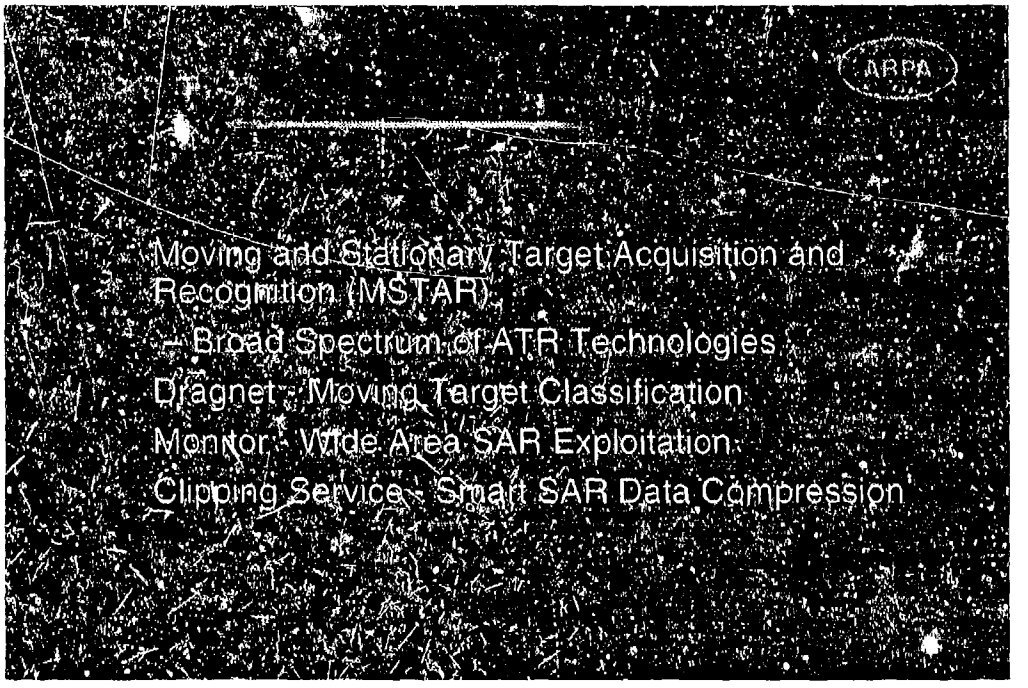
The name of the program is Sharpshooter. This program will exploit and integrate ARPA enabling advanced technologies to achieve the affordable, precision weapon improvement objectives outlined here. Technologies are applicable to manned and unmanned platforms, as well as fire and forget, standoff weapons. Retrofit and new weapon markets are candidates. Other programs are addressing the surveillance and targeting capability improvements. For example. Dr. Daly and Mr. Swartz just briefed you on the War Breaker I&P and S&T programs, respectively. These proposed efforts will provide responsive, robust, wide-area surveillance and targeting with accurate geolocation, both in the nearterm and farterm. Also, Mr. Entzminger briefed you on a nearterm development of a related capability this morning, TIER II+. The primary set of ARPA technologies to be exploited in Sharpshooter include:

- The Global Positioning System (GPS) Guidance Package, or GGP,
- Common Grid,
- Low-Cost Infrared Focal Plane Technologies,
- Multi-Missile Manufacturing, and
- Low-Cost Synthetic Aperture Radar

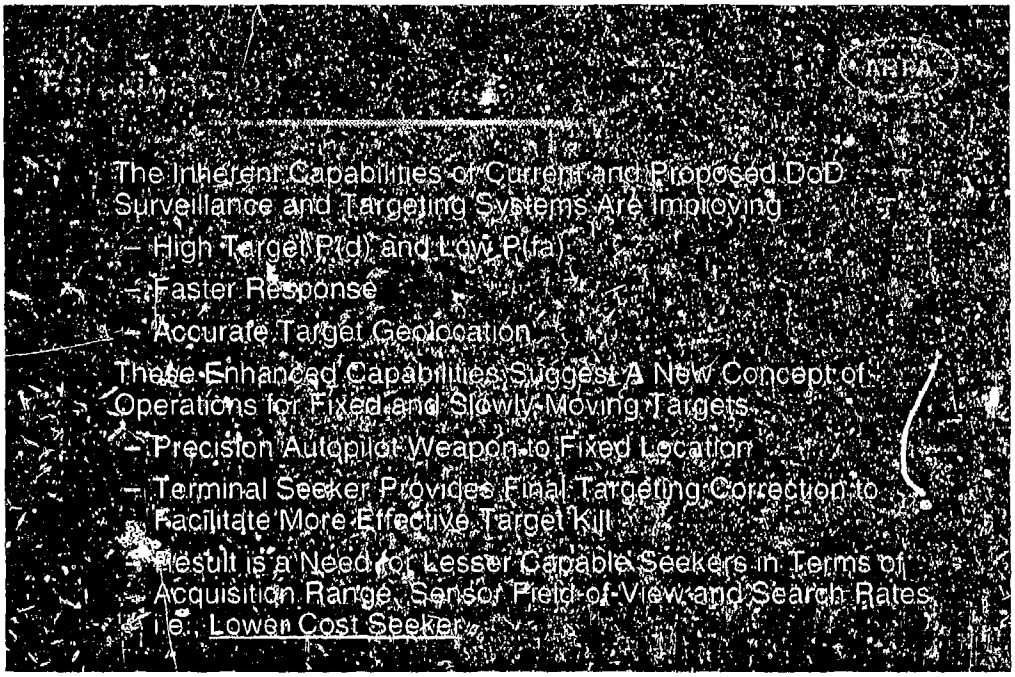
Mr. Balcerak and Dr. McGrath described Low-Cost Infrared Focal Plane Technologies and Multi-Missile Manufacturing this morning. Mr Swartz discussed Low-Cost Synthetic Aperture Radar in the previous talk. I will describe GGP and Common Grid, as well as the potential integration of all these technologies in the remainder of my talk. Other ARPA technologies such as electronic packaging, Microwave Monolithic Integrated Circuits and MicroChip Modules supporting the Sharpshooter concept will not be discussed because of the time. These supporting technologies are important to system affordability and that should become evident in several of tomorrow's talks.



Many of the Application programs described earlier are feed by the automatic target recognition (ATR) technology developed under the program summarized here. ARPA is investing in a major thrust to dramatically improve ATR performance by fully exploiting model-based reasoning. Prior ARPA programs exploited target and sensor models for ATR. Here we are expanding the research to include models of the environment, scene, target behavior and force structure to allow the reasoning process to exploit all information available.



ARPA intends to conduct several procurements in FY95. The items shown here will be formally competed and appropriate announcements will be found in Commerce Business Daily.

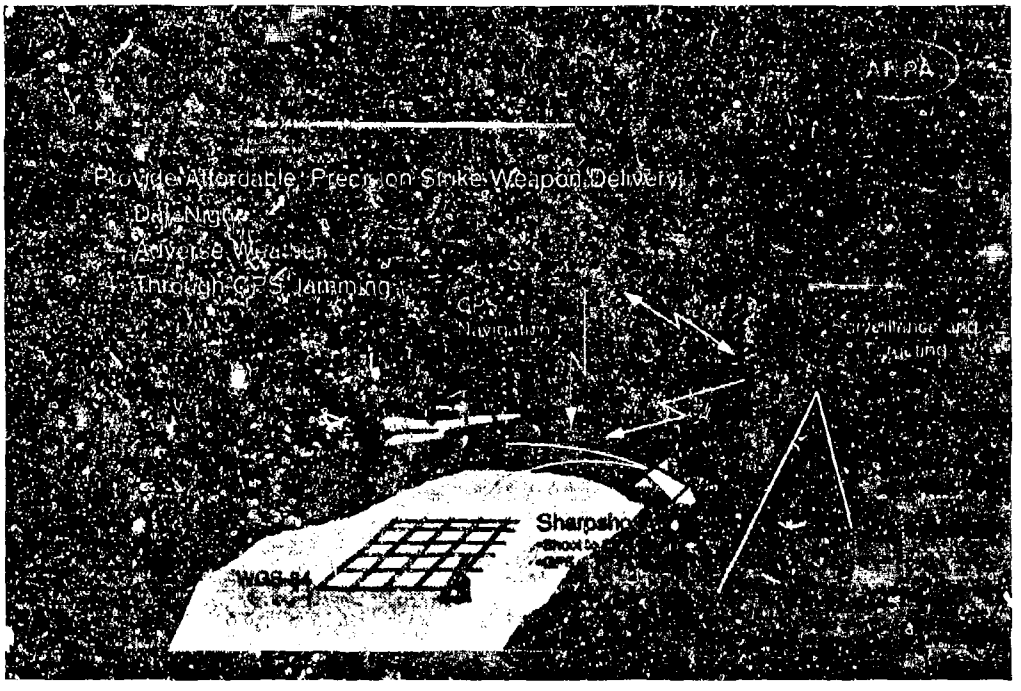


During Desert Storm, a major shortfall existed in the surveillance, targeting and prosecution of mobile, time critical targets. Key Commanders at the time, such as General Short, Deputy Director for Operations, Air Combat Command, identified major problems such as:

- Intermittent sensor availability,
- Ambiguous target detection, classification and identification,
- Variable targeting accuracy, and
- Response outside enemy weapon cycle time

In Fiscal Year 1992, the DoD responded with improvement programs in all four areas for existing surveillance and targeting systems such as ASARS-2 and JSTARS. In addition, new proposed systems such as TIER II+ and TIER III- have addressed these shortfalls beginning with the initial design. These enhanced capabilities offer a paradigm shift in precision weapon delivery.

With accurate target detection, classification and geolocation of fixed and slowly-moving targets, one can direct (or autopilot) a weapon to an earth coordinate and use a weapon seeker to perform the endgame target location error correction/fusing operation. The advantage is that the seeker can operate within a shorter acquisition range to the target, use a reduced set of target masks, utilize a smaller field-of-view as set by the geolocation error, and not need large search rate capability. The result is a potentially lower cost seeker head because of the reduced performance requirements. Also, it may improve the weapon's probability-of-kill and minimize collateral damage.



The notion of affordable, precision strike weapons has much merit. It is complicated by the need to provide capabilities now lacking:

–Operations day/night and in adverse weather

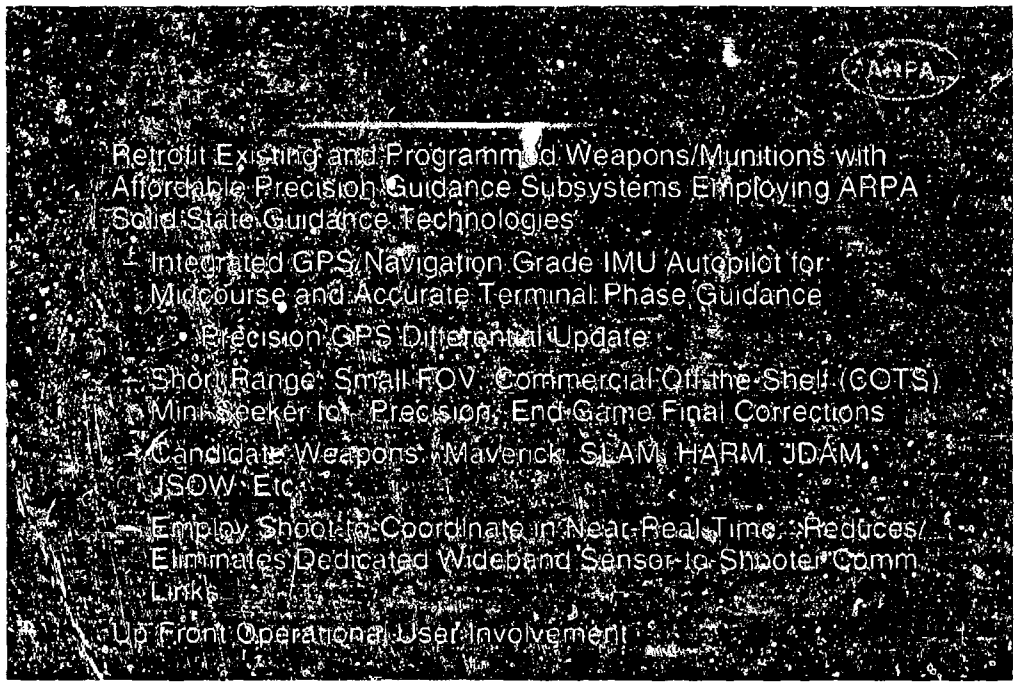
–And since GPS is our standard for world-wide navigation, effective target prosecution when our GPS receivers are jammed

The concept of operations implies that the weapon can shoot to the target coordinates. How would this be done?

–The surveillance and targeting platforms operate with accurate geolocation

–So does the strike aircraft and the weapon

–This is all done in the GPS, i.e., WGS-84, coordinate system



This is not a program to develop a new air-to-ground missile, a new smart bomb or a new imaginary weapon.

We can retrofit existing weapons and/or munitions.

The key innovative factors are designated at the arrows.

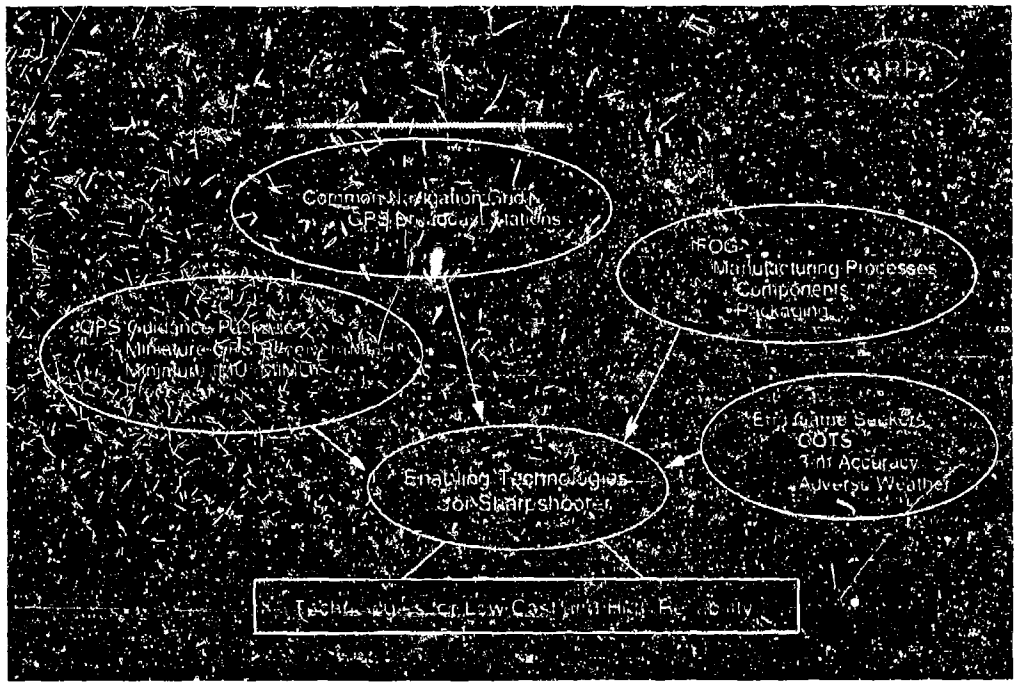
–We incorporate both [emphasize *both*] GPS navigation and navigation grade inertial for midcourse and terminal guidance

»Both GPS and inertial nav are on the weapon

–The combined benefits of more precise targeting, navigation to the launch point, and weapon guidance will reduce the range, FOV and complexity demands on the weapon terminal seeker.

We can shoot to the coordinates of the target and we do not need dedicated sensor to shooter communications.

Our concept and accomplishments for all of this will be under the cooperative scrutiny, up front, by the primary; the USAF Air Combat Command.



The components of the ARPA program are shown on this chart.

The GPS Guidance Package (or GGP program) combines a miniature GPS receiver with a Miniature Inertial Measurement Unit (MIMU) to form a tightly integrated navigation sensor. This combination couples the high quality, long term performance of a GPS receiver with the relatively short term, high performance of an IMU. Associated digital processors are included to form a high quality, integrated navigation unit. The ARPA solid state, MIMU features IFOGs. Hence, IFOG manufacturing is a natural outgrowth of and contributor to this program.

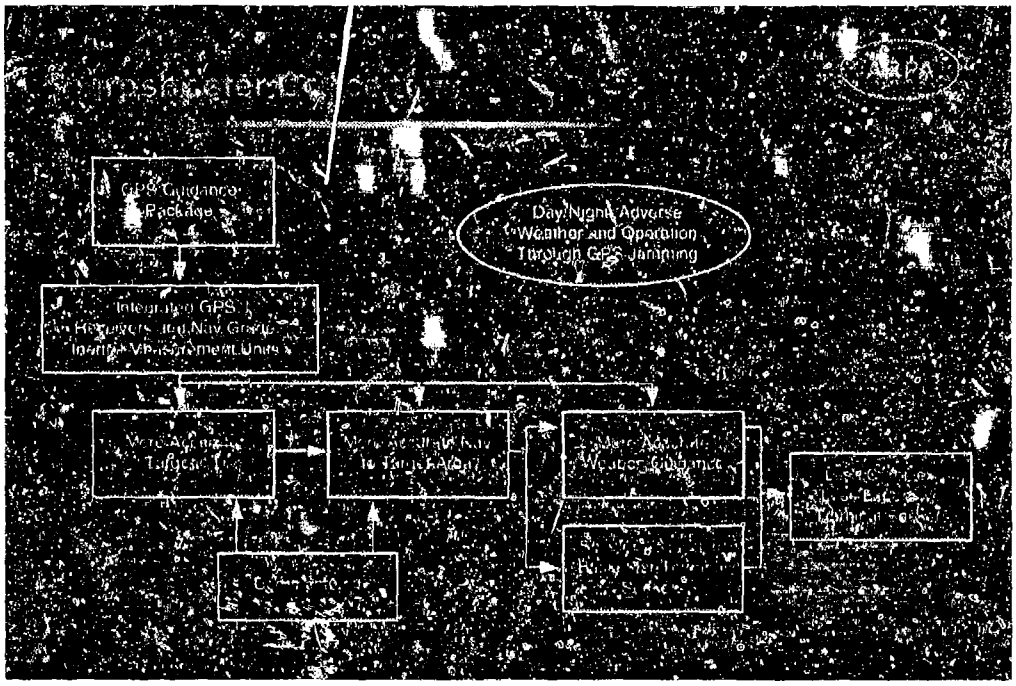
The Common Grid program will provide a theater-wide, highly accurate common position and timing reference for targeting and navigation. Common Grid capitalizes, among other things, on the miniature GPS receiver developments in GGP.

The IFOG Manufacturing component will provide for the development of the manufacturing infrastructure to develop high performance, navigation grade, low cost IFOGs. The fabrication technologies needed to produce such an IFOG will be developed. This effort will develop the capability to produce highly reliable miniature IFOGs at low cost and will develop improvements in the components and in the packaging to meet these goals.

These technologies will be available for insertion into a number of systems such as:

- –Surveillance and Targeting Platforms, Launch/Strike Platforms and Precision Guided Weapons
  - »One of the last of these is Sharpshooter

The bottom line is that we are capitalizing on advanced guidance technologies in order to increase force effectiveness with an emphasis on low cost and high reliability.



This chart is a diagram of the logic of the concept for Sharpshooter. Availability of guidance and navigation units such as GGP will enable ...

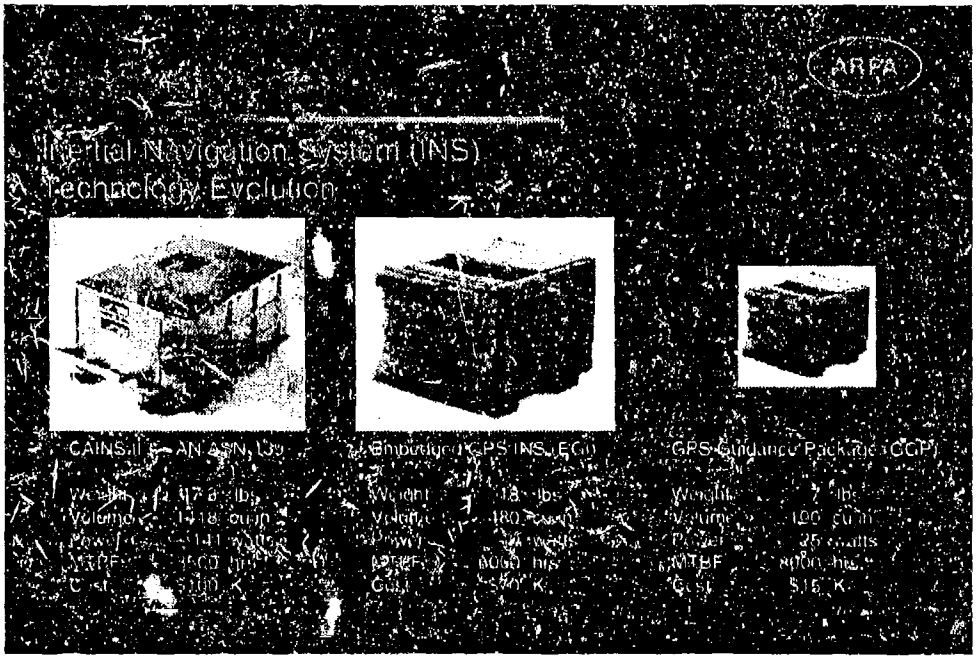
–More accurate geolocation and sensor pointing aboard surveillance platforms – thus more accurate targeting

–More accurate navigation of strike aircraft to the target coordinates

–More accurate navigation and guidance of weapons, after release, to the resultant acquisition basket.

–A smaller resultant acquisition basket, thereby reducing the demands for search and acquisition on the part of the weapon terminal seeker, there by allowing the seeker to be less complex and less expensive.

Accuracy of navigation and target geolocation can be further augmented by the ARPA integrated technologies for Common Grid.



Here is a comparison of two navigation sets, CAINS II and EGI, with the GGP goals. We are in source selection for contracts to extend the development of GGP to these goals. Note, for example, the reduction in weight, volume and power of GGP vs CAINS II:

7 lbs vs 47.3 lbs, a factor of about 7
100 in^3 vs 1,418 in^3, a factor of about 14
25 w vs 141 w, a factor of about 6

All solid-state components in the GGP will also result in increased mean time between failure and reduced cost.

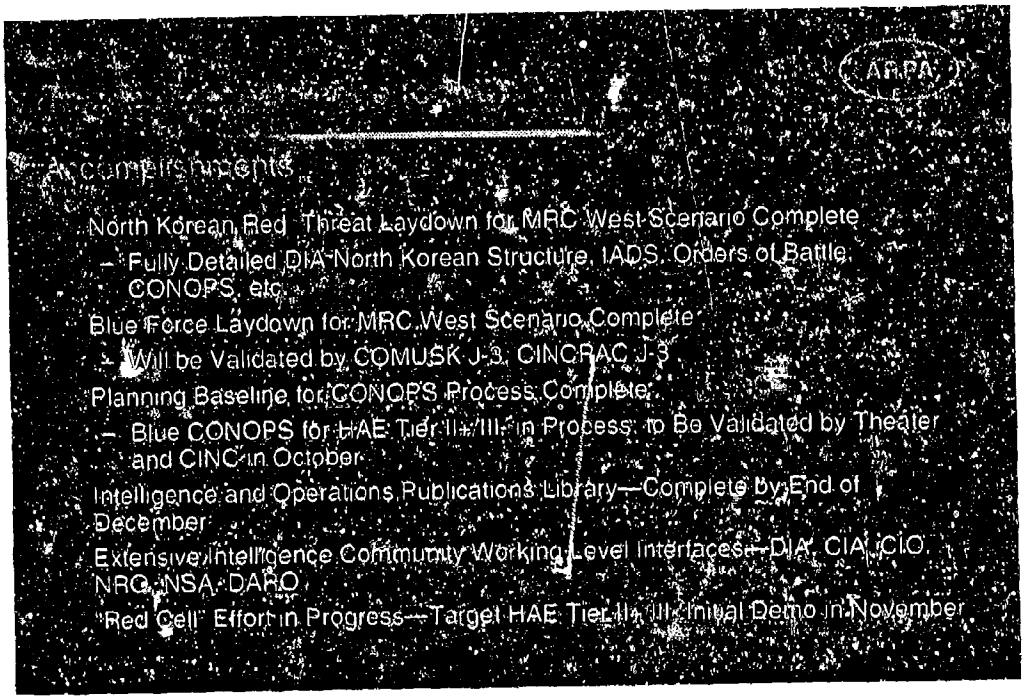


Without changing the components or operation of the Global Positioning System, we can provide theater-wide enhancements to navigation and target geolocation. This can be done in the common GPS coordinates, which correspond to WGS-84.

Specifically, platform location accuracies can be reduced from 15 meters to one-to-three meters. Worldwide GPS timing accuracy of 100 nsec can be reduced to 5-10 nsec, in theater.

Ground-based, mobile, self surveying transmitter stations will refine GPS accuracies, transmitting corrected signals to authorized users such as surveillance platforms and strike aircraft. This project is a classic technology integration one for ASTO.

There is also an important technology issue already being addressed: a frequency standard, or atomic clock.

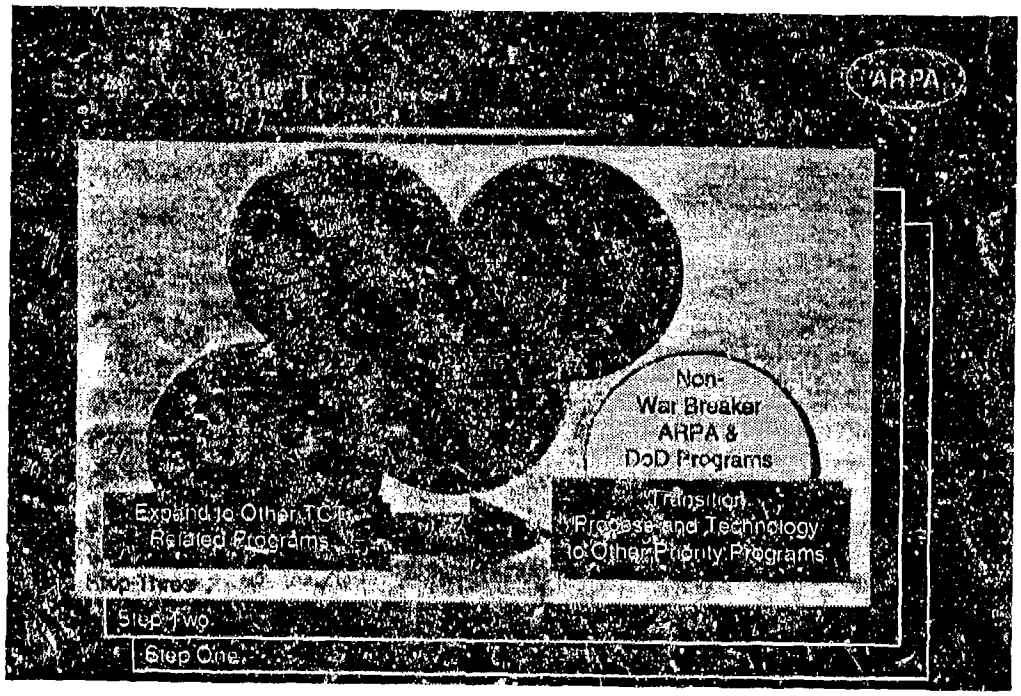


The Korean portion of the "Road to War" will be completed by the end of October in preparation for use in analyses to be conducted in support of Tier II+ and Tier III- High Altitude Endurance (HAE) unmanned aerial vehicle (UAV) development programs. The analyses and simulations will be used to develop the concepts of operations and performance

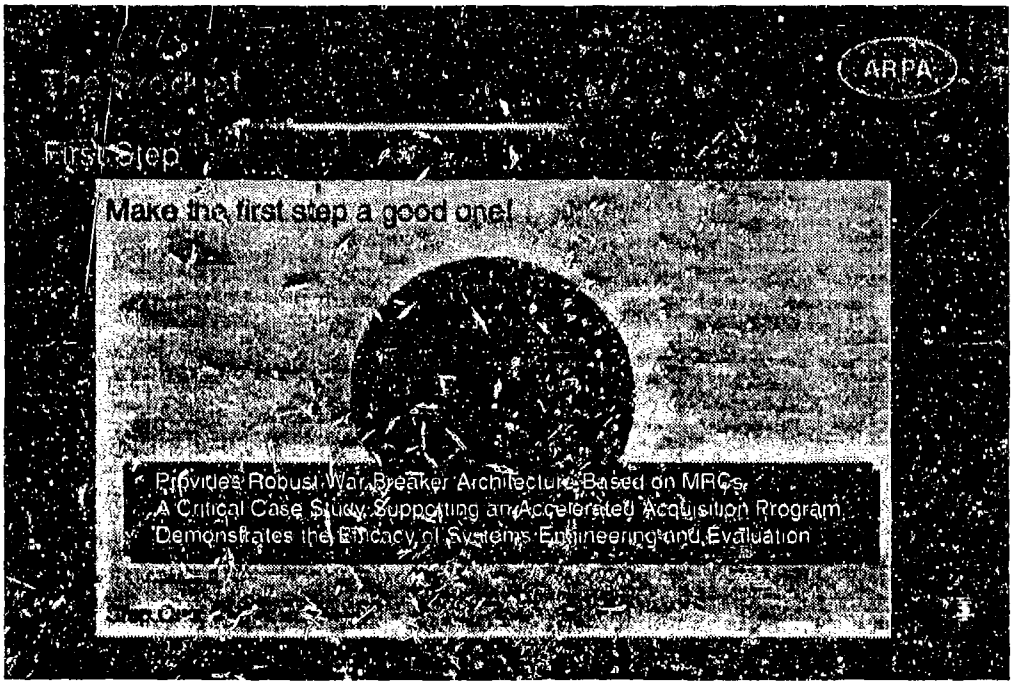
evaluations for the aircraft sensors..



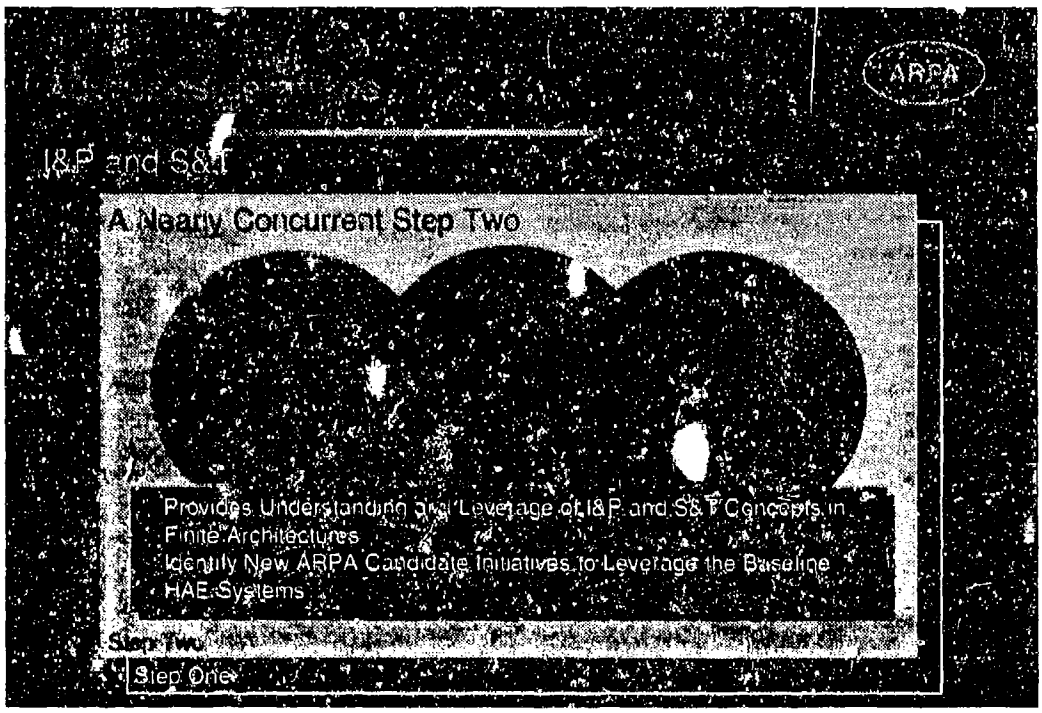
All source analysis, to date, has focused ARPA interest and effort into technology product areas listed on the "products" slide. All of the areas listed fill an identified need in prosecution of time critical targets. Notice that I have included the tool set used in the analyses as well as any future tools developed. This list forms the foundation for the two following presentations in War Breaker Intelligence & Planning and Surveillance & Targeting efforts.



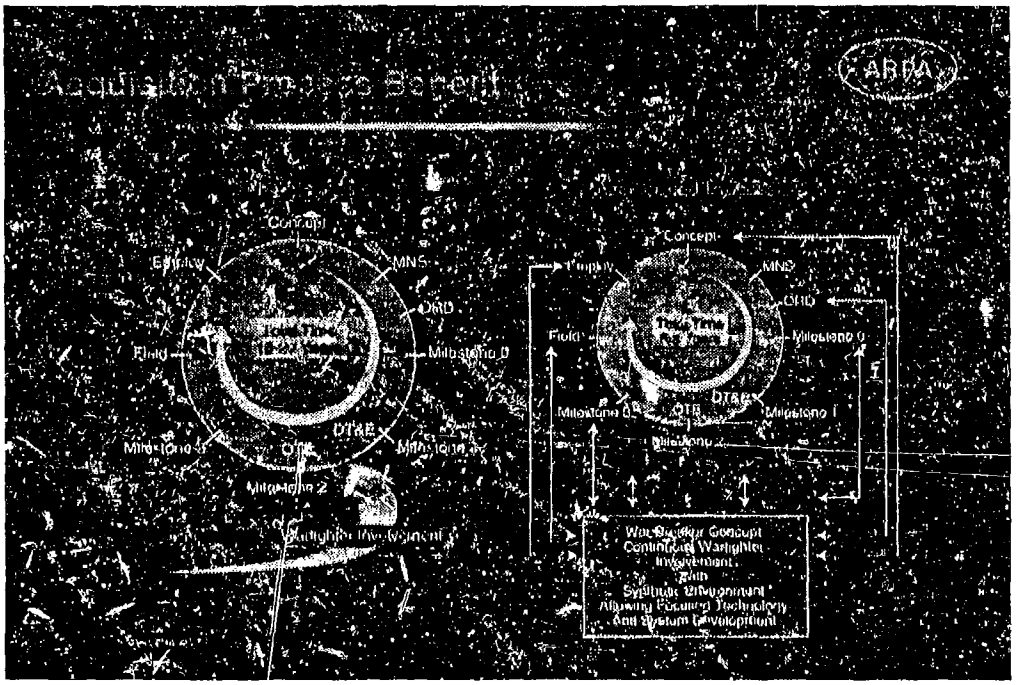
Controlled expansion of the systems to be analyzed will progress to include other ARPA initiatives such as Signals Intelligence (SIGINT) collection platforms. The step-wise progression of analysis enables controlled cause - effect insight to be gathered in the complex interactive scenario trade space.



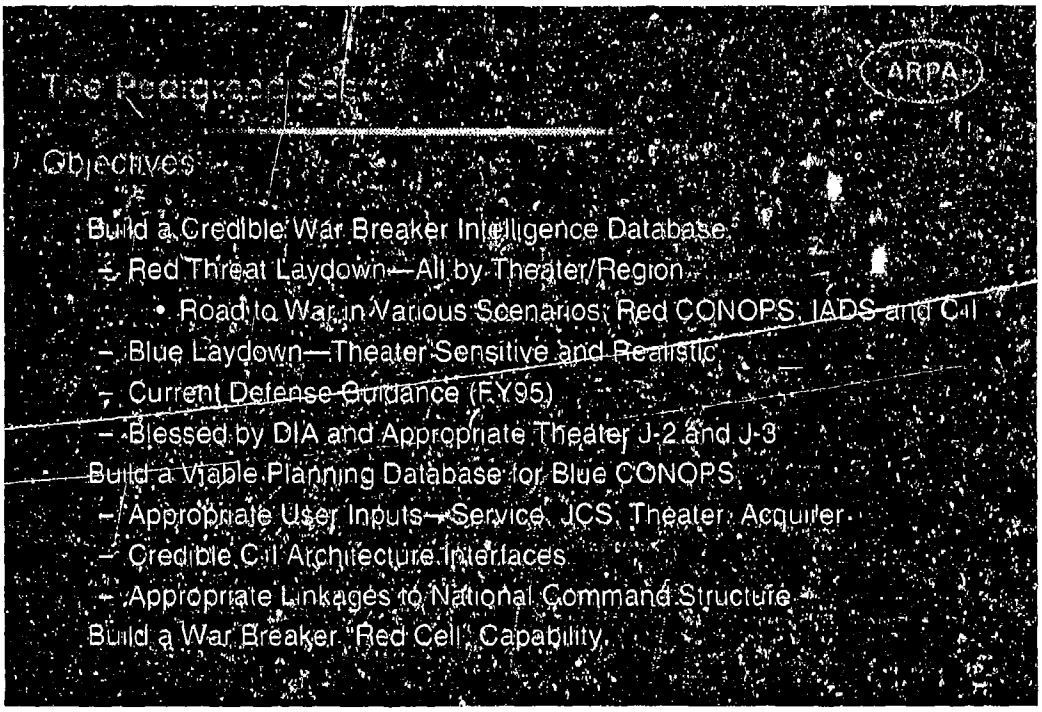
The first step is a big step and entails preparation of the battle space to support the analyses and the analytical process definition to employ simulation encapsulated analytical tools. In this case, the bulk of the preparations are generic to any systems analysis. Only the unique models that tie directly to the UAVs would be included in the normal preparation. The "road to war" is a reusable environment in which to conduct numerous analyses.



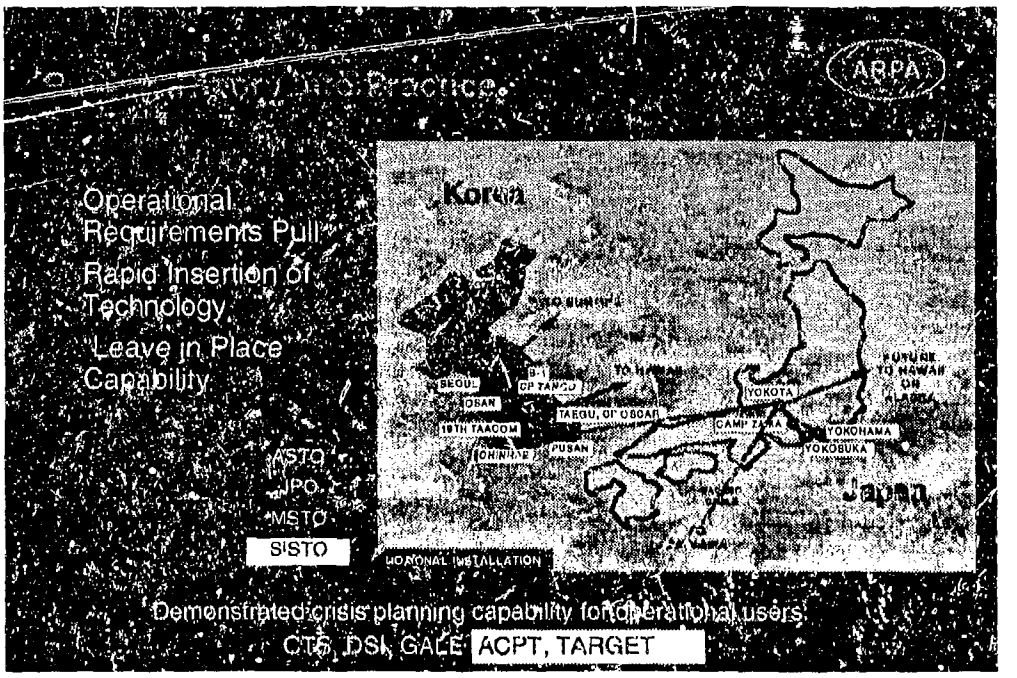
An expansion of the HAE UAV analysis will come from sensor systems trade study analysis wherein additional features or improvements will be considered. Similarly, changes in information dissemination and command and control could be injected into the analysis to evaluate performance sensitivities. Environment replication and other factors must necessarily be controlled in order to avoid the "statistical noise" associated with absolute free play. These evaluations would result in a set of pre-planned product improvement (P3I) candidates to be applied to the Tier II+ and III- sensor payloads if funds become available.



Knowledge gained through the use of all simulation based analyses enables the systems to be exercised and stressed before, during, and after development. The simulations enable sensor level insight to be gained on the systems' performance with or without a man in the loop. Applied in the early phases of the acquisition cycle, performance based design changes can be made to better tune the systems' design to meet the users' needs. Applied in the test phases of the cycle, simulation based analyses can stress the system and operator to gain insight into the best application of the system and can lead to development of employment tactics. In short, the system simulation and analysis dramatically shrinks the acquisition cycle and better defines the product to fit the tactical commanders' needs.



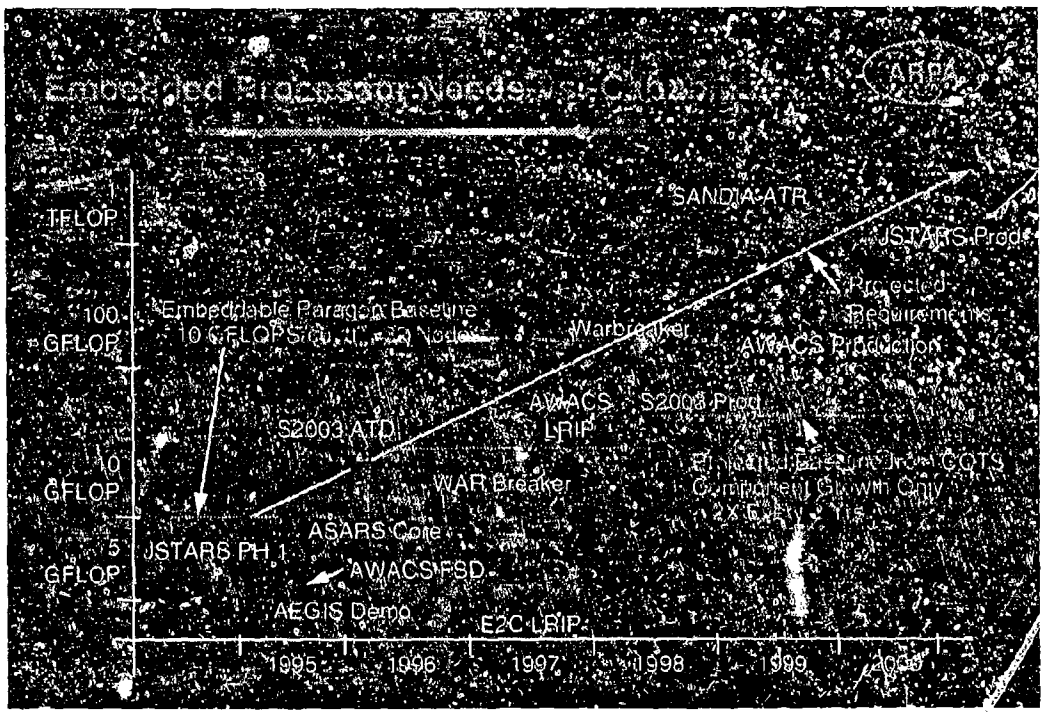
Since everything but actual war is simulation, the scenario used to represent a war becomes crucial to the validity of the analyses conducted. A "Road to War" with various scenarios is being put together based upon the JCS approved nearly simultaneous dual major regional conflict situation involving a North Korean invasion of South Korea and an Iraqi invasion of Kuwait. The National Air Intelligence Center is providing the actual intelligence threat target laydown and multi-spectral threat profile with doctrine based concepts of operations and C4I structure. Similar blue force laydown is being prepared in accordance with current defense guidance and the whole evolution is being blessed by DIA, Theater J-2 and Theater J-3 review. Terrain data bases and features data bases are being prepared for the Korean peninsula and road network overlays are being constructed. Also note the existance of a Red Cell capability to be exercised with men-in-the-loop during threat excursion sensitivity analyses.



The best testimony to the success of the development approach is the recent successes in the installation of five different support systems in Korea. These advanced command and control systems were funded specifically by Congress to provide enhanced capability in support of real world events.

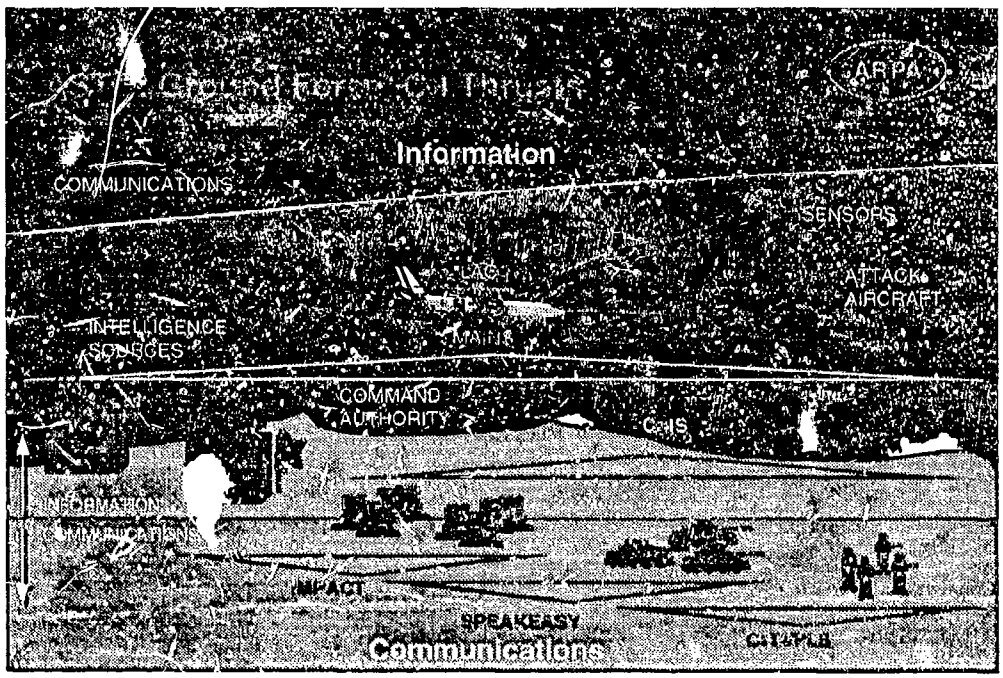
The Functionality ranges from better communications throughput, significant new red force tracking ability, advanced air planning, distributed collaborative planning, and a greater capability for all service information to provide a shared perception of the area of concern.

Each of these systems were ongoing efforts that were rapidly adapted for application in the Korean scenario. They are examples of user involvement and evolution, and provide a leave-behind capability consistent with our implementation strategy.

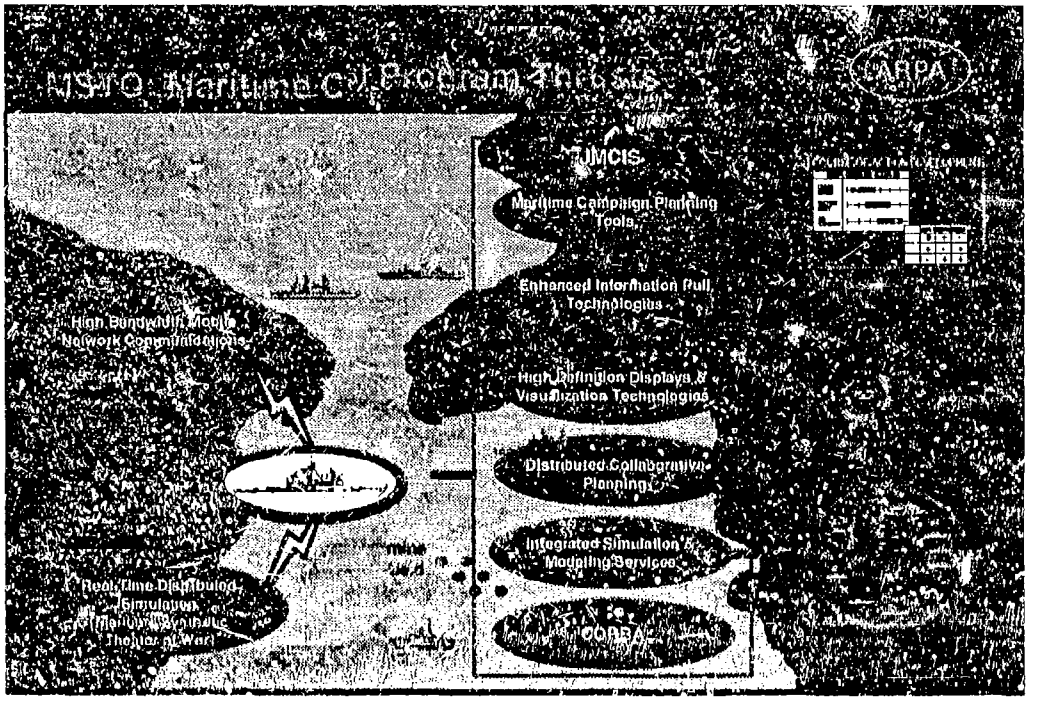


Many defense platform computing requirements have been identified over time and are represented on this chart. Requirements for 1995 and 1996 are reasonably accurate but requirements in the out years are likely to change significantly as missions and budgets change. However, there is a clear trend indicated by the projected requirements line superimposed on the scatter plot of requirements.

This line represents an exponential growth in computing performance over the next few years with multiple teraflop applications by the year 2000. The stair-step line represents the embeddable computing baseline of 10 gflops/cu.ft. which is the near-term computing density target for this program. The stair-step performance tracks the same 1 cu. ft. computer over time assuming only the processor performance improvements expected in the commercial market. This chart concludes that system performance derived from processors alone will fall short of demand by 1996. System requirements may be met in the out years by scaling up the number of nodes or by increasing the computing density of each individual node through performance acceleration.



The C3I thrusts within ASTO are focused at the Land Combat Level. Starting at the lower right, the Commercial Communications Technology Testbed and the Personal Location System are efforts to support the individual combat soldier. The C2T2 program is evaluating commercial communications for military use in a soldier worn display. C2T2 will participate in the Advanced Warfighting Experiment 96-02. The PLS will provide the individual soldier position location and a "911" capability. Moving up and to the left, the SPEAKEASY program is the development of a multi-band, software reprogrammable radio using Open System standards to provide flexible interconnectivity and wide bandwidth, Phase I has just been completed with a demonstration of simultaneous operation of SINCGARS and HAVEQUICK. IMPACT is a program to pursue technologies that can provide improved performance at lower cost for MILSATCOM terminals. Command and Control Information Systems (C2IS) is a new start that will focus on C2 challenges in Early Entry scenarios. Goal is Near Real Time, Fused, situation assessment at the Battalion Level. The Multpile Access Intelligence and Nomination System (MAINS) is an extension of the JTF ATD to the tactical User to support target nomination. A demonstration of this revolutionary targeting process was conducted with CTS/TACCMS in Korea The Local Attack Controller links Operations and Intelligence for Time Critical Target Prosecution. It will be demonstrated during the Joint Air Force/ Army Attack Operations at Roving Sands in FY95.



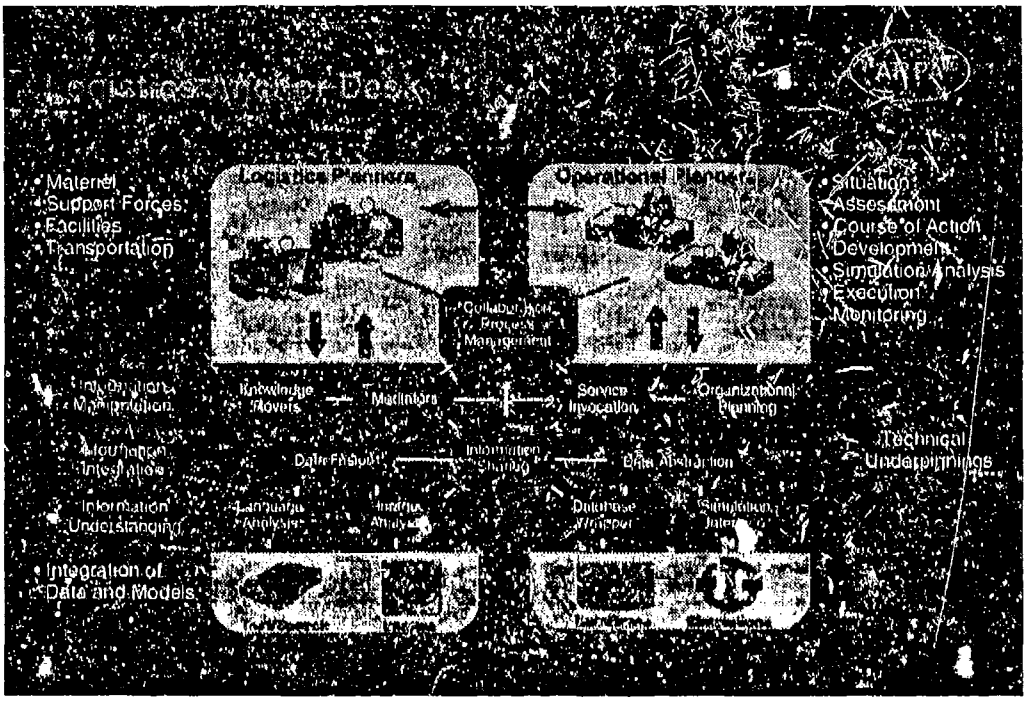
The development process employed by MSTO is similar to those of ours in SISTO. In a maritime environment, they identify technologies which offer best, most rapid improvements for Maritime C3I & Planning. Employing the Intelligent Engineering approach, they enhance technologies for optimum contributions to maritime C3I and adapt them to operate with & within the existing JMCIS architecture Installations, tests, and demo's are conducted on C7F/C6F Flagship at regular intervals. Finally the proven technology is transitioned to SPAWARSYSCOM.



Key developments ongoing within SISTO face technical challenges which are being translated into development opportunities. They relate to both the process and the end product.

The products include agile decision support through development of tool boxes to support access to other applications, enhanced communications availability and throughput, and anchor desks providing ready access to technical expertise. Vertically integrated object oriented development will provide the framework from which to build applications, incorporate various types of functionality, and which as they progress will be demonstrated frequently through technology integration experiments (TIEs), Interoperability Feasibility Demonstrations (IFD's) and the annual Joint Warrior Interoperability Demonstration (JWID) series. Bandwidth adaptive communications will provide systems the capability to live within the reality of a dynamic communications environment.

New techniques are being used in systems development, employing some of the very tools that are being evolved. For instance, multiple group object oriented system development (itself a new approach) will be done by distributed development facilities employing video teleconferencing, distributed collaboration, and shared information over existing communications links.



A vital part of the concept of anytime, anywhere information on demand is that of the anchor desk.

The anchor desk concept is one where the CJTF has immediate access to experts in many fields (a virtual staff) with further access to information far greater than that normally available at the lower echelons. Through global communications the CJTF may access detailed logistics information, weather information, medical information, and many other types of expertise.

SISTO is currently developing the logistics anchor desk to give the warfighter the visibility over his logistics assets and analyze the sustainability of various Courses of Action (COA's). Warfighters will have needed information related to supply movements, repairs and sparing information, log planning and replanning impact statements; in short the types of information the warfighter needs but to which he doesn't have access in the field.

An extension of this concept will be the ability to anticipate the requirements of the warfighters and formulate queries based on that information. Answers will be available for the questions that "were meant to have been asked" but may not have been properly formulated.

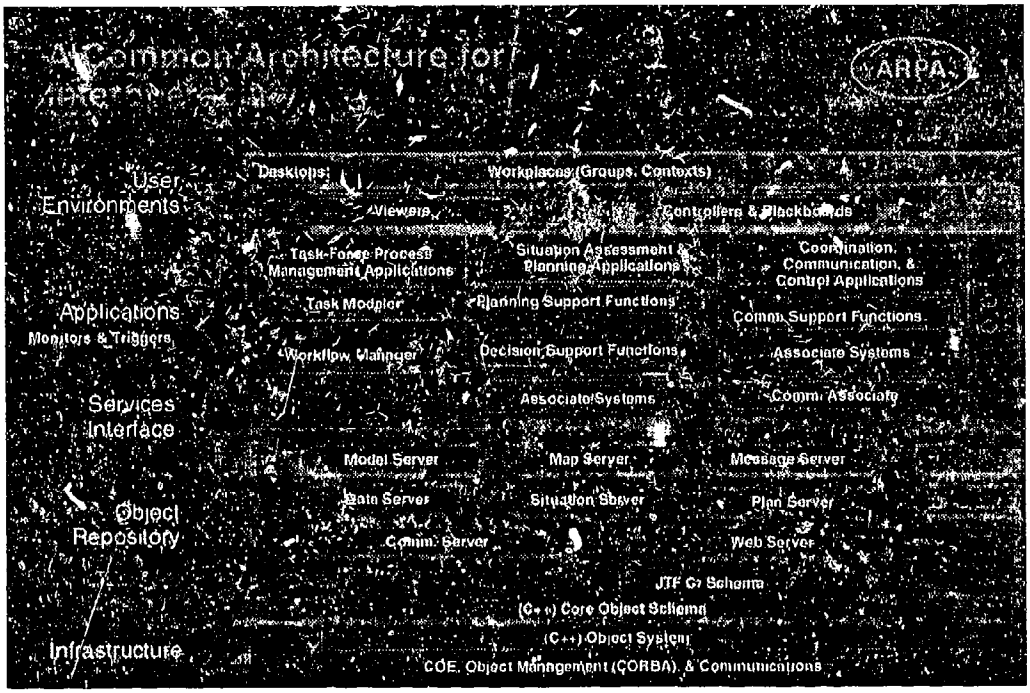


Through extensive user involvement in the process, utilization of the technology available from industry in commercial off the shelf products (COTS), and reuse of software where sensible with Government off the shelf (GOTS) products, ARPA has been able to leverage development to provide new and enhanced capabilities. One example, discussed later, are the recent C2 system installations in Korea which provide enhanced interoperability, enhanced shared perception of the Area of Operations, and an initial capability for distributed collaboration.

Current and future efforts within SISTO form the basis of an implementation strategy and build on these initial efforts. Through the definition and construction of a reference architecture, development of planning tools and decision aids to support distributed collaborative planning, anchor desks to provide subject matter expert support, and the capability for shared perception provide the basis for C2 systems of the future. Conducting development with a user involved, build a little, test a little, field a llittle approach allows streamlining of the acquisition process and the ability to field systems more quickly and affordably

Working with the operators to refine and perfect the requisite tools, and leaving them with the operator with adequate support and the ability to evolve them as the requirements dictate, will ensure optimum warfighting capability for all levels of command.

Added benefit to the ARPA initiatives is the injection of leading edge technologies into both the non-DOD federal and the Commercial sectors.

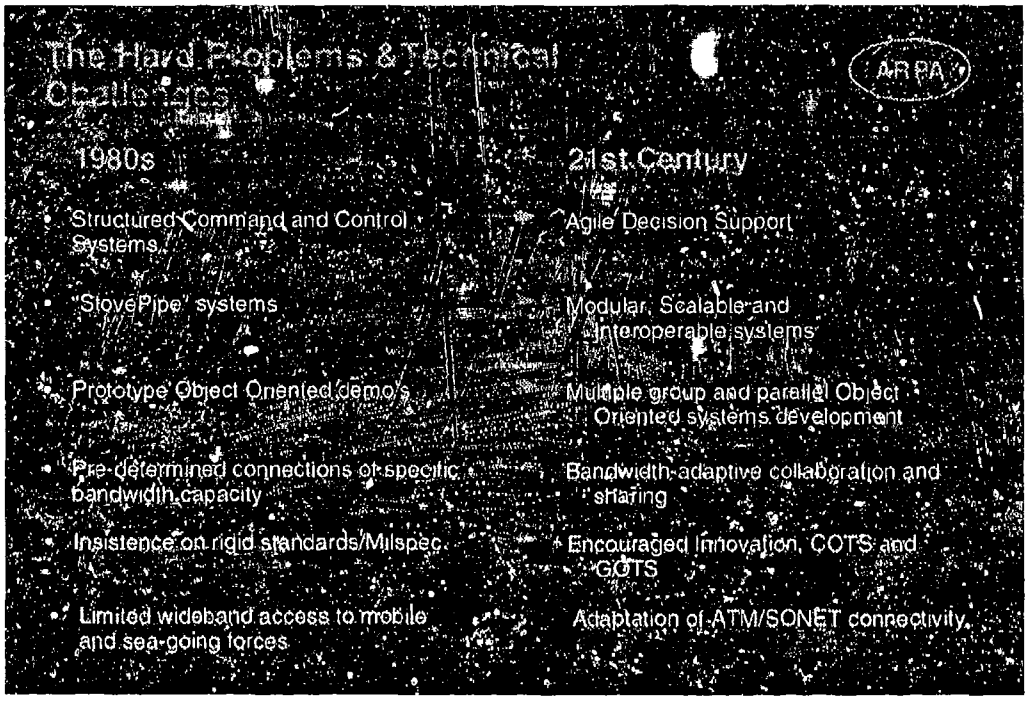


To evolve Command and Control into a realm of full interoperability and ultimately one of optimal integration requires identification and definition of a new architecture.

The ARPA Joint Task Force Advanced Technology Demonstration is developing and evolving that architecture. It is of necessity object oriented and is database centric. It is layered, and based on solid communications, common operating environment and object-oriented (CORBA based) infrastructure. Various servers are being developed as objects for ease of interface, and modularity to enhance flexibility and evolution. The infrastructure and object repository service base interface with the applications that are also modular, and employed as required by the scale of the specific architectural application. The operators access the system through a common user environment.

The primary advantages to this approach are interoperability between legacy systems by enclosing them in "wrappers," scalability depending on the particular implementation, and evolutionary flexibility.

This architecture will support a continued technical insertion to allow it to expand in the future. As additional server requirements, C2 schema's and applications are identified and developed they can be inserted into the structure. This is a current area of opportunity for industry.



Their are many problems and technical challenges involved in making the C2 changes required. In the 1980's systems were developed and constrained to rigid and often archaic government and military specifications. They often did not involve the end user until development was complete and the system was delivered in a finished, non-evolvable form. Developments took years to deliver dated products. The products were frequently user-hostile, hard to learn, and provided stovepipe functionality aimed at single applications rather than distributed support. Systems were limited to available communications bandwidth regardless of fluctuating needs, and because of their architectures, limited in speed and flexibility. Other than adherence to aging specifications, there was little overall standardization for interoperability between systems.

Advances in technology, increased emphasis on involvement with the users, and change to the acquisition process have allowed great strides in alleviating these problems, but there is still far to go.

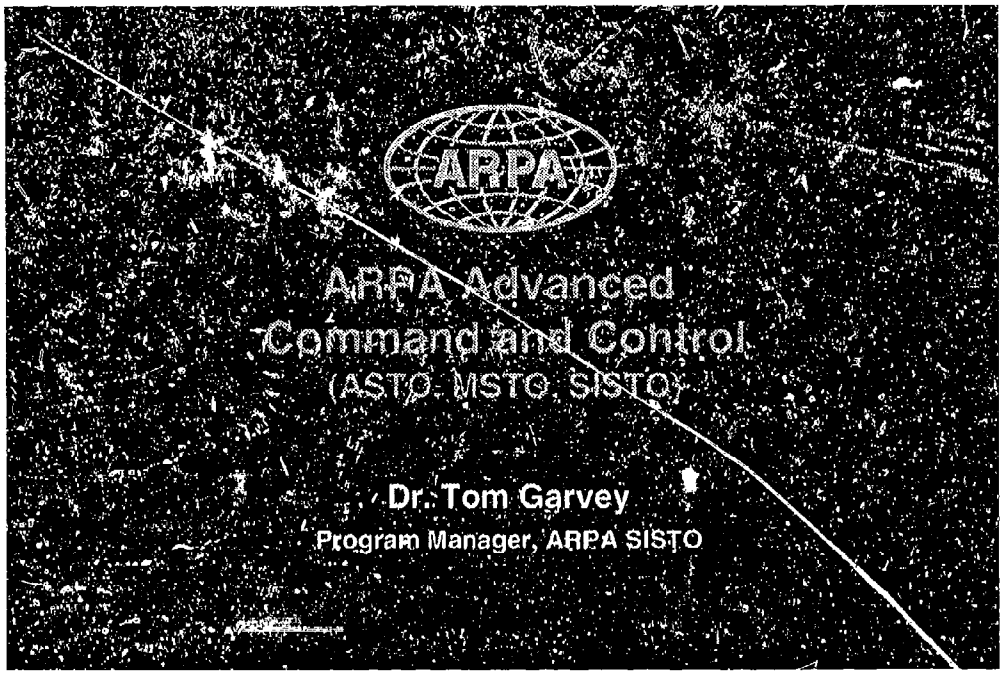
Innovation and the provision of leading edge technology enhanced through user involvement are thrusts in the right direction. Distributed and scalable systems development emphasizing industry standards, a reference architecture, and a means to exploit that architecture using object oriented methodology are all tools that will help enable the C2 community of the future. ARPA is already using those tools and fielding initial systems.



The new world order has created an environment requiring major change to the way the military does business. There is no longer one monolithic adversary for which we have years to prepare warplans and build up our resources. Crises now seem to come in the form of smaller and possibly multiple events throughout the world. The Defense budget and hence available resources, is shrinking, requiring better, more efficient planning, and much faster planning and reherearsal turnaround. Most conflicts now require buildup and execution measured in days. They can be likened to a basketball pickup game, where you won't know who'll be on your team, who will be the opposition, the location of the game and maybe even what the rules are until game time.

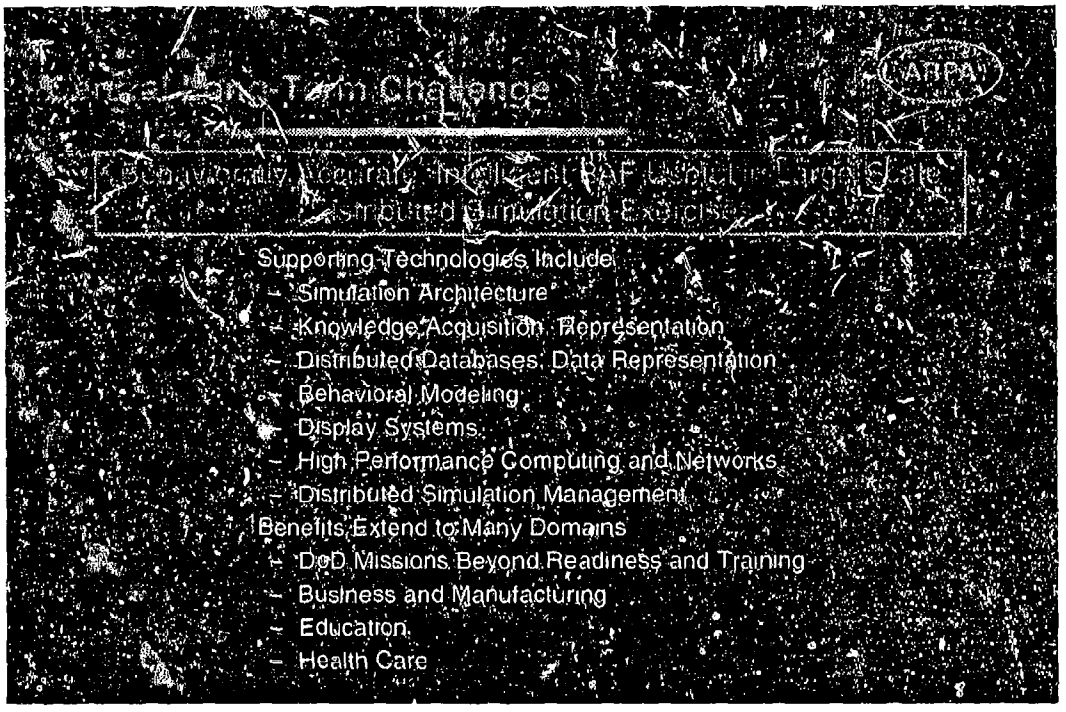
ARPA is working on methods to improve C2 and crisis response in this new environment, and the flexibility required to support it. Improvements must be made in planning, operator education, simulation and reduced software development time and costs. Innovation must be applied to Concepts of operations, C2 Architecture, and organization. Improvements must relate not only to conducting military actions, but also non-military operations and civilian relief actions as they arise. Simultaneous global operations in support of areas such as Bosnia, Haiti, Korea, and the potential for hurricane or earthquake disaster relief support are all real, require resources, and mandate a revolution in the way we do business.

Systems must be highly interoperable, innovative, and above all must be affordable.



Good afternoon. I'm Tom Garvey of the Software and Intelligent Systems Technology Office. I'll be addressing the Command and Control thrusts ongoing in three of the ARPA offices; SISTO, the Maritime Systems Technology Office (MSTO), and the Advanced Systems Technology Office ASTO).

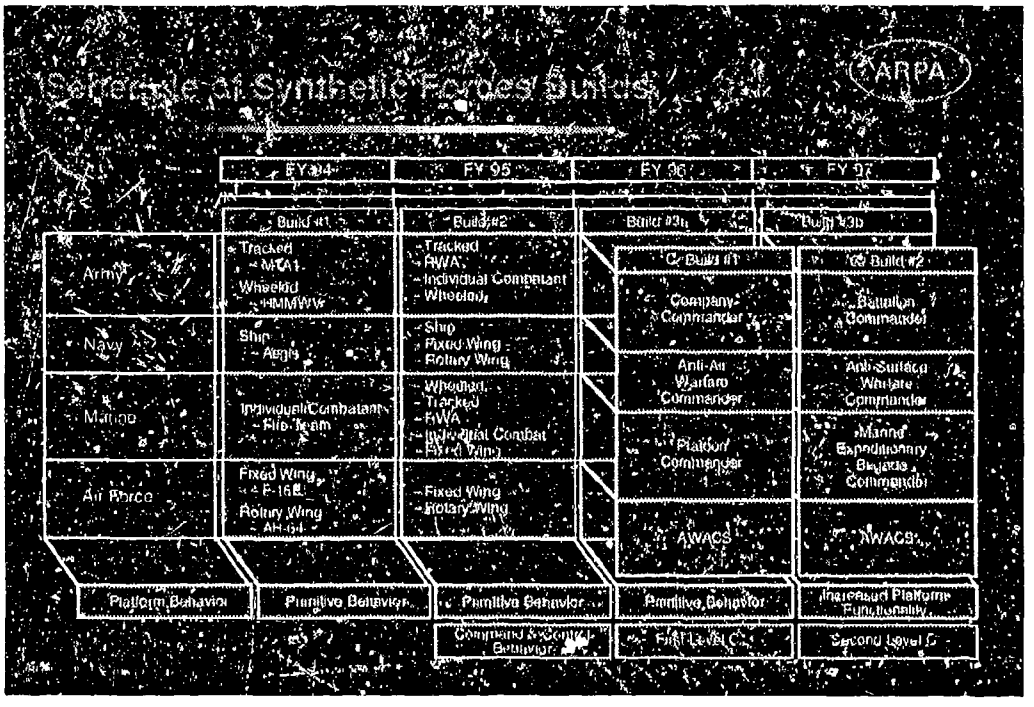
I'll discuss the recent change in the warfare and developmental environments, its effect on the research direction ARPA C2 is going and why, what we have accomplished, and what we have planned for the future.



The most challenging technical objective in ADS is the development of behaviorally accurate semi-automated forces. You don't need to be involved in theater-level exercises to need a good SAF. Training the individual combatant in synthetic environments is challenge enough. Large numbers of SAF entities, SAF operating in complex environments, and the visual displays of of SAF entities each impose challenging goals.

As examples of our plans for FY 95, we plan to issue a BAA for expanding the scope of command post entities to other services, and a BAA in the area of Distributed Exercise Management.

Achieving these goals will produce capabilities useful to many other applications.

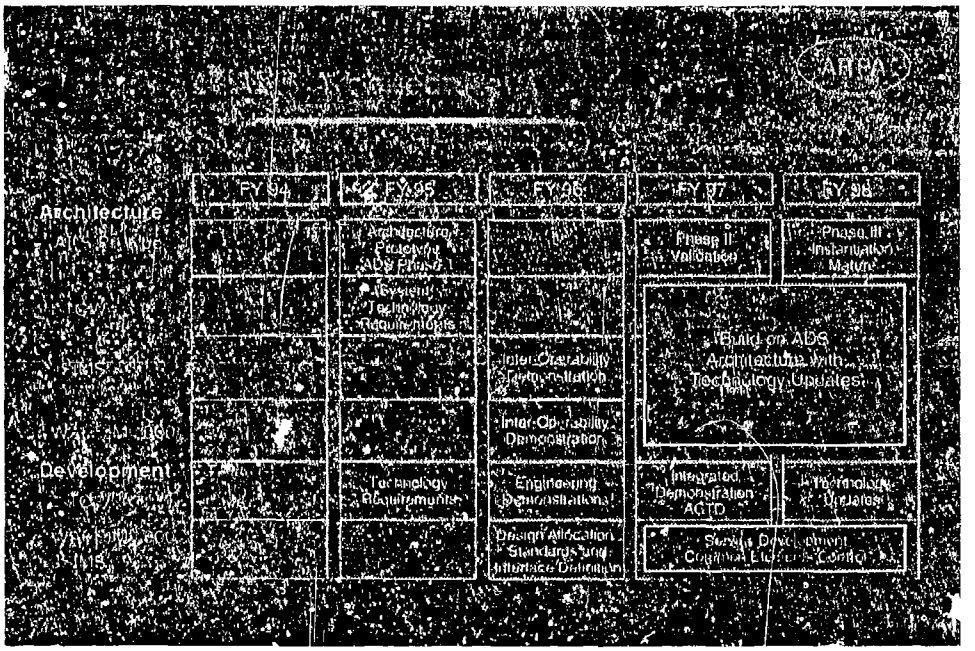


This chart illustrates not only how important synthetic forces are to ADS, but also the complexity of this technology area.

Synthetic forces, also known as Semi-Automated Forces (SAF), were first developed during the SIMNET program as an inexpensive means to fill out the battlefield populated with entity-level simulators. Even after more than 6 years of active research and development, the SAF entities encompass only the lowest echelons and exhibit no more than primitive behaviors.

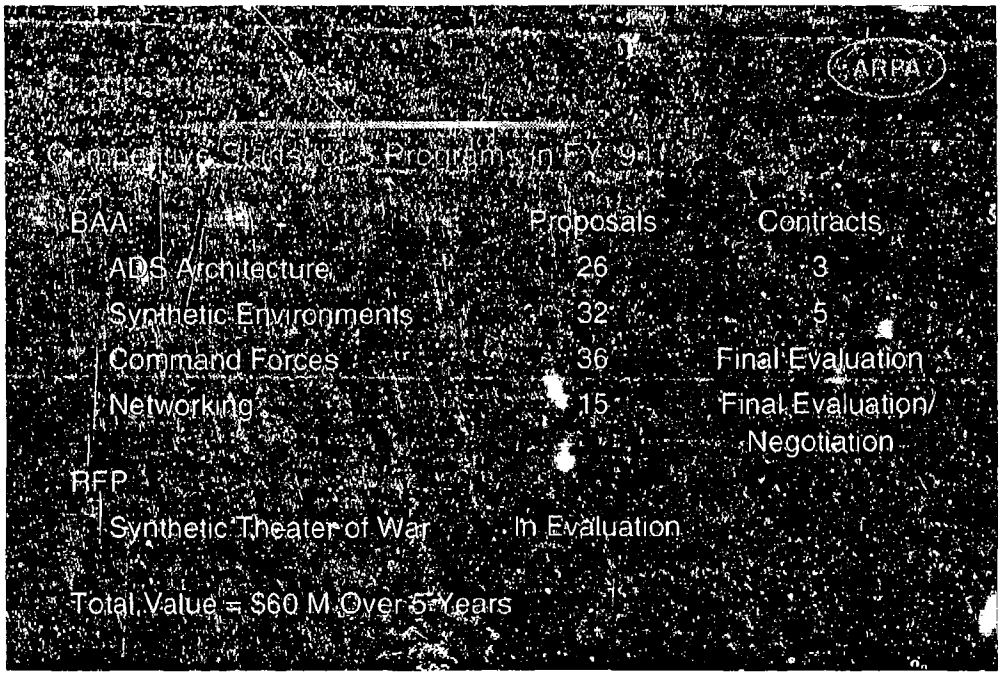
The thrust of the Synthetic Forces program is two-fold. First, is to extend the coverage to more platforms and to higher levels of command. For example, the Command Forces program, initiated via a BAA process during FY 94, will develop command and control entities, versus platform entities.

The other thrust is to enhance the intelligence and automation of the synthetic forces. This long-term research area encompasses areas such as knowledge acquisition and representation that have applications beyond warfighting simulation.

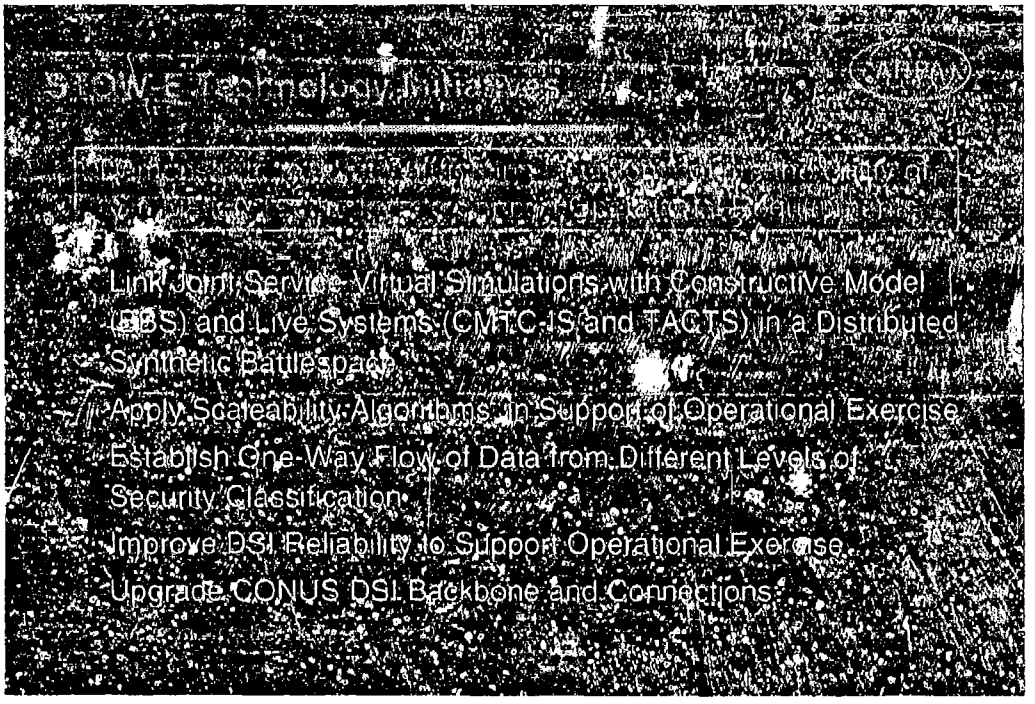


ARPA is developing as a first step a technical reference model for an ADS architecture . This process began this year with three concept studies.

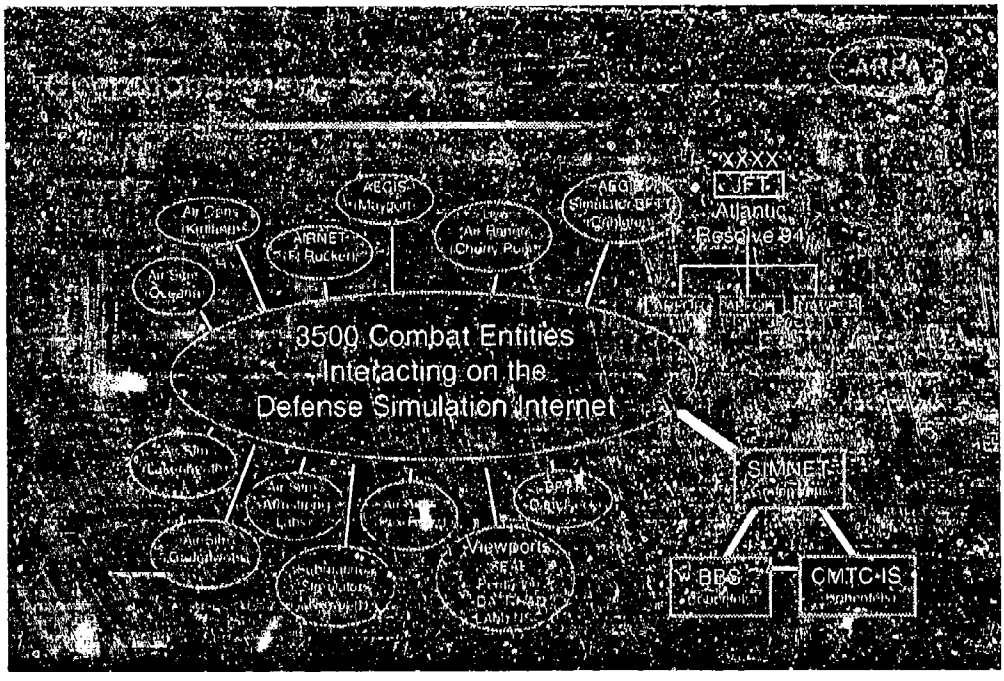
Our approach to simulation architecture, depicted in this chart, represents a change in ARPA's culture. The emphasis is on the integration effort, one that will eventually merge the work of 3 programs: STOW, JSIMS, and WARSIM 2000. ARPA will become a customer of the architecture for other ADS applications.



Five major programs have been initiated in a competitive environment. These starts represent a significant 5-year investment, but present many opportunities in the future.



The ability to create an operationally useful simulation capability depends on technical advances in many areas. Here are a few of these technologies that support the STOW-E exercise.

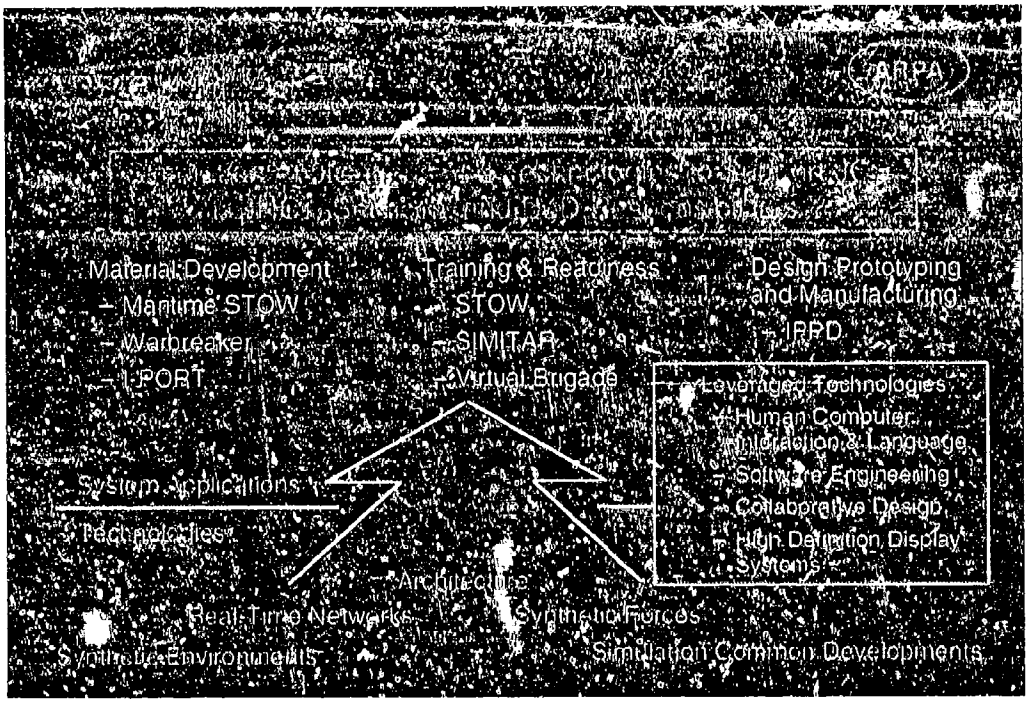


STOW-E represents an important test for ADS for three reasons.

First, it is the most technically challenging experiment to date. There will be 3500 entities interacting on the Defense Simulation Internet; an order of magnitude larger exercise than ever before. The scenario is a brigade level training exercise occurring within the context of Atlantic Resolve 94.

Second, this is the first use of a mixture of constructive, virtual, and live simulations tested in an operationally relevant scenario and with a defined training objective. This aspect of ADS, the joining of virtual, constructive, and live simulation is a main philosophical point of the use of ADS technologies.

Third, the STOW-E system represents ARPA's new approach to developing and transitioning technologies, namely by leaving in place operationally useful systems that embody the new technologies. This approach is central to the Advanced Concept Technology Demonstration (ACTD) programs.

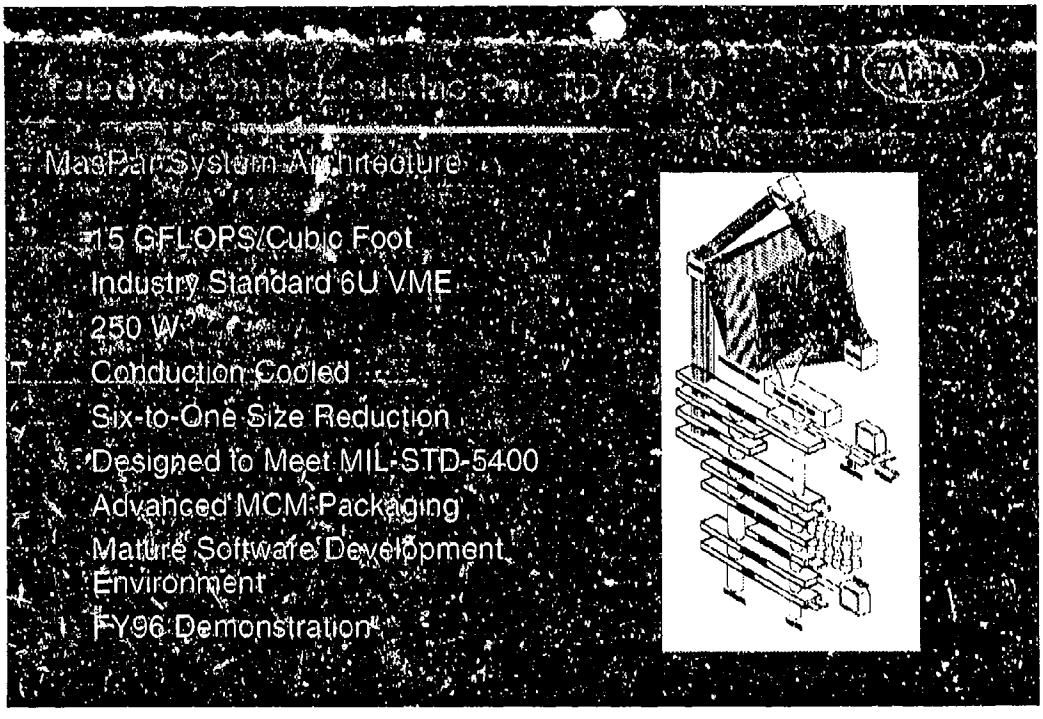


The ADS program goals are:

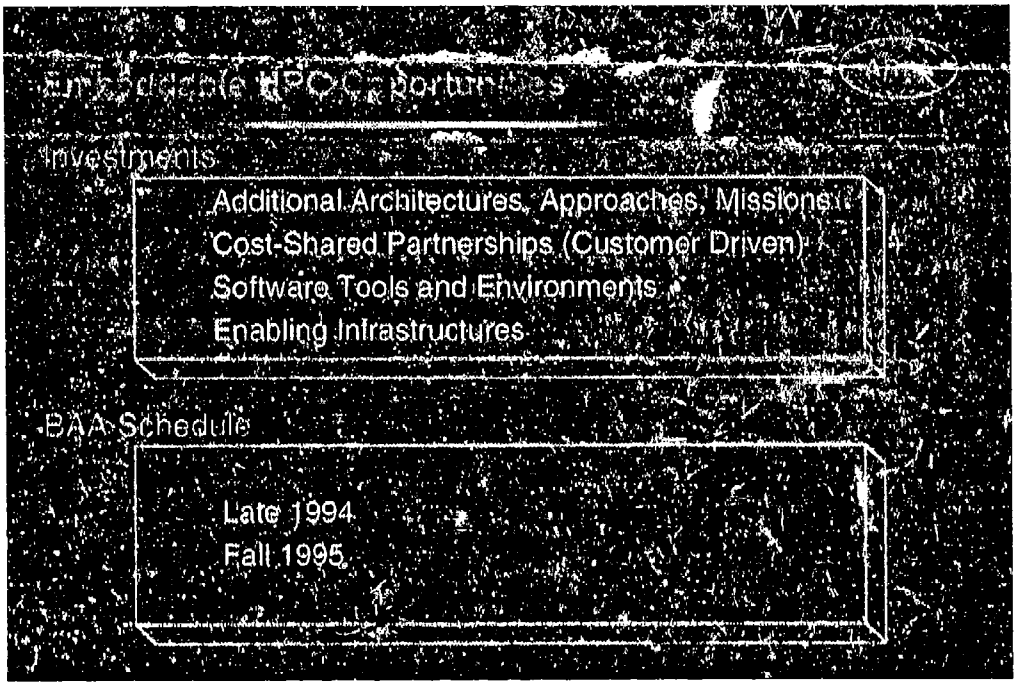
To develop and transition to the CINCs, Services, and DoD the required concepts and technologies to create a synthetic, theater-level battlefield addressing the JCS warfighting responsibilities and the Services' Title 10 responsibilities such as: training and readiness, design prototyping and manufacturing, contingency planning and operational mission rehearsal.

These goals are being pursued these goals from two directions. First, by investing in 5 basic technology areas underlying all the system applications - simulation architecture, real-time networks, synthetic forces, synthetic environments, and a collection of software technologies to enhance the common development environment for these applications. In addition, the applications rely on advances made by other ARPA programs, for example human computer interaction and language technologies.

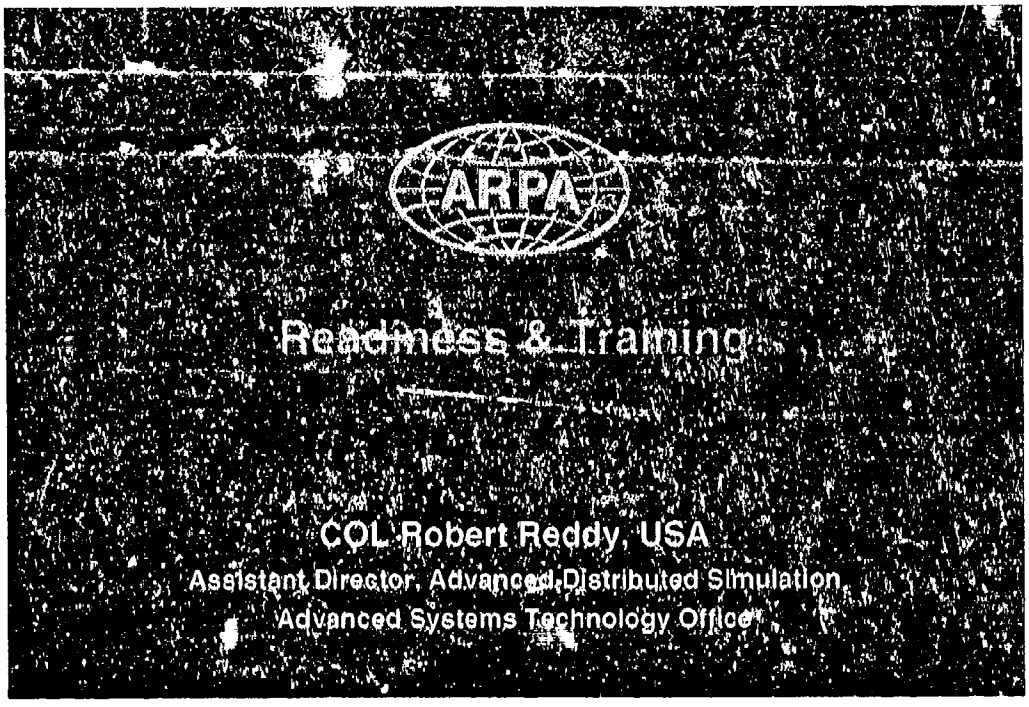
Second, each of the system applications is oriented toward an operational need, ranging from operational rehearsal for the individual combatant to joint task force commander exercises. The STOW-E technology demonstration, which is the first major milestone in the STOW program, illustrates this point.



The second HPC architecture initiated under this program is a fine grain SIMD architecture from MasPar, Inc. In this effort Teledyne will re-package the architecture on industry standard 6U format cards to form a 15 Gflops/ cu. ft. conduction cooled system. These efforts share several features in common: they are derived from unmodified commercial HPC architectures, they are scalable, they are brought to the military market by military systems houses, they run commercial software, they are members of the HPC family of upwardly compatible, exponentially increasing performance, commercial architectures.

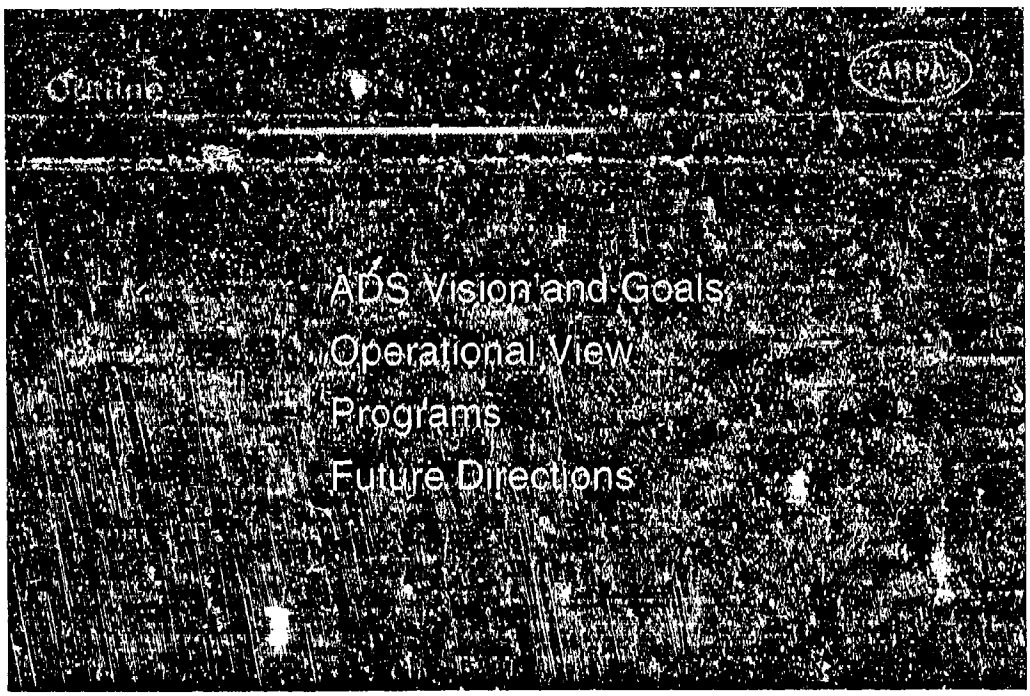


The Embeddable HPC program will be seeking additional architectures, approaches, and missions in upcoming program announcements. Likely investments will support customer driven cost-shared partnerships, software tools and environments, and enabling infrastructures. Investments will be made to address these interest areas with BAAs scheduled in late 1994 or early 95 and Fall 1995.



The ARPA Advanced Systems Technology Office is developing Advanced Distributed Simulation (ADS) technologies and systems for a wide range of Defense applications.

The ADS program will focus on the critical area of maintaining the readiness and training of our forces.



There are four basic messages.

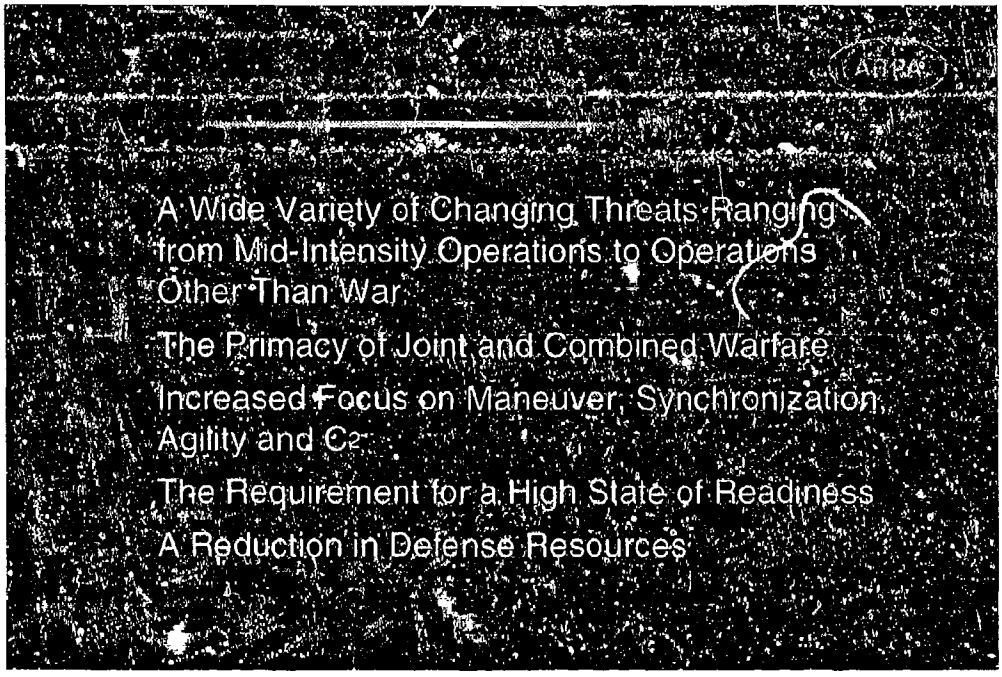
First what is Advanced Distributed Simulation (ADS), and how ARPA is developing ADS technologies for a range of Defense missions.

Second, ADS is focused on operationally useful applications, and I'll describe a major technology demonstration being conducted next week, STOW-Europe.

Third, on the business side, we've initiated 5 major programs using an open, competitive process.

And finally, outline how the full potential of ADS will require substantial effort.

What motivates this work is, of course, the urgent demand that the United States develop and maintain a ready, well-trained force.



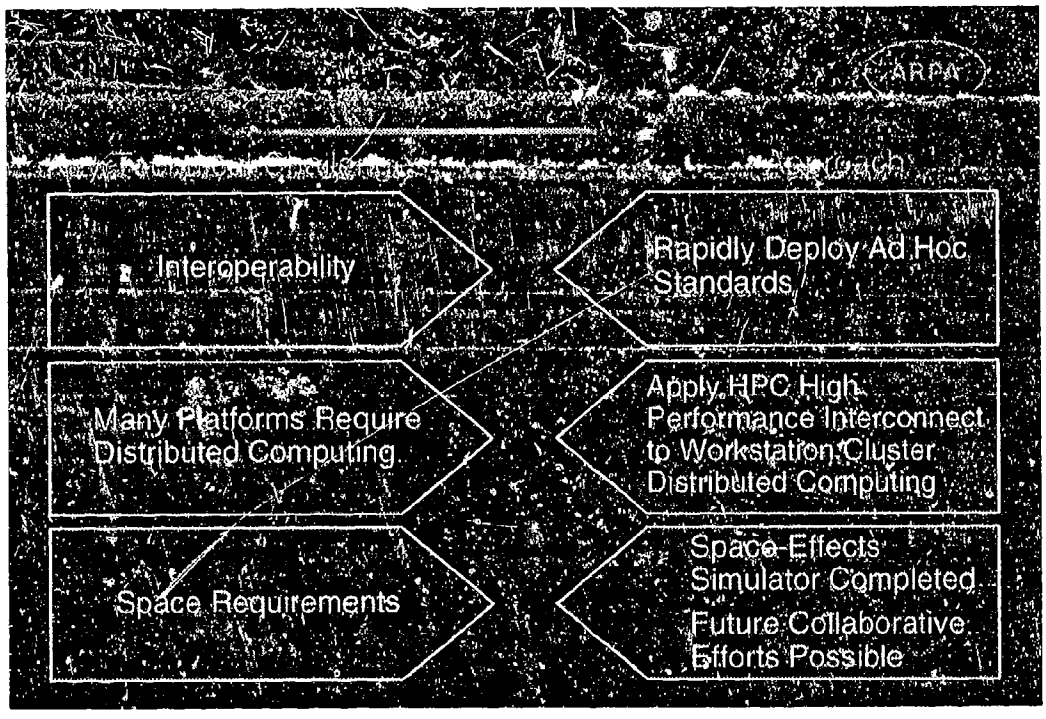
Every aspect of providing for the readiness and training of our forces is harder today than ever.

The Services must now be able to respond to a wide range of potential threats much different than in the past, as events of this last year illustrate. Combat forces will be organized for combat differently, with the emphases on Joint and Combined task forces being sent into highly charged battle spaces and with a different operational concept. New technologies will enable greater use of maneuver, synchronization, and agility to defeat the enemy.

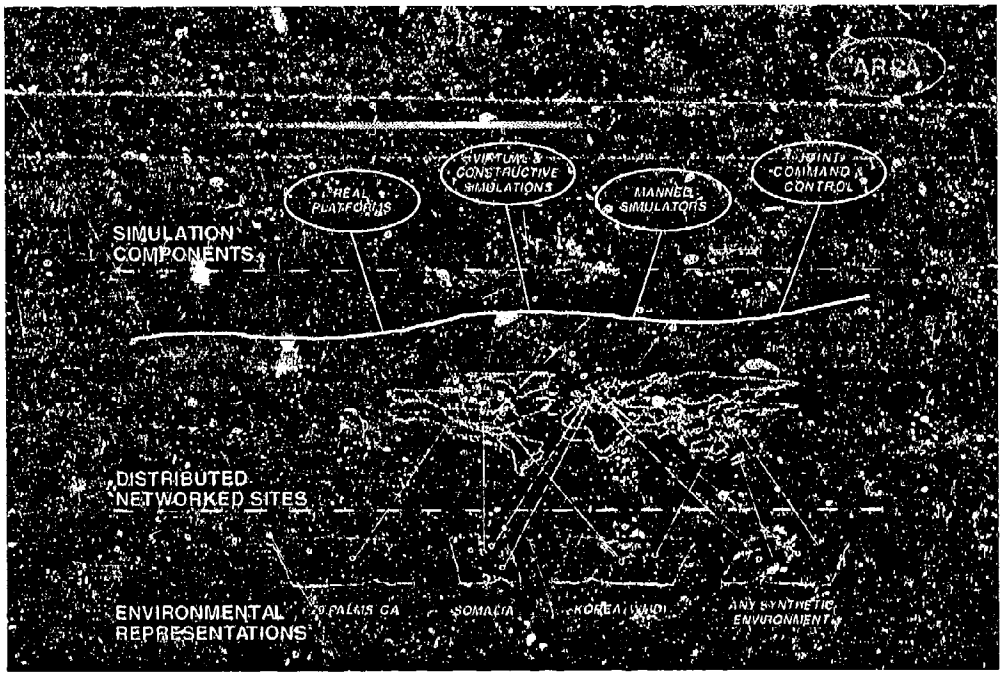
The diminished forward presence of our forces will create deployment and training problems. Unlike the past, we will not be able to train in the areas where forces will be deployed.

Yet the success of the Persian Gulf war established in the public's view, and thus the political requirement that we maintain a high state of readiness. In the future we cannot rely on having the same opportunities to prepare as we did then.

All this must be accomplished with fewer resources-- personnel, materiel--and a greater expectation of rapid, complete success on the battlefield.



Three additional challenges are interoperability, distributed computing requirements, and space requirements. Rapidly deploying Ad Hoc standards will address the interoperability issue. Finally, distributed computing and space requirements will be addressed by applying HPC high performance interconnect to workstation cluster distributed computing, and utilizing space-effects simulator as well as possible future collaborative efforts.



The long-term vision of ADS is depicted here.

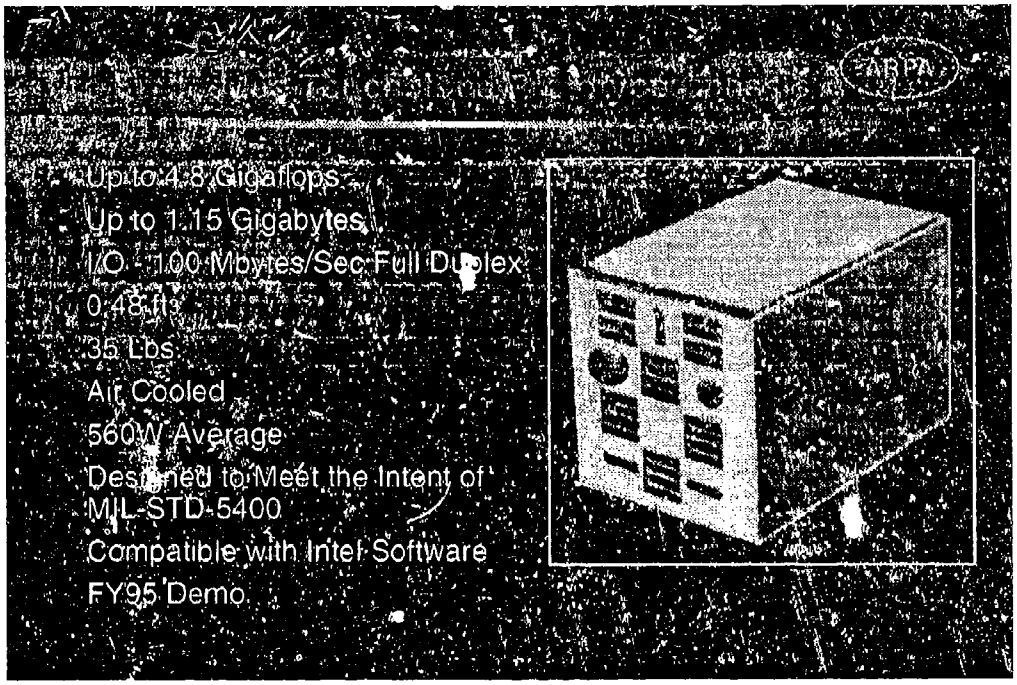
The central idea is to create a synthetic, or virtual, environment in which soldiers, weapons, and commanders can exercise as though they were on a common battlefield. The warfighting assets can be geographically distributed, being connected by a global network, thus providing less costly and more frequent training opportunities.

In more technical terms, the vision for ADS is:

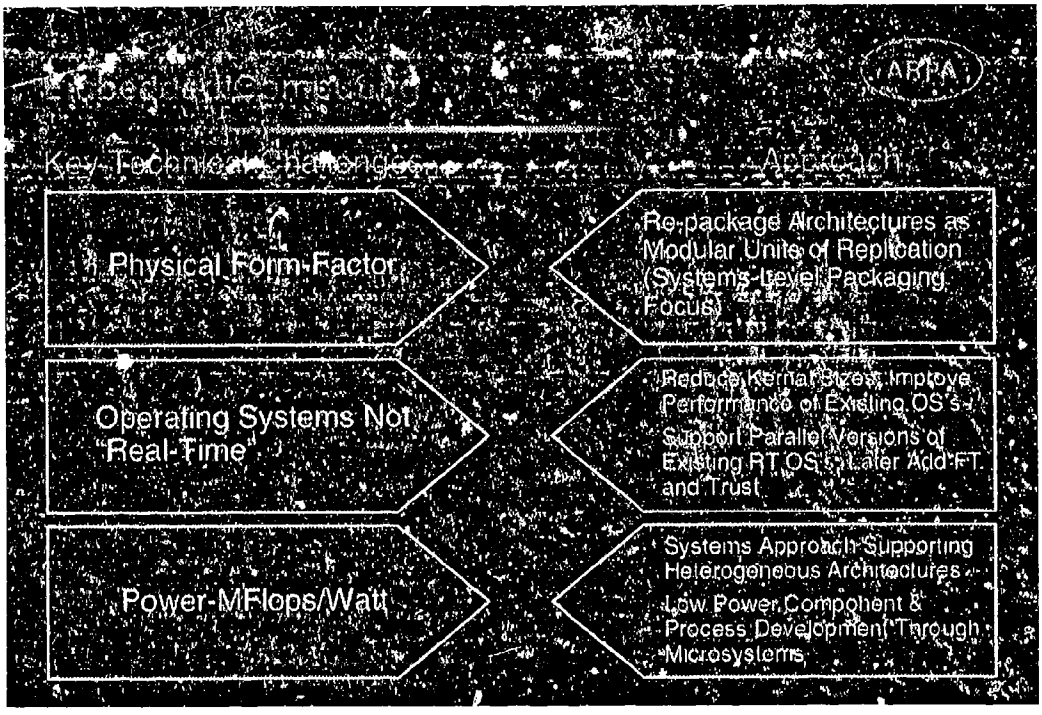
- To create a synthetic world distributed over a global network, realistically populated with:
  - high resolution, dynamic terrain
  - tactically significant environmental effects
  - individual combatants and weapon platforms of varying fidelity
  - validated representations of a broad range of command elements
  - a broad range of tools

- Able to interface with
  - appropriately instrumented "live" test ranges
  - appropriately designed constructive models with different levels of fidelity

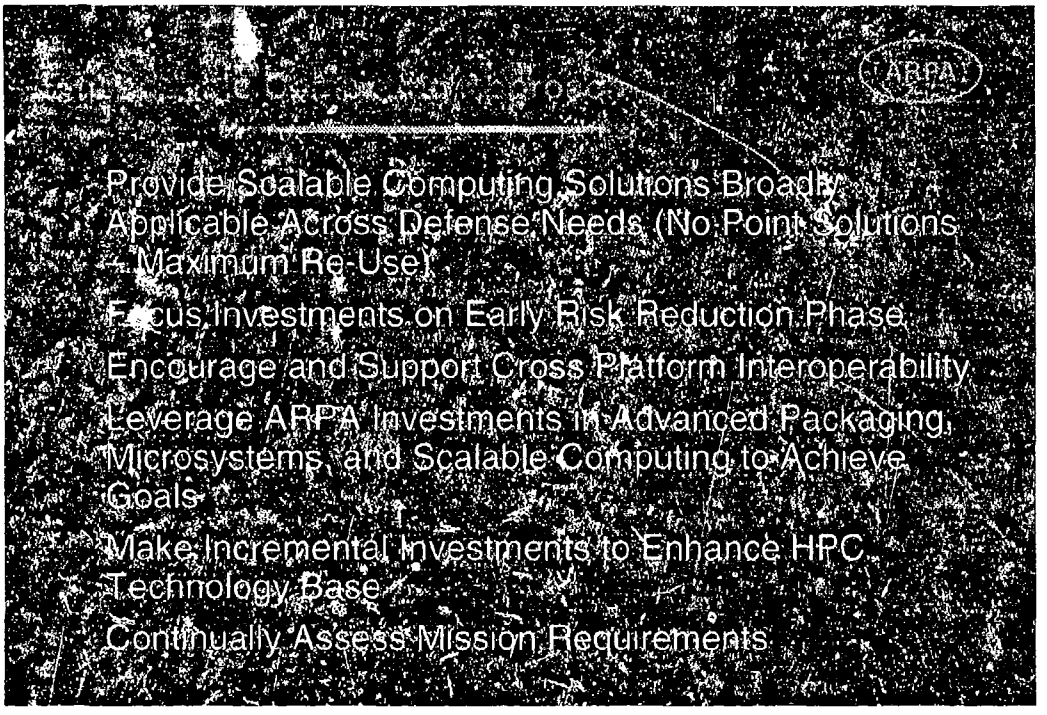
- Supporting readiness, training, acquisition, test and evaluation, and other missions.



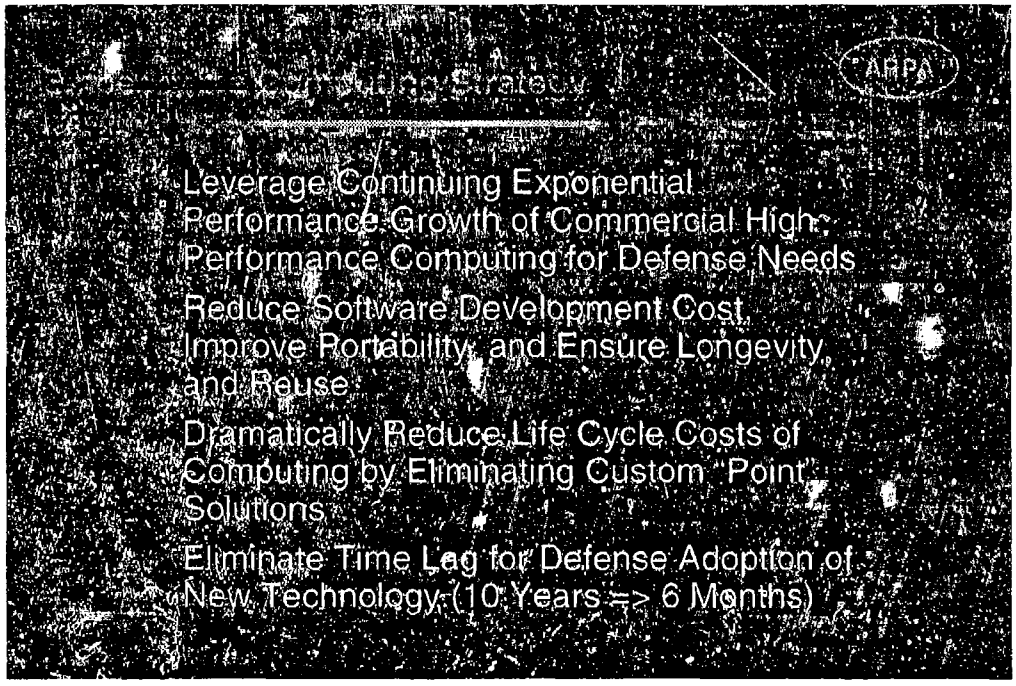
Two efforts are underway in the embeddable computing program including a militarized version of the Intel Paragon being developed by Honeywell. This 0.5 cubic foot box will provide a peak 4.8 GFlops packaged on air-cooled SEM-E cards. The system will run the Intel Paragon operating system as well as a realtime version of the MACH operating system. The box will be demonstrated and introduced early in FY95.



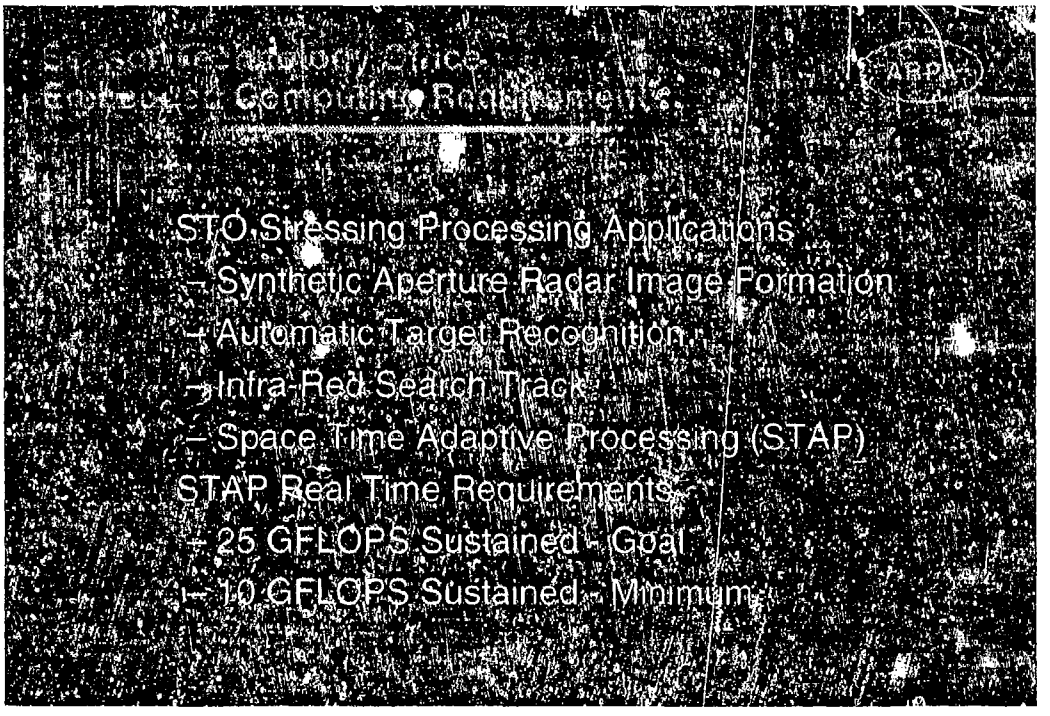
Three key technical challenges for the Embeddable HPC program include physical form factor, real-time operating system, and power. Physical form-factor challenge will be addressed by re-packaging architectures as modular units of replication and focusing on system-level packaging. Real-time operating systems can be achieved by reducing kernel sizes supporting run-time modularity and improving performance of existing parallel operating systems. In addition, parallel versions of existing operating systems will be supported and enhanced by fault tolerance and trust. Reducing power for MFlops/Watt can be achieved by systems approach supporting heterogeneous architectures and low power component and process development through microsystems.



The Embeddable HPC program will achieve its objectives by providing scalable computing solutions broadly applicable across defense needs (no point solutions, maximum reuse), focusing investments on early risk reduction phase, encouraging and supporting cross platform interoperability, leveraging ARPA investments in advanced packaging, microsystems, and scalable computing, making required incremental investments to enhance HPC technology base.

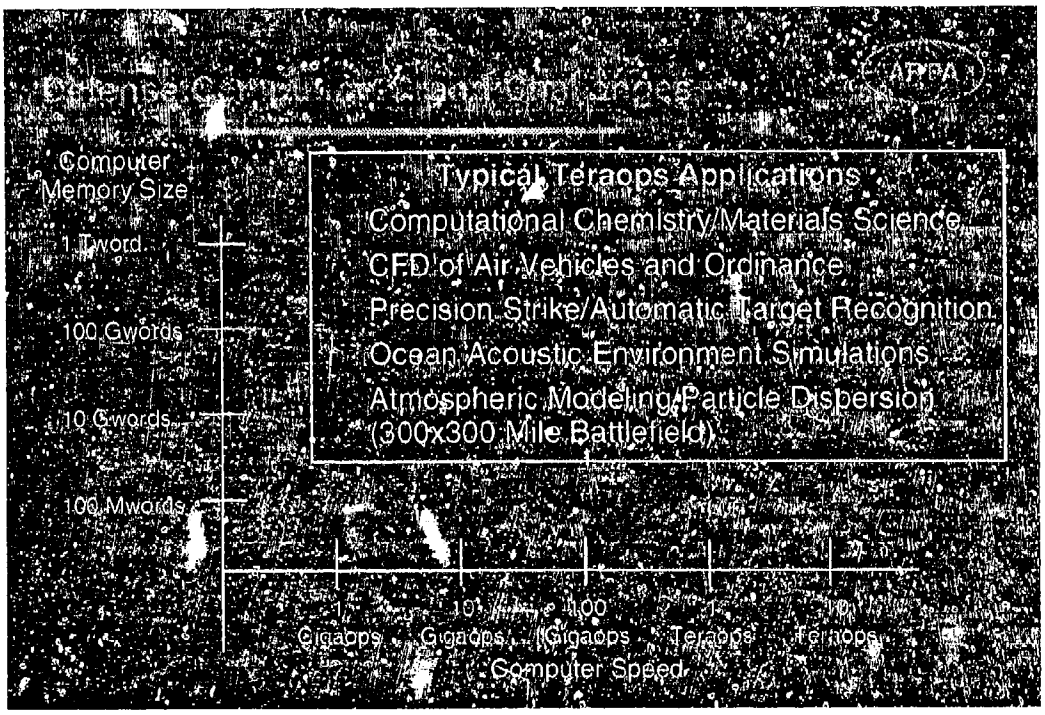


The Embeddable HPC program strategy is to leverage continuing exponential performance growth of commercial HPC for defense needs, reduce software development cost, improve portability, ensure longevity and reuse, dramatically reduce life cycle costs of computing by eliminating custom "point" solutions, and eliminate time lag for defense adoption of new technology from about 10 years to 6 months.



Additional requirements are derived from other ARPA programs such as the Mountain Top program in the ARPA Sensor Technology Office. Mountain Top is a Space Time Adaptive Processing (STAP) radar technology demonstration program. Under this program RSTER, an experimental radar has been used to collect a one Terabyte STAP database.

Problems of SAR image formation, ATR, and infrared tracking present significant processing problems for STO missions. Algorithms such as the STAP provide significant advantages in reducing interference and improving capability to selectively detect targets. STAP algorithms are computationally intensive requiring a sustained level of 25 gigaflops performance.



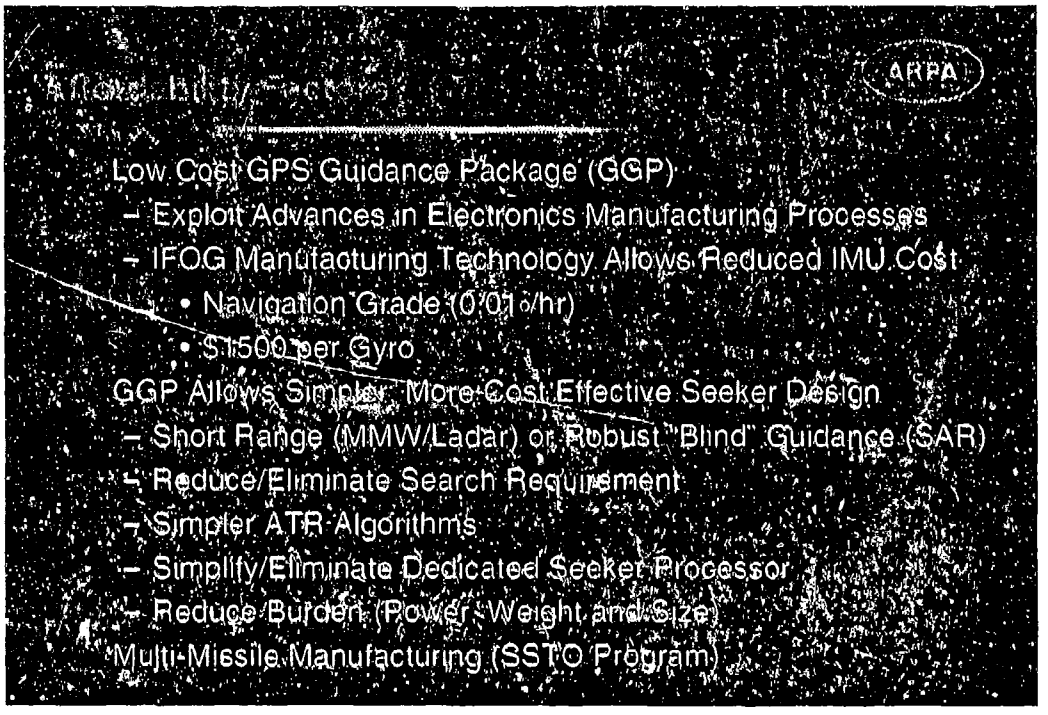
A number of military computing "Grand Challenges" requiring Teraflop performance and up to 100 GWords memory motivates the interest in providing solutions to these challenges. Applications include computational chemistry/material science, advanced materials/propellants (1000 atoms), CFD of air vehicles and ordnance, weapons release, weight/vulnerability reductions inadvanced land combat vehicles, precision strike/automatic target recognition, submarine hydrodynamics/unsteady flow, ocean acoustic environment simulations, revolutionary gun designs, and atmospheric modeling/particle dispersion(300x300 mile battlefield).



Sharpshooter is an integrated technologies/system demonstration. It exploits technology developments like GGP and ultimately benefits from ManTech projects such as the SSTO Multi-Missile Manufacturing.

It completes the sensor to precision attack shooter logic with accurate, affordable, adverse weather capabilities. There is no new weapon here. Sharpshooter will retrofit to existing weapon systems.

And finally, we are planning and will implement this future program with the cooperation and guidance of the people who will employ it -- the Warfighters.



This chart synopsizes the factors that justify the Sharpshooter affordability claims.

–A low cost GGP enables accurate navigation and geolocation across the board – from wide area surveillance to weapon terminal guidance.

–IFOG Manufacturing Technology, as discussed previously by Beth Kaspar, is an important factor in low cost GGP.

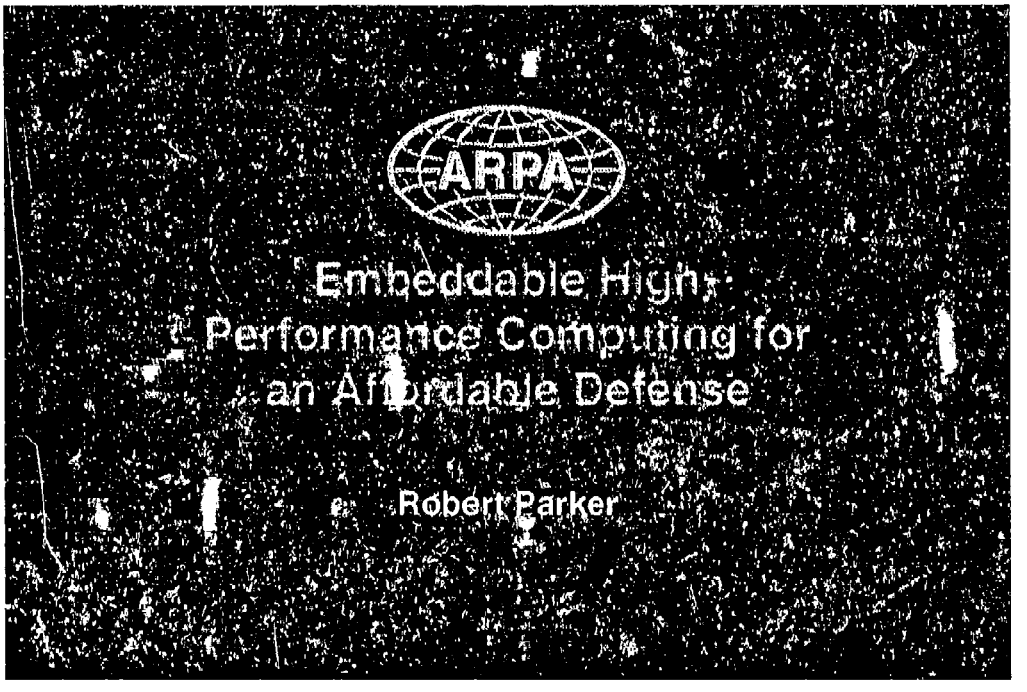
–Better targeting, strike platform navigation and weapon guidance allows simpler, more cost effective terminal seeker subsystems. This benefits, every aspect of the seeker subsystem:

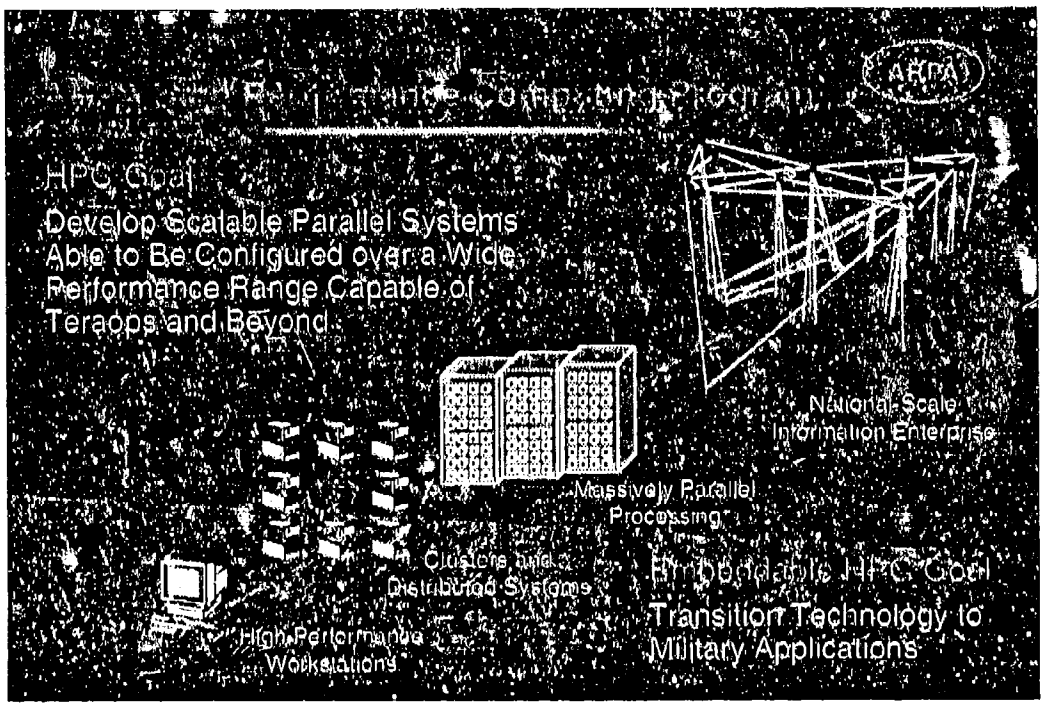
»Its search requirement

»Its detection and automatic target recognition (ATR) algorithms

»Its physical characteristics – e.g., lower weight, smaller size and less complexity.

We also look to the SSTO Multi-Missile Manufacturing program for the strategies and processes to reduce the cost of seeker manufacturing, across the board.

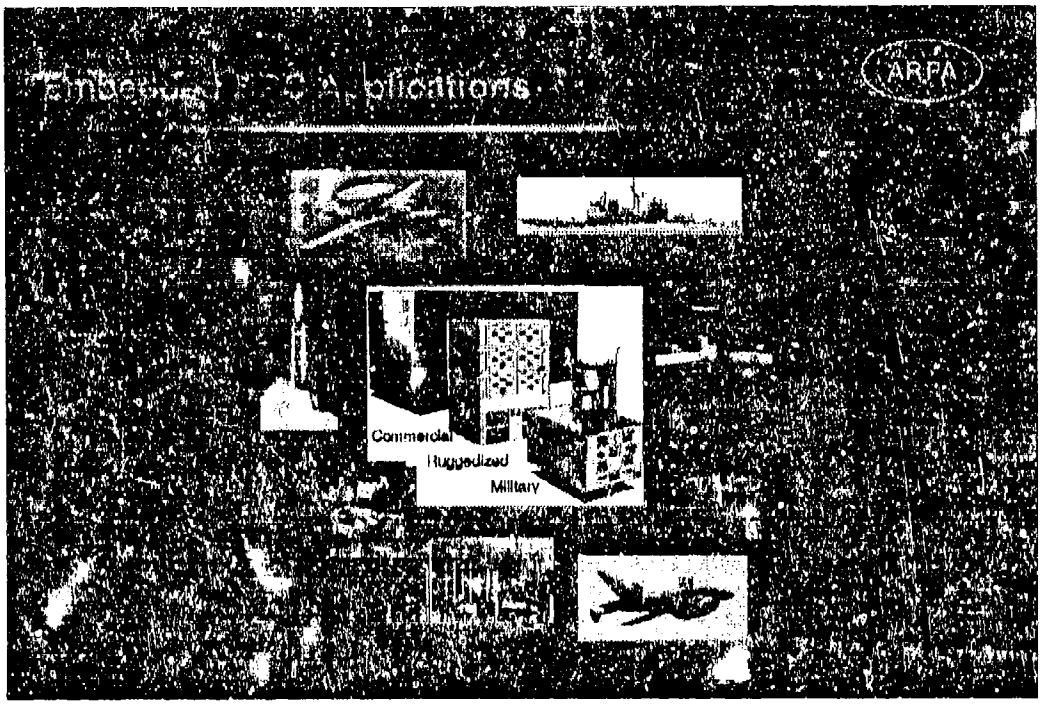

ARPA
Embeddable High-Performance Computing for an Affordable Defense
Robert Parker



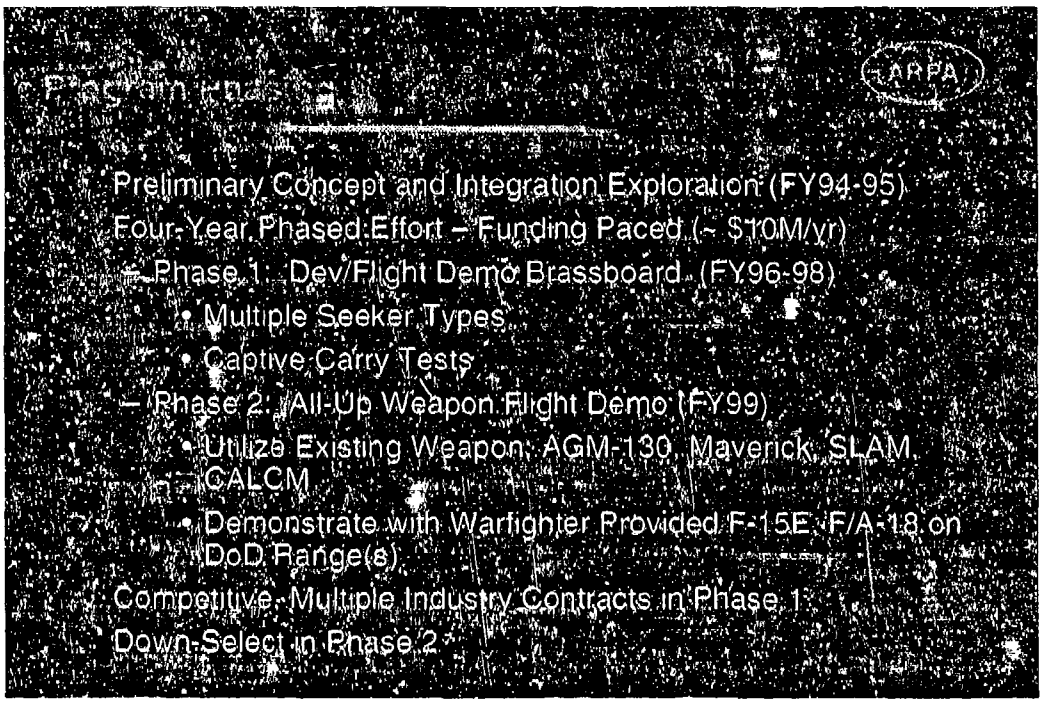
The ARPA High Performance Computing Program, part of the Federal High Performance Computing Program, is creating the commercial scalable computing technology base to meet large-scale scientific computing challenges critical to the nation. The program has created the enabling technology base for machines delivering 100 gigaflops sustained performance addressing several classes of problems from computational electromagnetics to oil exploration to finance. The goal of the program is to develop scalable parallel systems able to be configured over a wide performance range capable of teraflops performance and beyond.

Scalalable communications and computing components are being developed that unify the computing space from single workstations, through workstation clusters, to massively parallel computers and beyond toward a National-scale networked computing enterprise.

In FY94 ARPA CSTO initiated the Embeddable HPC program within the High Performance Computing Program. The purpose of this focus activity is to leverage the commercial scalable computing technology base to provide enhanced defense superiority. This activity will provide funding to lower the risks of migrating the commercial high performance computing base to military applications.



The Embeddable HPC approach will be to provide a family of computing solutions broadly applicable across military platforms and mission requirements. The approach will provide unmodified commercial machines for fixed land-based applications, ruggedized commercial boxes for large aircraft and ship board applications, and reduced form-factor solutions for fighter, satellite, and other size-constrained applications. This family of solutions will all share the same integrated circuits and the same software base. They will be identical machines differing only in form factors. Each form factor is scalable and strongly leverages the commercial technology base.



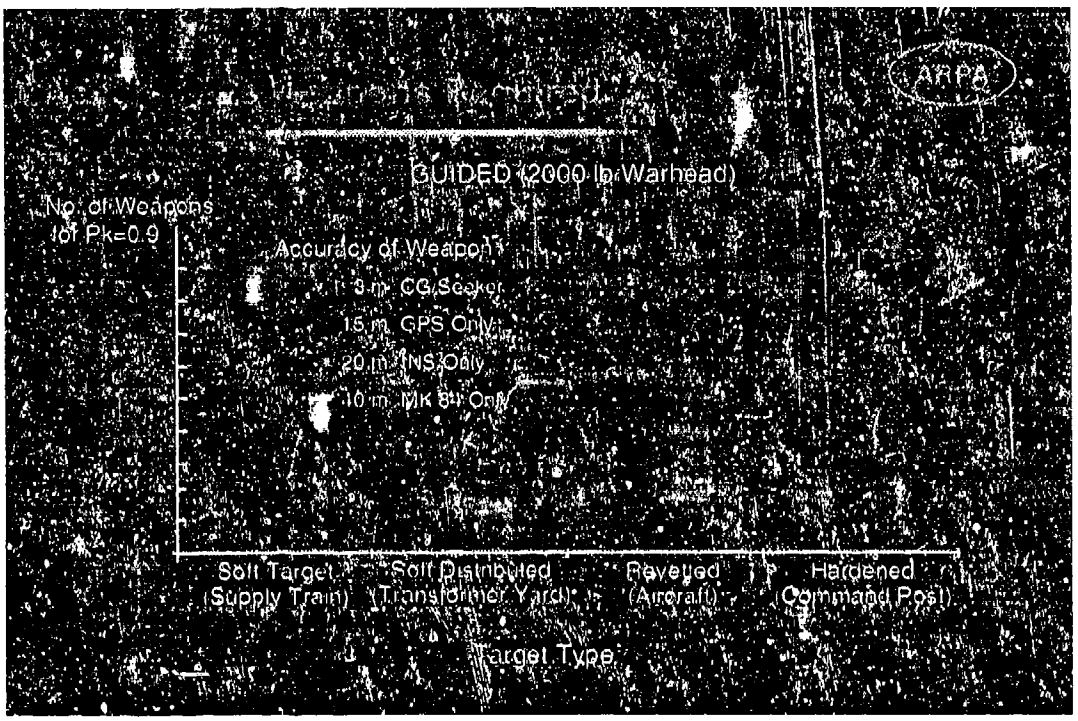
Sharpshooter is planned for an FY96 start. But, we have begun at a very low level, thinking about what kinds of sensor concepts would make sense for our demonstration. There also are integration issues. They include

Sensor integration to a weapon.
Sensor and weapon integration to a testbed, strike aircraft.
And of course , there are all the factors that go into an integrated demo.

POINT TO "PHASE 1, THEN "PHASE 2"

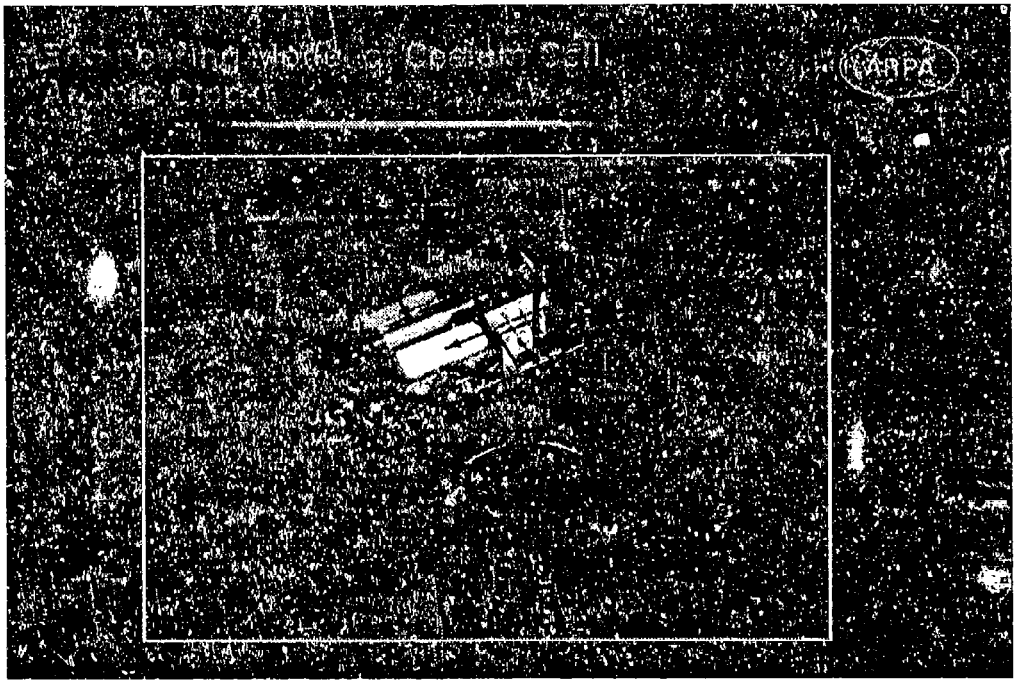
We view Sharpshooter as a two phase, four-year program with the key components shown here. Phase 1 will be the subject of a competition with, hopefully, more than one contractor selected. Phase 2 will be the subject of priced options. Funding constraints probably will force a down-selection for Phase 2.

We have done substantial thinking about Sharpshooter's goals. Our acquisition strategy, at this point, is preliminary.



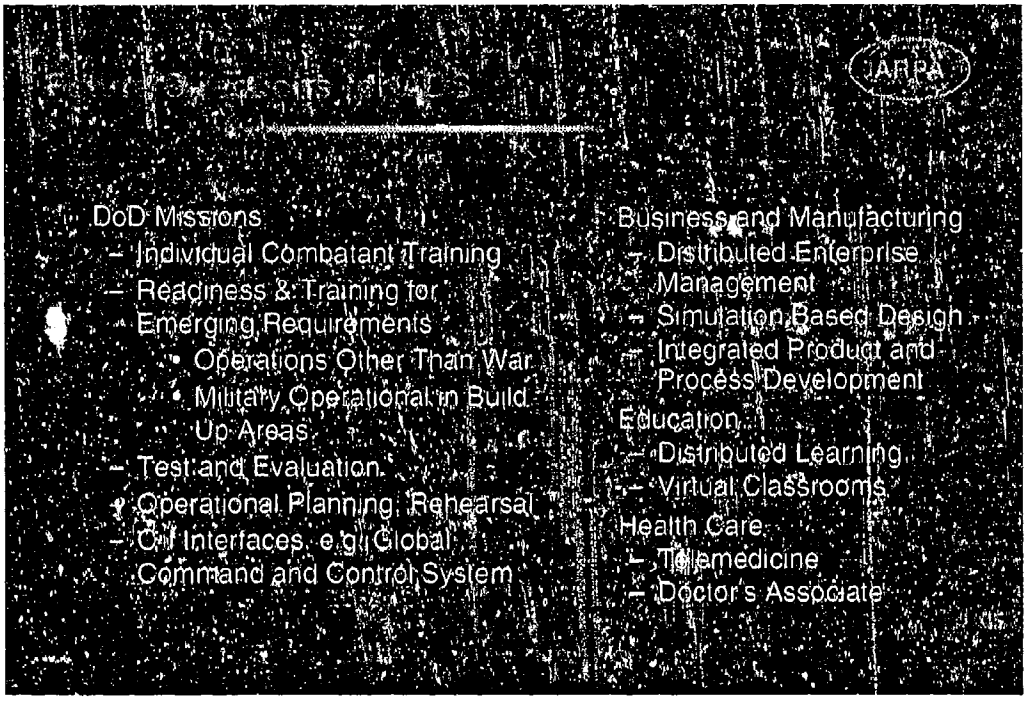
Security classification guidelines prevent me from quantifying the vertical axis of this chart. But it is apparent using the techniques of the Joint Munitions Effectiveness Manual, that increasing the accuracy of weapon delivery from say, 20 m to 3 m, greatly increases the effectiveness of destroying tough targets such as aircraft in revetments and hardened command posts.

The Sharpshooter goal is to provide weapon delivery accuracies of 3 m.



As a result of an Air Force Wright Laboratory competitive source selection, we are developing a miniature...

frequency standard that can be used in a variety of applications, including Common Grid.



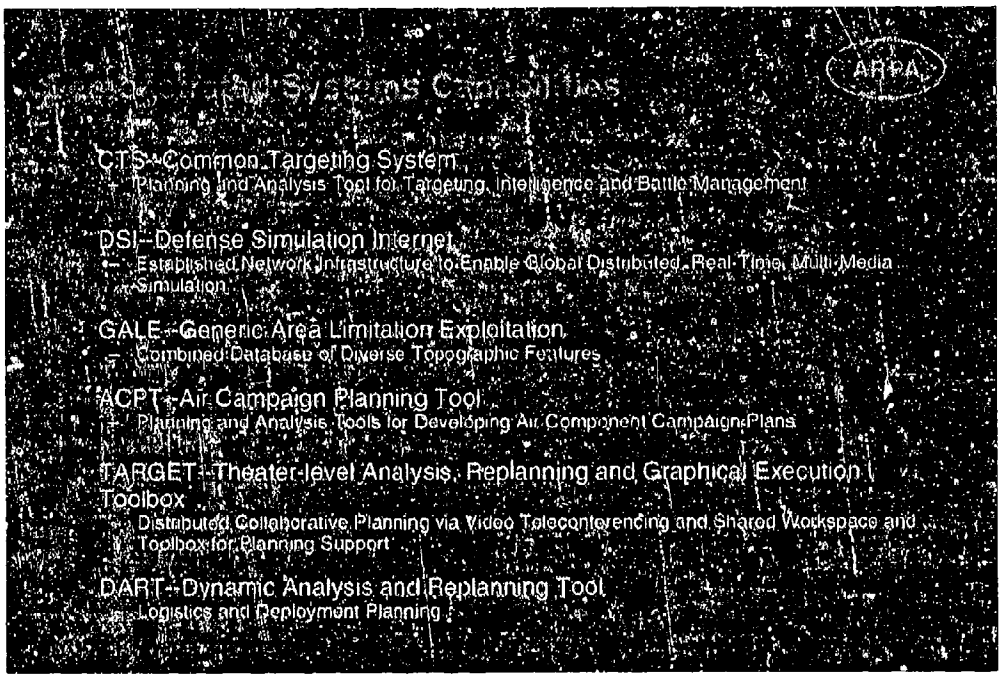
The basic technologies of ADS are fundamental to many aspects of our society, going beyond Defense missions to areas such as manufacturing, education, and health care.

Within Defense applications, the future directions are characterized by a broadening of the scope of what can be represented within the synthetic environments. More weapons and echelons will be included, and we will develop better means to use ADS for acquisition improvements. There are immediate priorities as well, dealing with how to use ADS to better prepare individual combatants.

Business and manufacturing may also benefit from simulation technologies. Being able to control a distributed simulation exercise involving thousands of entities may provide insight into how distributed enterprises will work.

The use of simulators for unit training, and the ability to join distant players on a virtual battlefield can also be used by students. They can work in a virtual laboratory, supervised by an expert teacher located far away.

Finally, the technologies that will efficiently capture the knowledge of the behaviors of soldiers and commanders for use in SAF might also be used to create an decision aid for a doctor.



The systems shown on the previous slide provide a significant command and control capability from many aspects:

CTS--Common Targeting System

- Planning and Analysis Tool for Targeting, Intelligence and Battle Management
- Distributed Mapping Resources and servers using all DMA products
- Operations and Intel database interfaces

DSI--Defense Simulation Internet

- Established network infrastructure to enable global distributed, real-time, multi-media simulation
- Provides connectivty to integrate all simulation and modeling functions from early design to battle rehearsals enroute the conflict

GALE--Generic Area Limitation Exploitation

- Combined database of diverse topographic features
- displays topographic overlays on area charts
- Generates "what if" tel location scenarios based on topographic and spatio-temporal data using boolean queries

ACPT--Air Campaign Planning Tool

- Planning and Analysis Tools for Developing Air Component Campaign Plans
- Supports Management and Analysis of Intelligence and Targeting Information to Build Master Attack Plan
- Facilitates Allocation of Critical Resources Against High Priority Targets in Master Attack Plans

TARGET--Theater-level Analysis, Replanning and Graphical Execution Toolbox

- Distributed Collaborative Planning via video teleconferencing and shared workspace
- Toolbox Selection for Planning Support to:
  - Plan viewing and Editing,
  - Wargaming and Simulation
  - Crisis Action Planning

  Logistics
  Employment
  Deployment

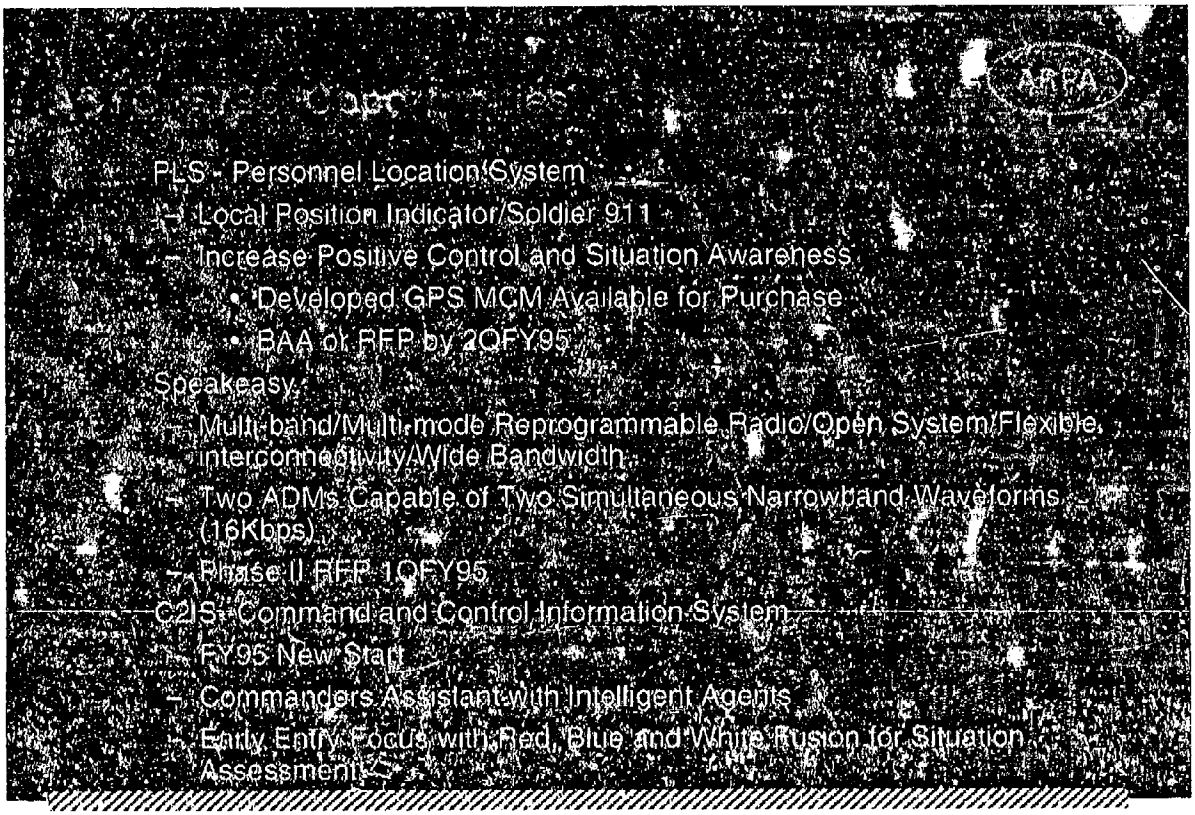
DART--Dynamic Analysis and Replanning Tool

- Deployment Planning
- Course of Action Selection and Transportation Feasibility Estimates
- Based on Asset Allocations and TPFDD Modifications



Theme:

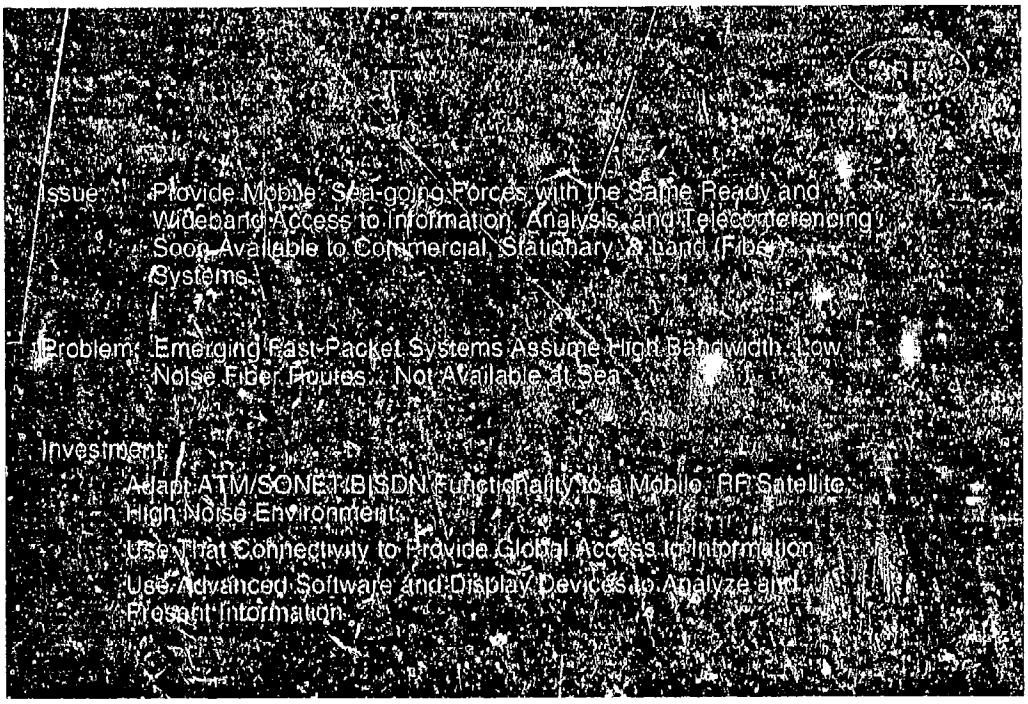
In the march from research to a useful product, either purely military or dual-use, a significant development effort must take place. A number of highly promising ARPA programs are at the stage where they have already demonstrated major technical advantages in the laboratory. The time is ripe to focus these programs toward those unique developments and/or demonstrations that will lead to new, significant military capabilities or dual-use markets.



Contract opportunities planned in FY95 include the release of a Broad Area Announcement or Request For Proposal in the second quarter of FY95 for the PLS - Personal Location System. We successfully developed a Global Positioning System Multi Chip Module which is available for purchase.

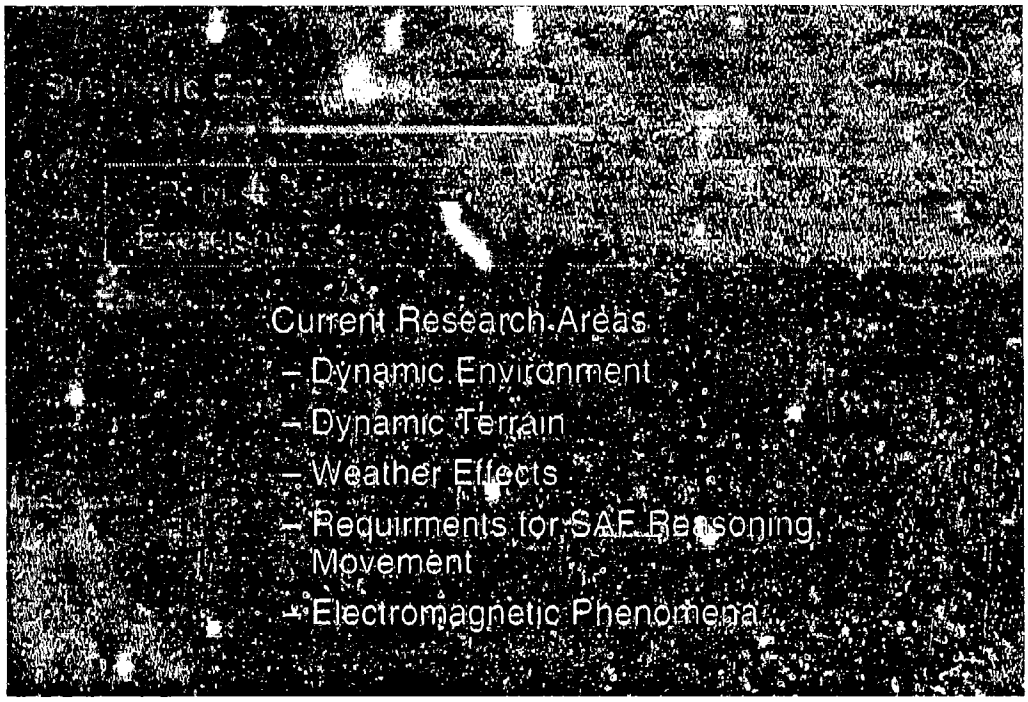
A Request For Proposal for Phase II of the SPEAKEASY is planned for release in the first quarter of FY95.

A Broad Area Announcement was released for the Command and Control Information System. This is a new start that is focused on the challenges presented in Early Entry.



A primary MSTO thrust is to provide wideband access to information, analyses and teleconferencing to the mobile and sea-going forces. These forces have traditionally suffered from a lack of high bandwidth and availability-restricted connectivity. Emerging system requirements require that bandwidth; the capability must be provided.

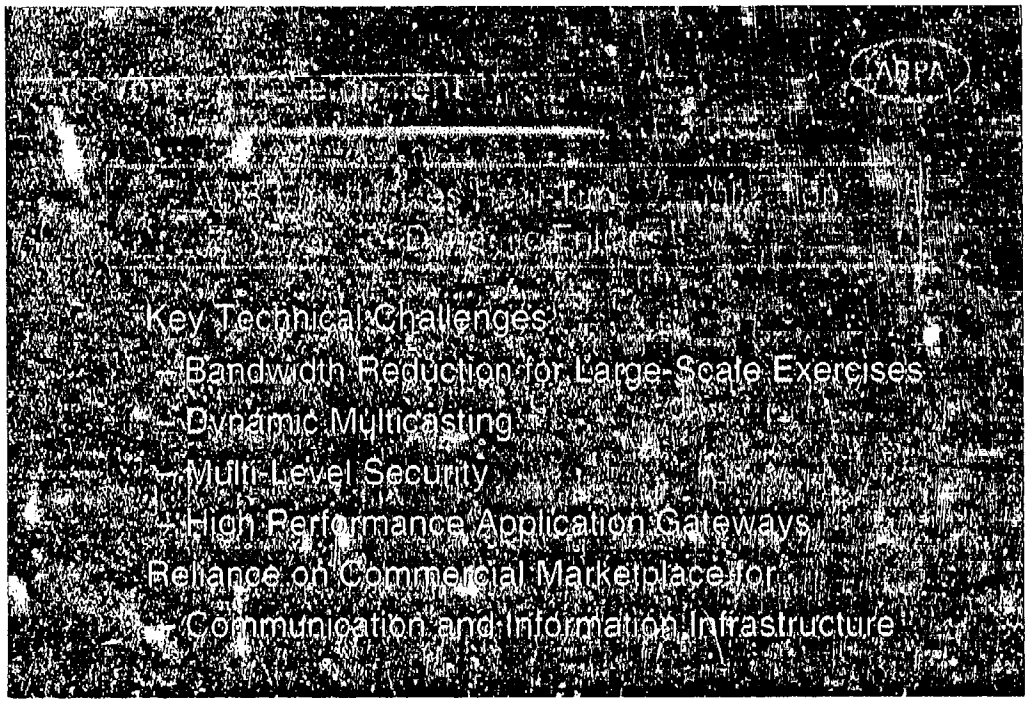
Through adaptation of ATM/SONET/BISDN, connectivity to global systems is achievable and is being pursued.



There are significant technical challenges in creating robust synthetic environments, especially for use in a distributed environment. This chart shows what areas will be emphasized during the next 4 years. Computing power, be it for calculations or for displays, will be the limiting factor in making the environments more realistic. The research program is geared towards obtaining a better understanding of what effects, and at what resolution, are operationally relevant.

For example, does each simulation entity need to have a complete world view? What is the architecture that would allow, for example, craters to be effected in real-time to all participants? Or simply to all interested participants?

Our approach for the long-term will be to demonstrate certain capabilities only in selected portions of the battlespace.



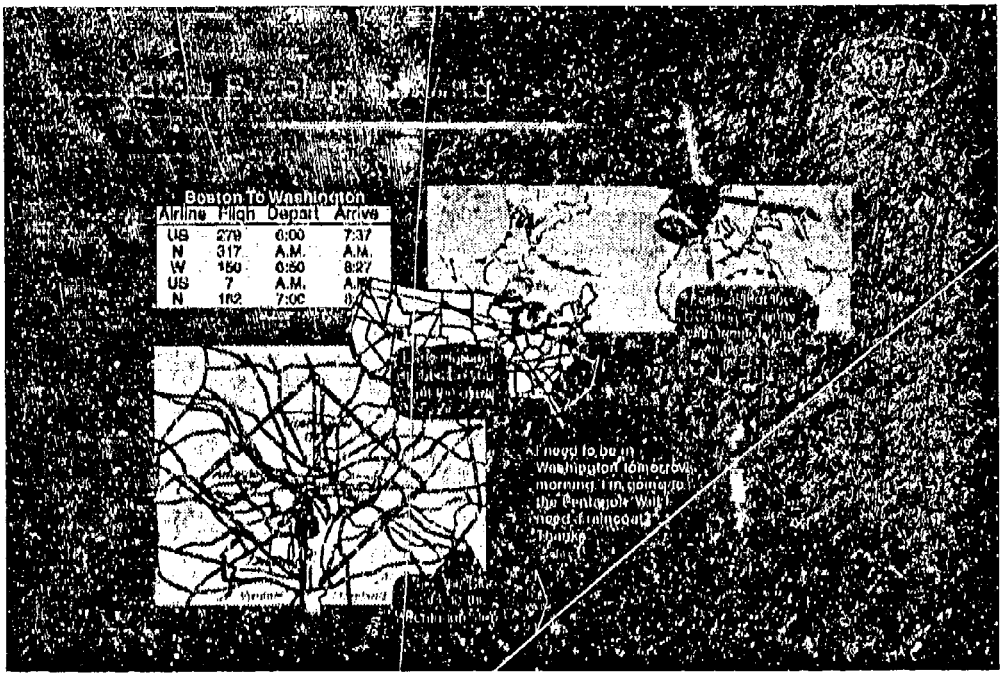
ADS imposes unique requirements on information transfer and networking technology, due to the real-time nature of the simulation and to the high-resolution, 3-dimensional visualization capabilities.

The technical challenges are significant. For example, a theater-level distributed simulation exercise may involve 100 times the bandwidth that STOW-E requires, while maintaining stringent perceptible real-time performance, a stringent requirement.

The requirement to provide dynamic, multicast routing of the simulation traffic might also be necessary, yet with the added requirement that only commercially viable equipment and commonly accepted protocols be used.

The simulation exercises must operate in a multi-level security environment, rather that system-high security levels, without imposing significant degradations on the network throughput.

Finally, the commercial market for information and network technologies is much larger that that served by Defense applications of ADS. So we must work to leverage these other investments towards satisfying the Defense simulation needs.



The numbers of users is increasing dramatically. I have had some people object to the values on this graph as been overly optimistic. Let make the following observation, this graph crosses 80M users in 1993. As of last month, MS had sold more than 70M copies, of MS-DOS and more than 40M copies of Windows.

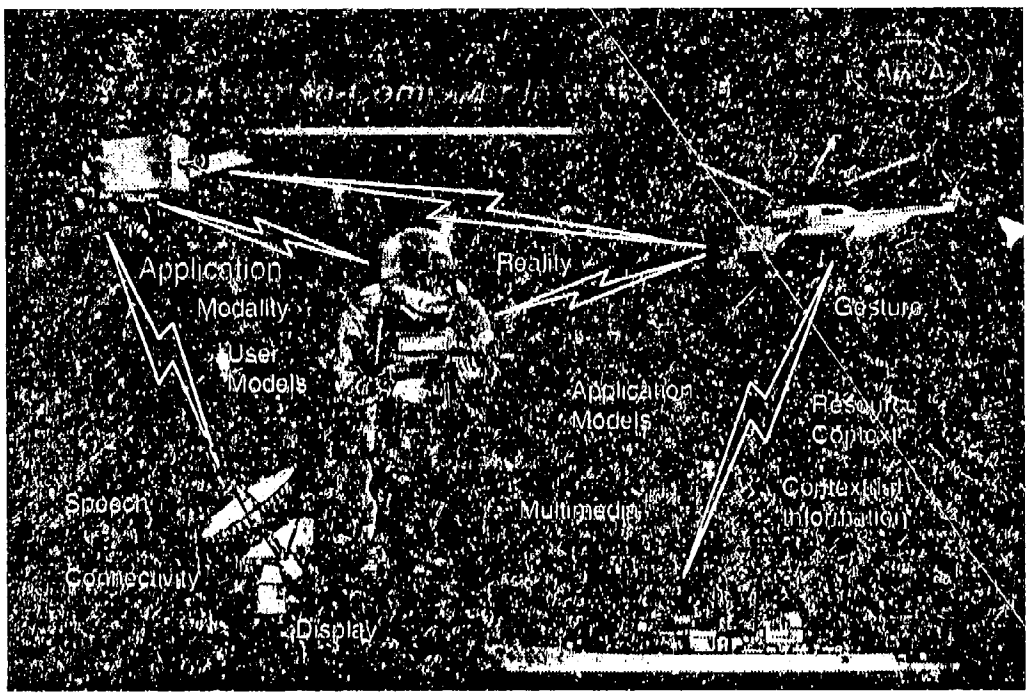
The markets in China. India, South America, and Eastern Europe are just beginning to open. Thus, I don't think the projected number of ~500M by 2010 is going to be off by a significant margin.

One point to be drawn from this exponential increase is that as the number of users increases the number of diverse applications will increase and we need more rapid means to develop applications that meet users needs, if they are to realize the productivity increases that computers can deliver.

The second trend of interest is the decreasing extent of what I've called Traditional Computer Knowledge, and by which I mean, knowledge of the underlying behavior of computers, operating systems, machine languages, even traditional programming languages . Its readily arguable that the 2 most widely used "programming languages"today in terms of the number of people using them are the macro languages in Lotus 123 and Excel.

To the extent that users know less and less about the underlying mechanisms of computing, the greater the need to make their interaction more closely represent familiar terrain in terms of presentation of the task and mode of interaction.

These trends requires a new generation of intelligent, user-interaction development tools to rapidly develop natural, solution-focused, user-application interactions and more natural, less intrusive mechanisms of interaction



The focus on human-computer interaction is in harnessing the compute power to deliver users solutions. People need solutions not tools, and too often they are provided tools.

Virtual reality & human language technologies...

Application Models: Spreadsheet, Database Access, Word Processor. .

Connectivity: Isolated, Internet, Local, Distributed. . .

Contextual Information: Meeting Chair: Co-located, Routine Planning Mgt., Inform Search, Training. . .

Display:Wall, Desktop, Notebook, PDA, Wristscreen. . .

Gesture: Hand, Pointer. . .

Modality: Visual, Auditory, Haptic. . .

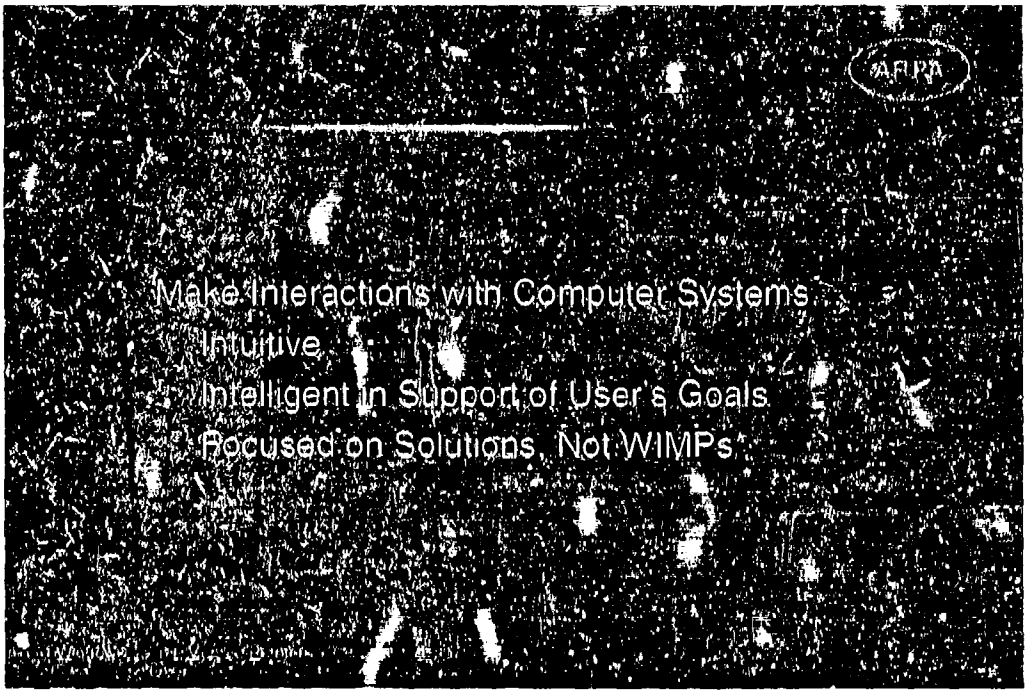
Multimedia: Text, Live Video, Stored Video, Animation, Simulation. . .

Reality: Virtual, Augmented, Enhanced. . .

Resource Context: Office, Fixed, Command Center, Shipboard, Field HQ. . .

Speech: Input, Output. . .

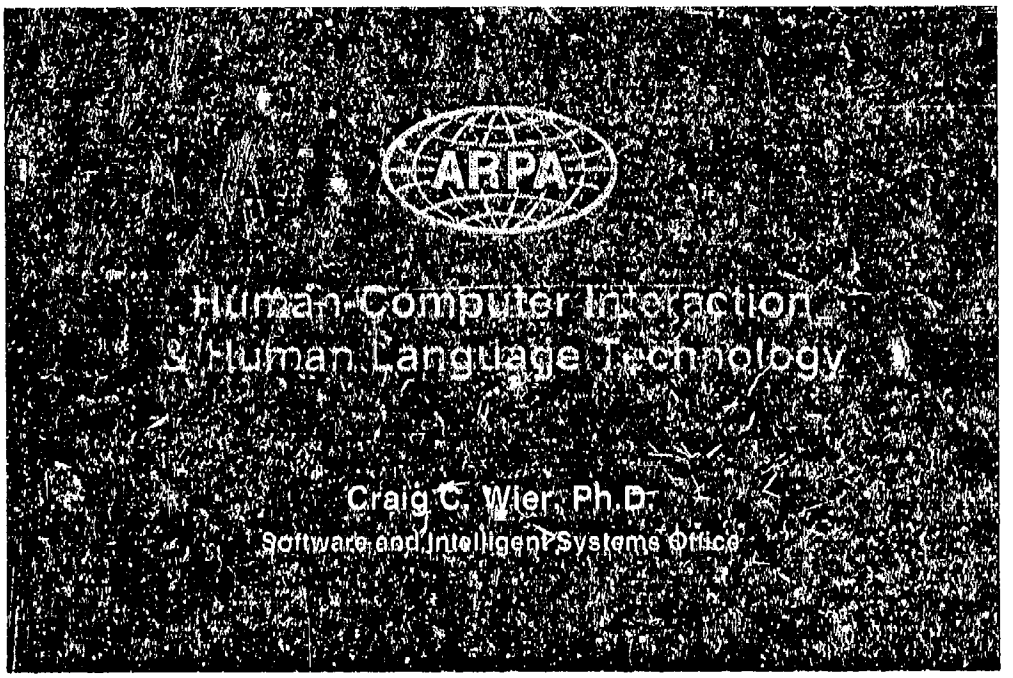
User Models: Warrior, Analyst, Cmdr.,Planner. . .



The vision for the HCI program is to make human interaction with computer systems focused on intuitive use directed toward real end-user solutions, not WIMPs.

And to incorporate intelligent behavior into applications in support of user's goals — make computers more "user literate."

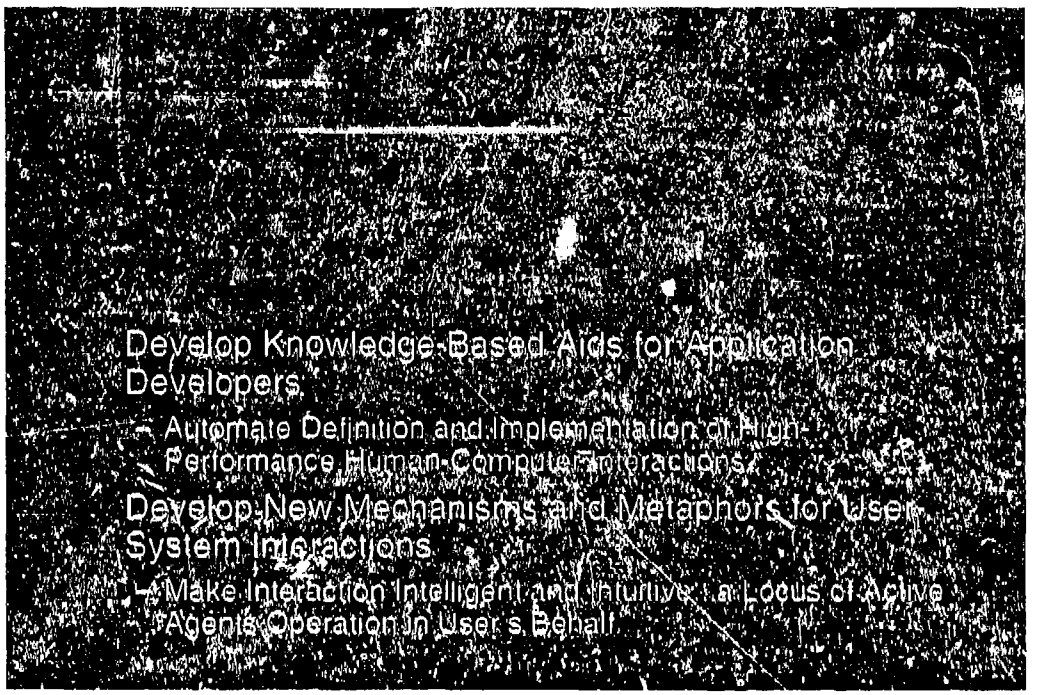
Finally, the vision includes the application of technologies from other programs within our office to support both software developers and users to realize this vision, and then to deliver demonstrations of this vision in projects initiated within SISTO and in our sister offices.



The bottleneck to improving interactive usefulness of computer-based systems increasingly lies not in performing the processing task itself, that is the underlying bit manipulation, nor in actual data retrieval, but in communicating requests and results between the system and the user.

Faster, more natural and convenient means for users and computers to exchange information are needed.

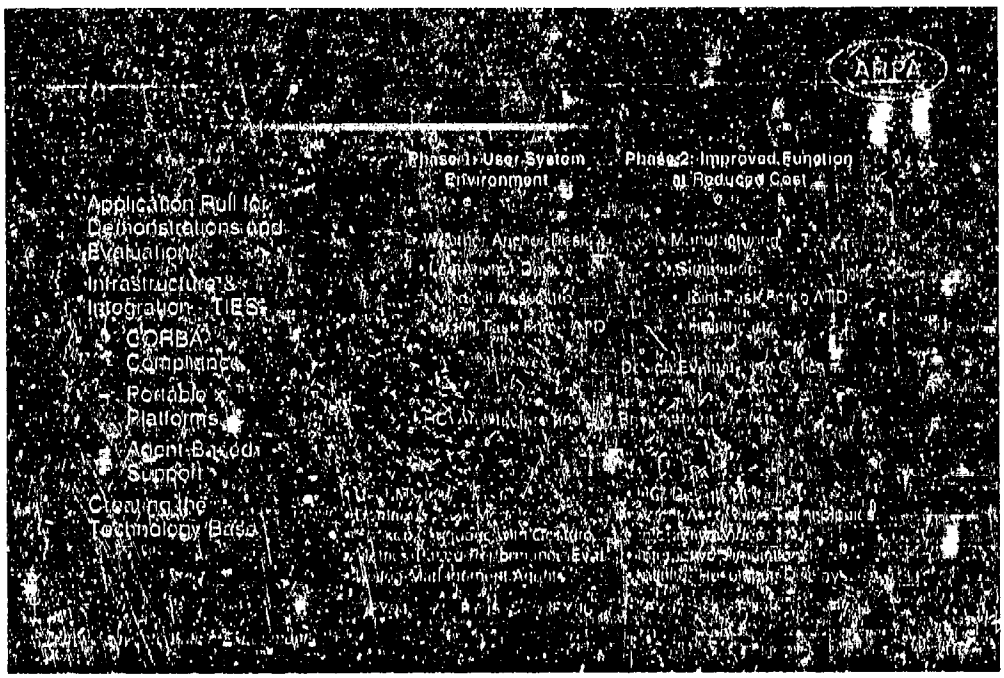
Discovering and proliferating those more natural and convenient means is the task of the HCI program.



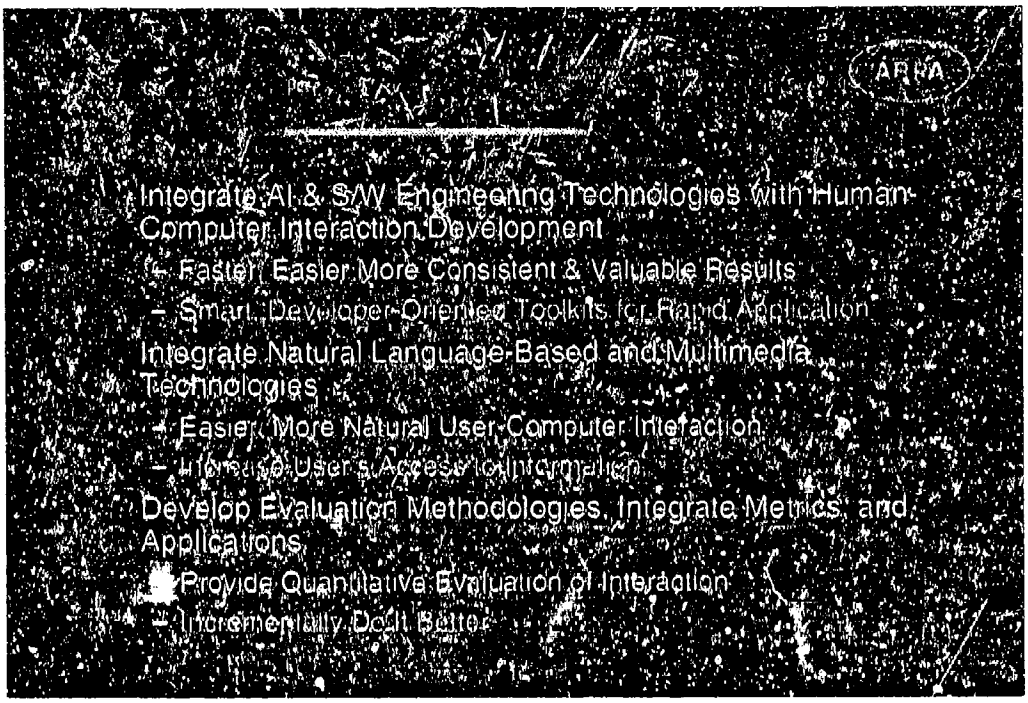
The focus on human-computer interaction is in harnessing the compute power to deliver users solutions.

People need solutions not tools, and too often they are provided tools.

Virtual reality & human language technologies…



Characterizes the dual thrust of the ARPA HCI program — one toward developers, the other toward end-users

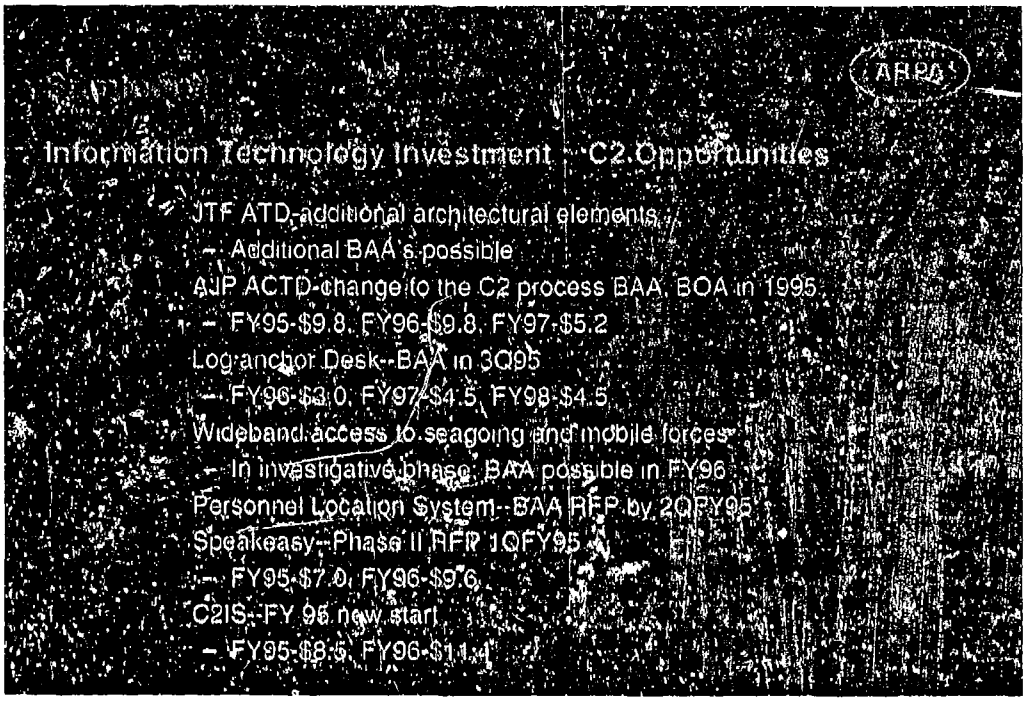


Here we see an example of a scenario supported by work done at MIT building on work supported by the HLT program.

The user stands in front of a large screen display with no keyboards, boxes or monitors insight. Speaking to the screen, the user asks seeks information using spoken questions. Speech recognition, natural language technologies and speech synthesis are used to support the user's ability to access information from a variety of networked databases.

Airline reservation information, map-based weather information, and detailed directions for local travel.

It does not require a great leap of the imagination to envision use of this technology in a military command and control center, or a civilian crises management milieu.



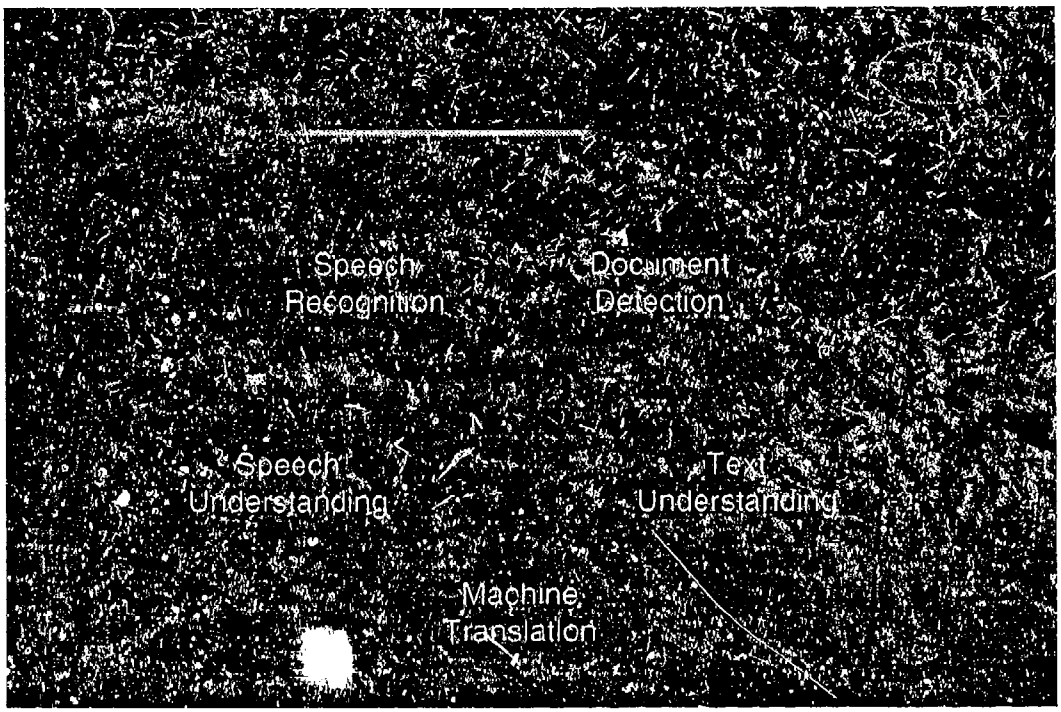
In summary, ARPA is developing the architectural structure and tools necessary to promote the information requirements for the future; for the military and other DOD, and with application in the commercial sector as well. Potential near term opportunities in our information technology areas is shown here.

In SISTO, future expansion to the reference architecture, the implementation of the ACTD,and of the Logistics anchor desk are opportunities.

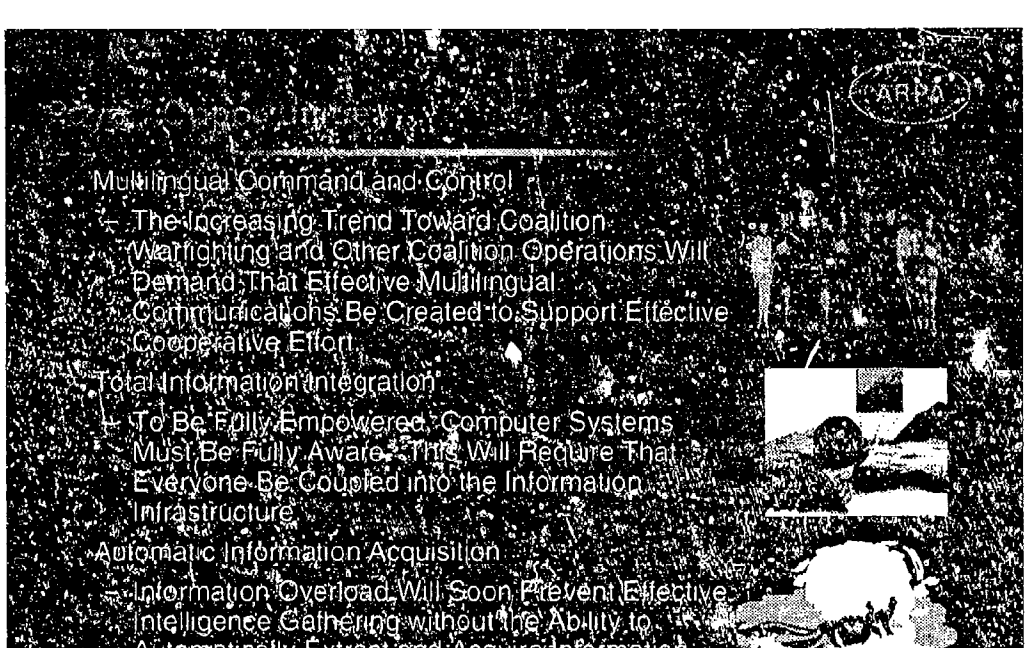
In MSTO the wideband access to the seagoing and mobile forces is an area of potential investement.

In ASTO, the PLS, Speakeasy, and the C2IS all offer potential

This list is not necessarily all inclusive, but does denote the areas of current emphasis. Industry plays an important part in the ARPA development process. New thoughts in participating in these or other areas of the ARPA development environment are always welcome.



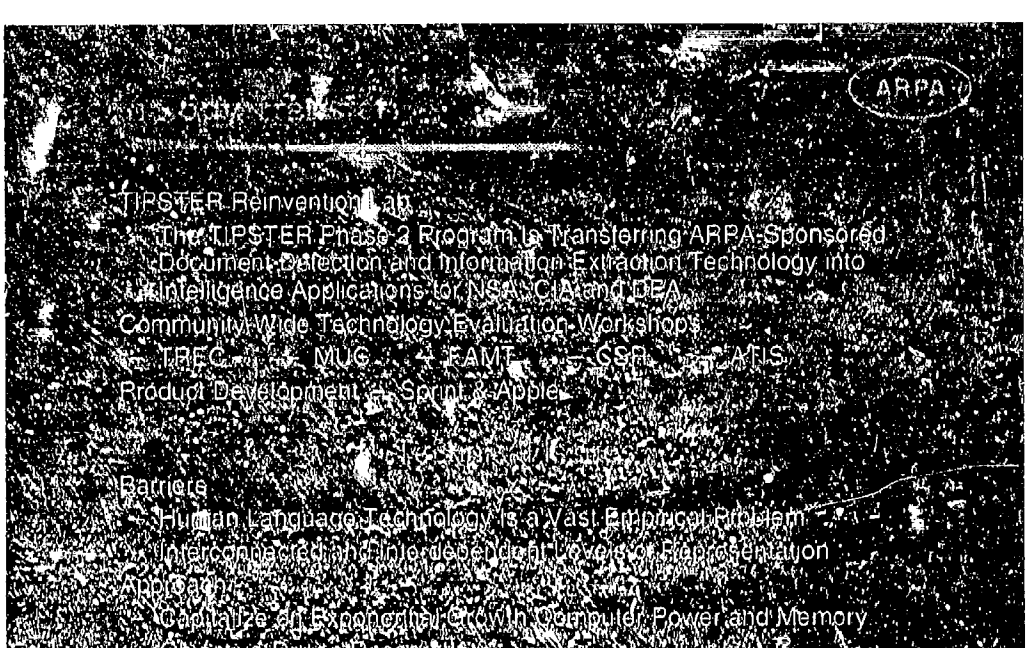
Identifies the three key ideas that drive the program — apply intelligence to software engineering effort; apply developments from Human Language Technology program to make interfaces more intuitive; and develop metrics to improve ability to quantitatively characterize improvements



Multilingual Command and Control -- We have begun an initial sortie into this area by funding a study and concept demonstration of speech-to-speech language translation for battlefield coordination of multinational forces.

Total Information Integration --This will demand speech understanding and text understanding technology to support communication of information with people who are not specialists in information technology. They must be able to communicate with information systems without the need for specialized training. Examples include field troops, logistical supply clerks, medics, and everyone else involved in coordinated warfighting.

Automatic Information Acquisition -- The intelligence analysis problem is today a daunting and frustrating task in coping with data beyond the bounds to process. Tomorrow promises such a glut of information that our ability to profit from it will go to zero without a means to acquire information automatically from natural language text.



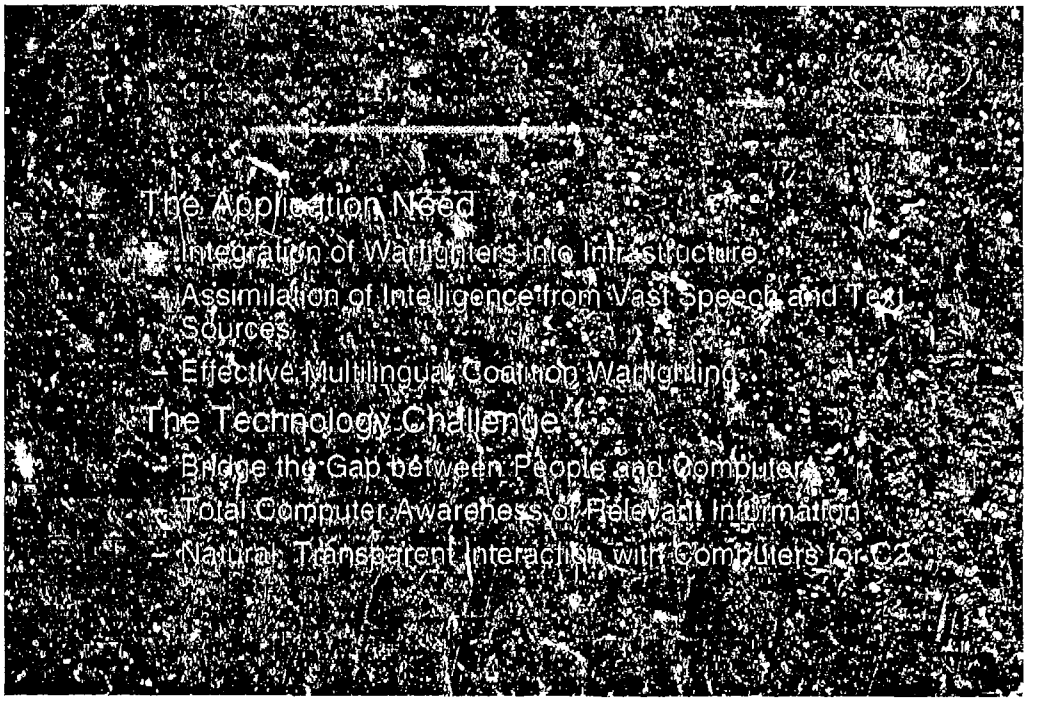
TREC - Evaluation of document detection based on text processing using natural language queries.
MUC - Evaluation of information extraction from text.
FAMT - Evaluation of fully automatic machine translation of text.
CSR - Evaluation of Continuous Speech Recognition.
ATIS - Evaluation of Spoken Language Understanding for Air Travel Information Service database queries.

Product development efforts go far beyond what is possible to identify on this foil. ARPA contractors are involved with many different applications of HLT using ARPA-sponsored technology. The applications identified here exemplify the kind of impact that the ARPA HLT program is making:

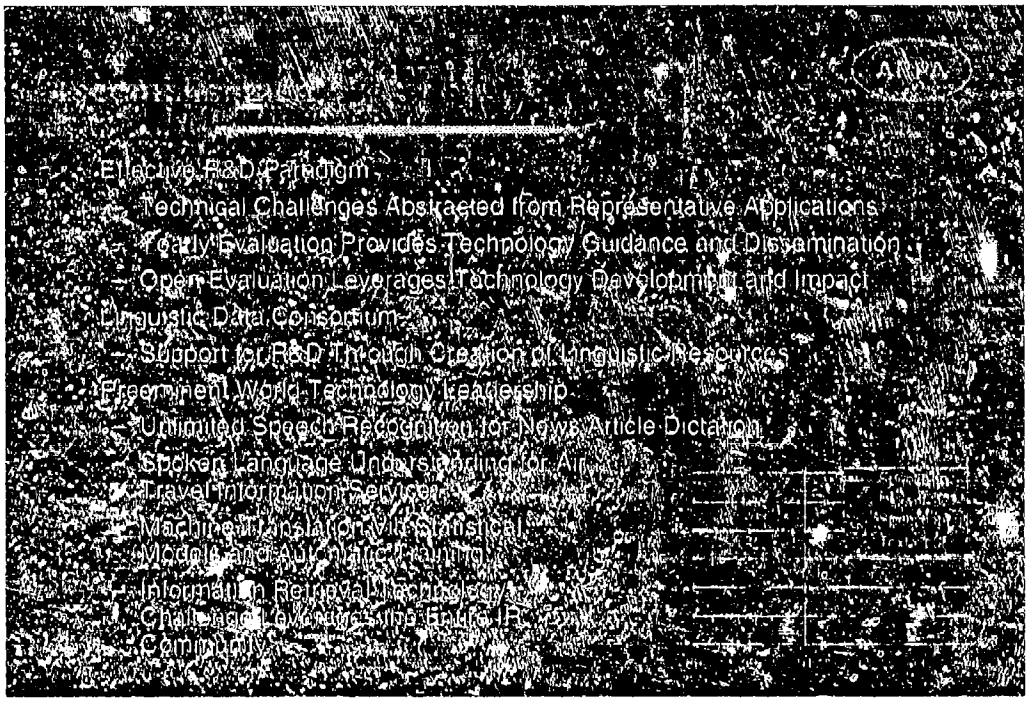
> The **Sprint long distance voice activated calling card** evolved from a speech technology effort at Texas Instruments. ARPA funded TI to develop robust speech recognition technology from 1984 through 1987. This was then used to address Sprint's needs for robust speech processing over telephone lines, starting in 1988.
>
> **Apple's speech technology effort**, which is now producing embedded speech recognition products in Apple computers, began when Kai Fu Lee "graduated" from the ARPA speech recognition program at CMU and joined Apple.
>
> **Human/Computer Interaction**: There are many application areas here. Of these, the effort at BBN is notable because of its application to aviation safety. BBN have two programs to extend computer awareness, by recognizing controllers' aircraft identification and by monitoring radio voice communications and identifying and classifying ATC activities.

Barriers - HLT is a vast empirical problem: Hierarchies of immensely complex and hidden models; Training complex models requires hugh knowledge bases. Interconnected and interdependent levels of representation: Correct speech recognition requires speech understanding; Correct text understanding requires domain knowledge.

Approach - Capitalize on expotential growth computer power and memory: Statistical modeling --automatic training of very large models; Vast shared resources -- corpora, tasks, metrics, evaluation. Objective-driven research: Application-focused technical tasks; Yearly cycle of formal evaluations.

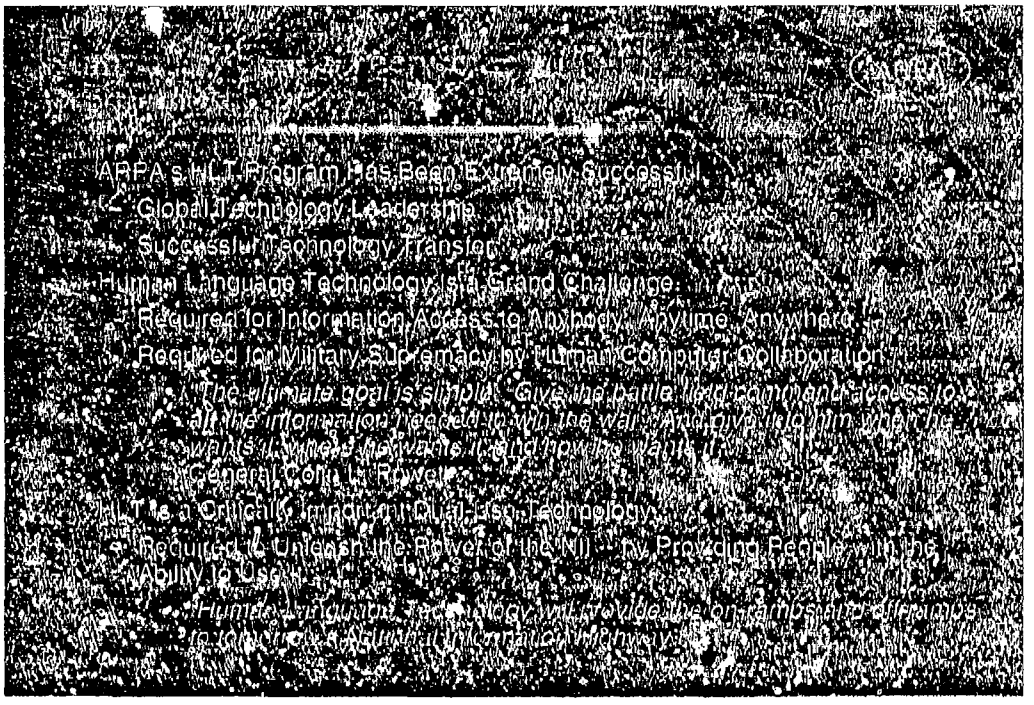


Characterizes the path from research through system integration and test to transitioning of the technology into operational demonstrations and test beds over time.

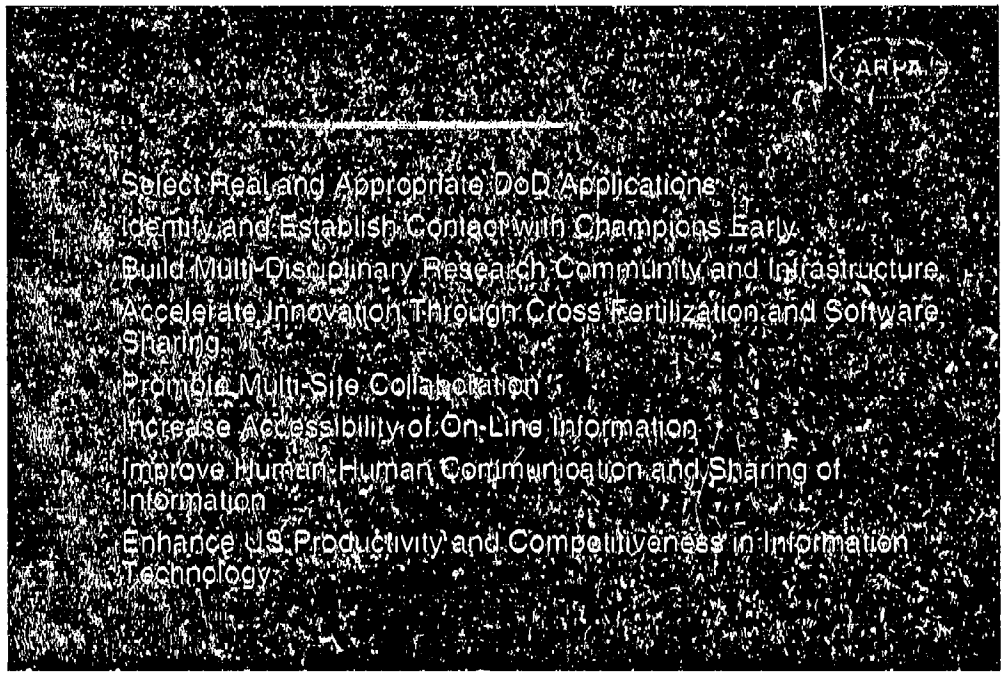


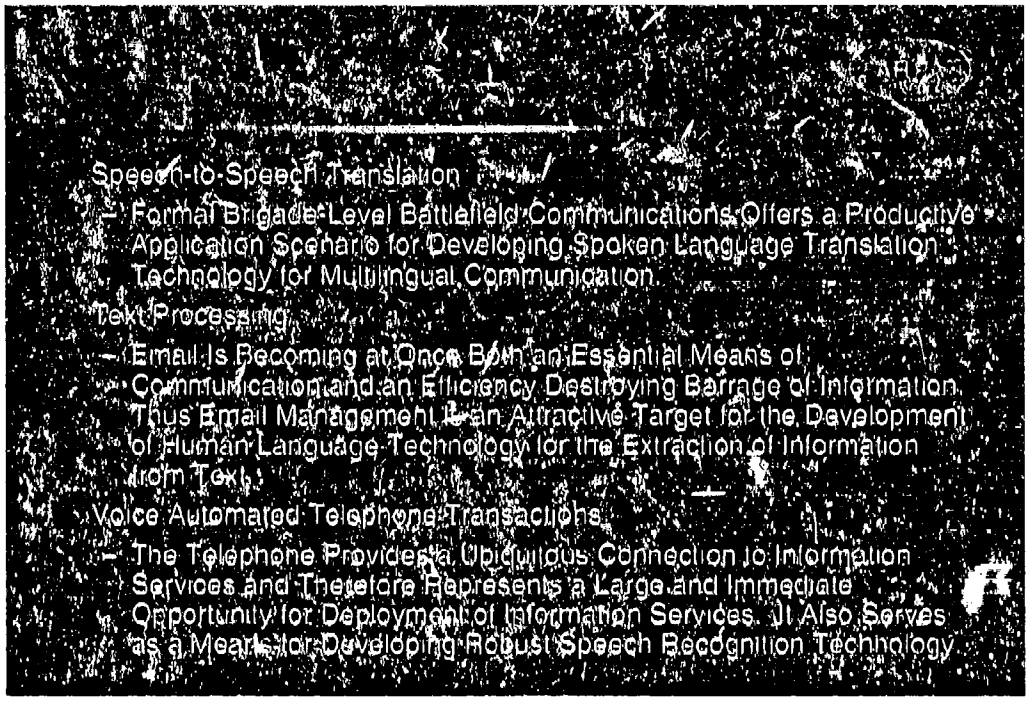
The **Linguistic Data Consortium** was created by a grant from ARPA to the University of Pennsylvania in 1992. The LDC has since that time provided major support to ARPA and to the larger language technology community by supplying the linguistic resources required to perform modern statistical corpus-based language technology development. LDC now has almost 100 members world-wide and stands as a major asset in U.S. leadership in language technology.

ARPA has also been highly successful in **transferring technology** to industry.



HLT Program Summary


ARPA
Select Real and Appropriate DoD Applications
Identify and Establish Contact with Champions Early
Build Multi-Disciplinary Research Community and Infrastructure
Accelerate Innovation Through Cross Fertilization and Software Sharing
Promote Multi-Site Collaboration
Increase Accessibility of On-Line Information
Improve Human-Human Communication and Sharing of Information
Enhance U.S. Productivity and Competitiveness in Information Technology

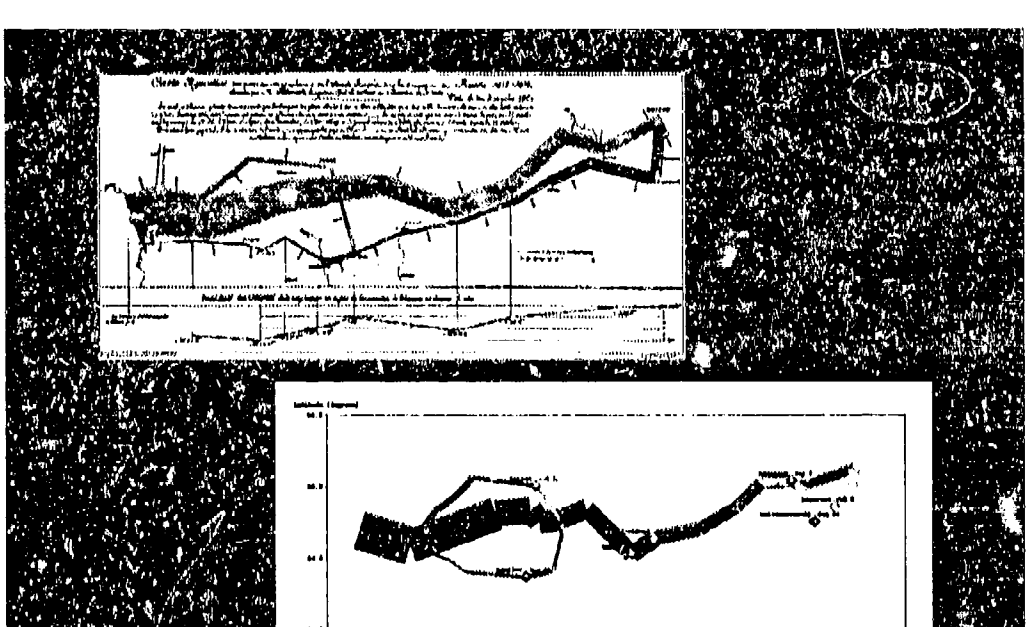


New Technology Initiatives

Speech-to-Speech Translation

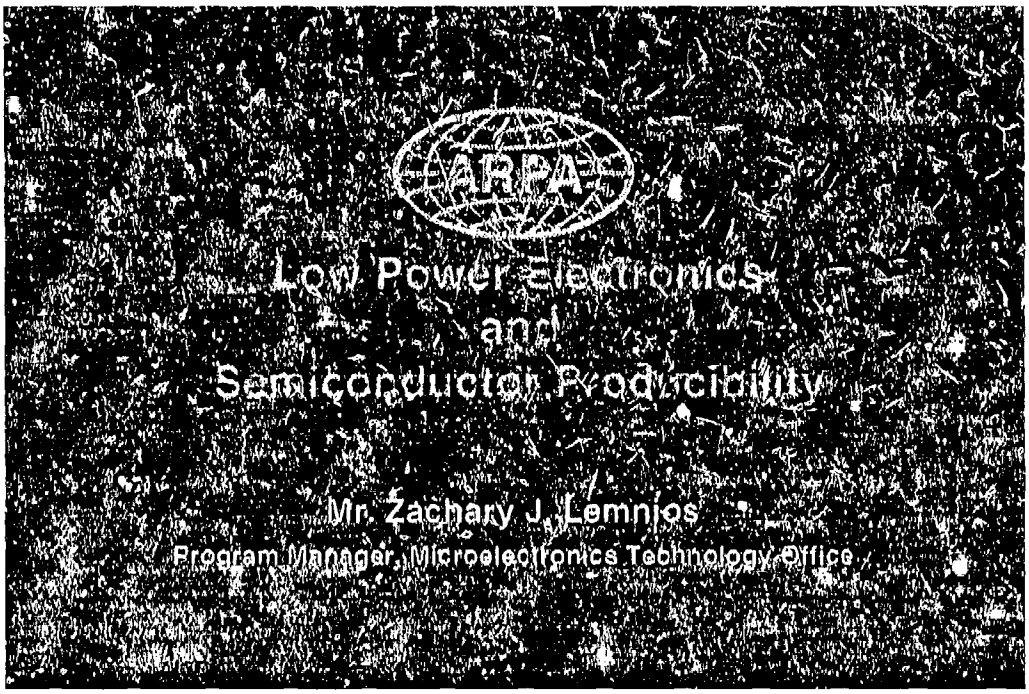
Text Processing

Voice Automated Telephone Transactions



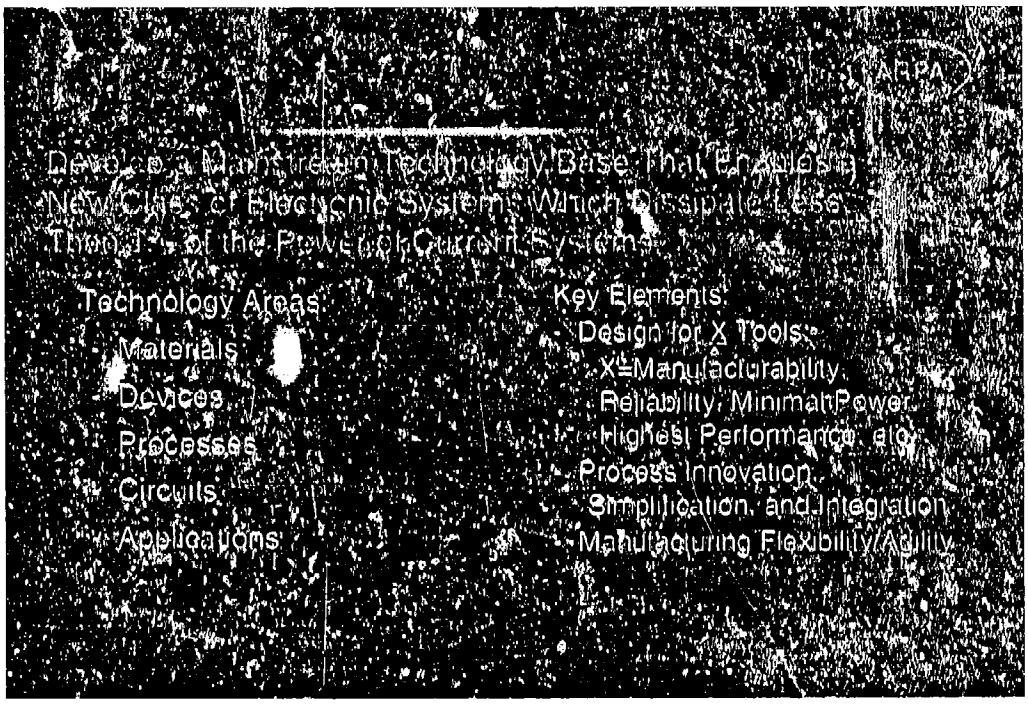
SAGE is an example intelligent system sponsored by the HCI program. SAGE automatically displays data in ways that maximize the information content for complex, multi-dimensional data.

Illustration of SAGE systems capability to generate meaningful displays from complex data sources. The figure at the top is a classic of information compression describing Napolean's march on Moscow. The figure on the bottom was automatically generated using the SAGE system



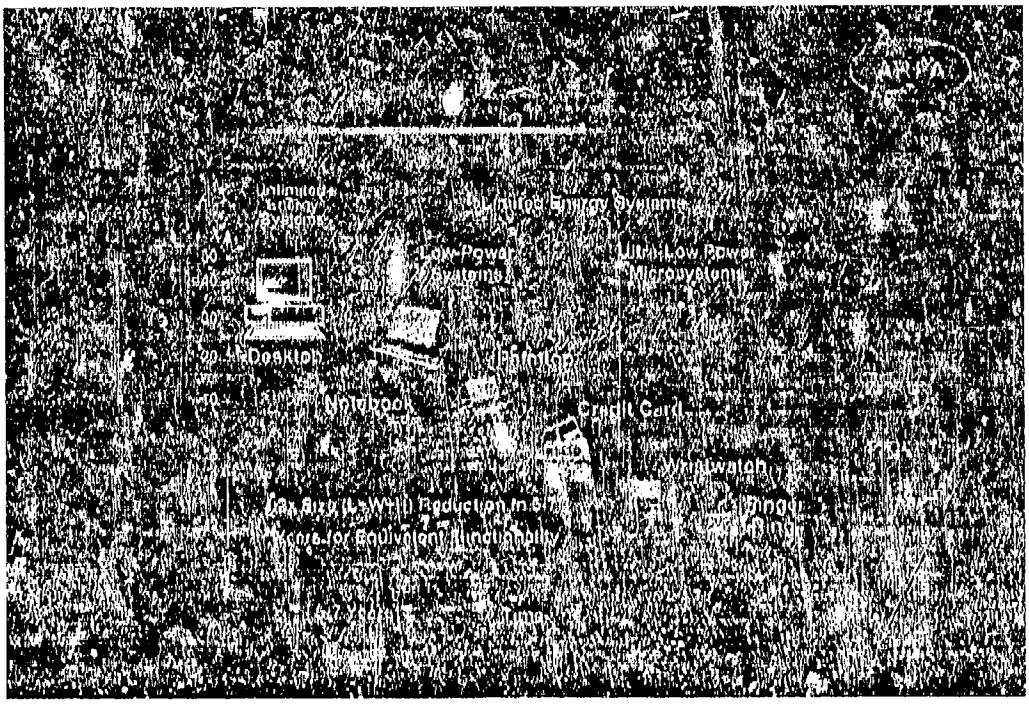
A revolution has occurred in the electronics industry that is resulting in a broad range of low cost, high performance electronic systems. Power dissipation and component manufacturing complexity are severe constraints on existing systems and present significant barriers for increased performance.

ARPA has initiated a core program in Low Power Electronics to create an infrastructure to surmount these barriers. Low Power Electronics is an important segment of the electronics industry and perhaps the area of greatest change and opportunity. This briefing will summarize the ARPA Low Power Electronics Program and present an approach for design coupled manufacturing that will significantly reduce manufacturing complexities.



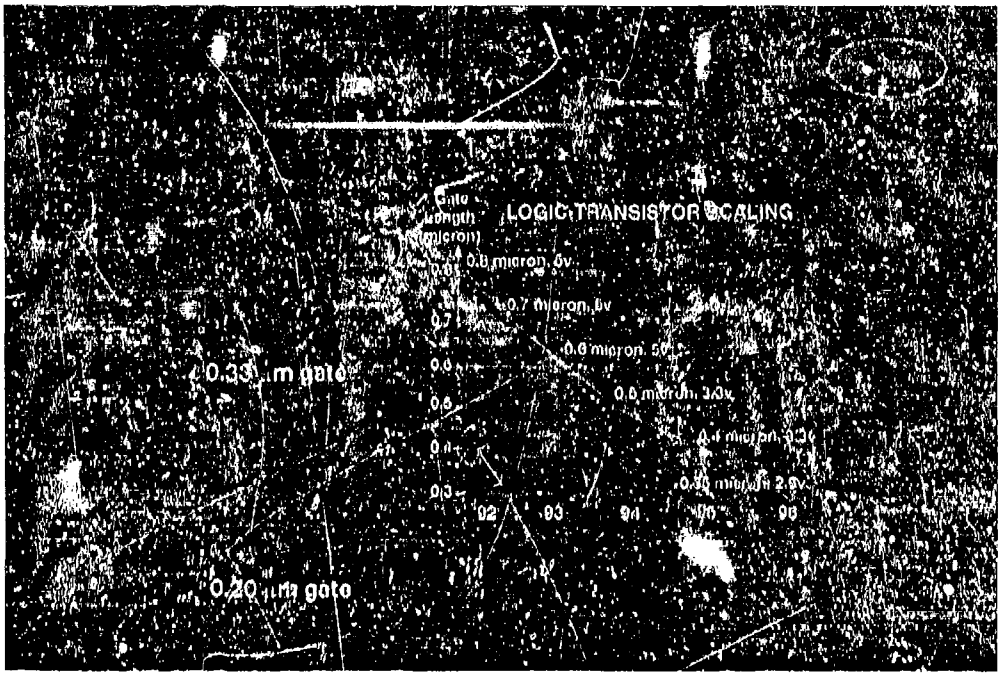
The objective of the ARPA Low Power Electronics program is to enable the production of electronic systems that dissipate two orders of magnitude less power than use of conventional technology would allow, while maintaining at least parity in performance metrics (i.e., clock frequency, bandwidth, noise margins, etc.).

Synergistic improvements in multiple technology areas will be needed to achieve the goals of this program. Improvements in materials and device technology must be coupled with effective design and power management tools for effective power driven system development. The resulting technology solution must demonstrate a viable avenue to cost effective manufacturing and must be broadly available to the industry.

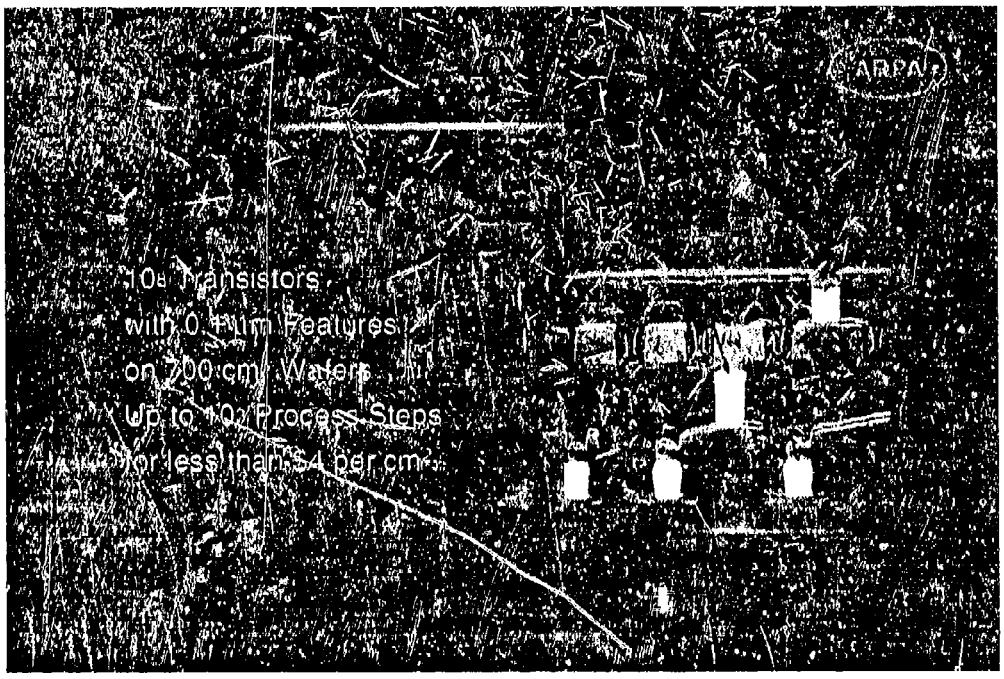


The trend in miniaturization of personal systems is clear. System volume has decreased by about 50% every 5 to 7 years, with at least equivalent functionality and in many cases superior functionality. As this trend continues, the demands placed on the semiconductor electronics for these systems will necessitate new manufacturing paradigms and technologies.

These trends also place a premium on low power strategies. Effective development of low power technologies must include a commercialization plan to sustain the resulting technology base.

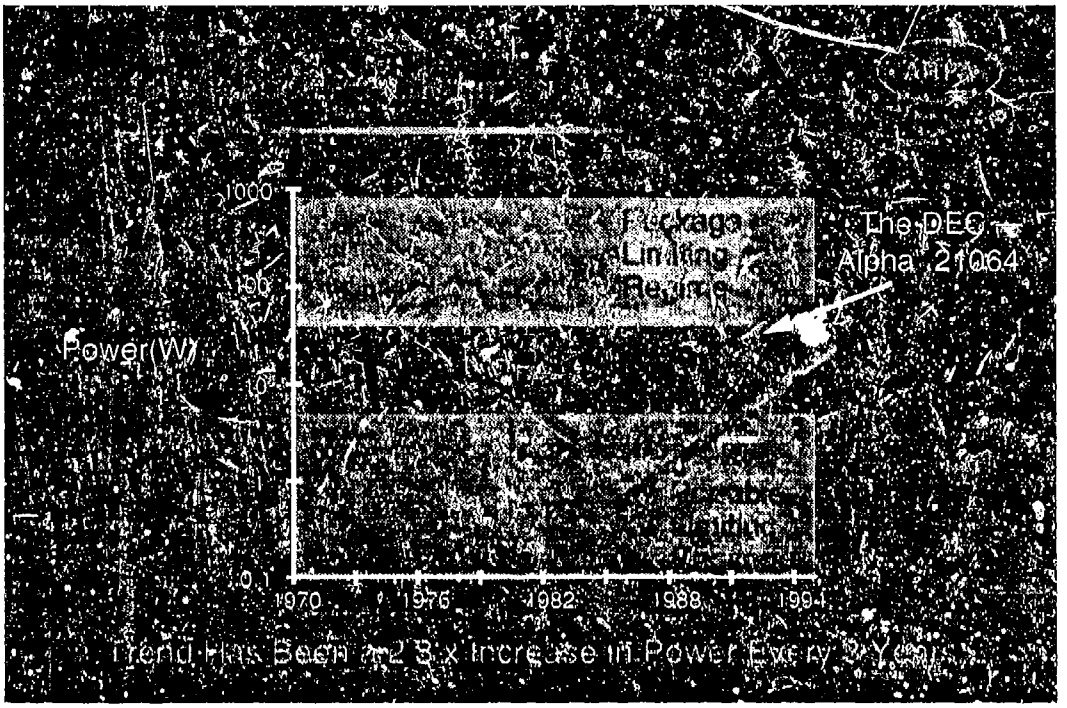


These system trends are a result of dramatic improvements in component manufacturing and performance. We have reached a point in the process that the device geometries are approaching the exposure tool wavelength and the film thicknesses are approaching the electron tunneling limits. The challenge is to support these requirements without significantly adding to the manufacturing complexities.



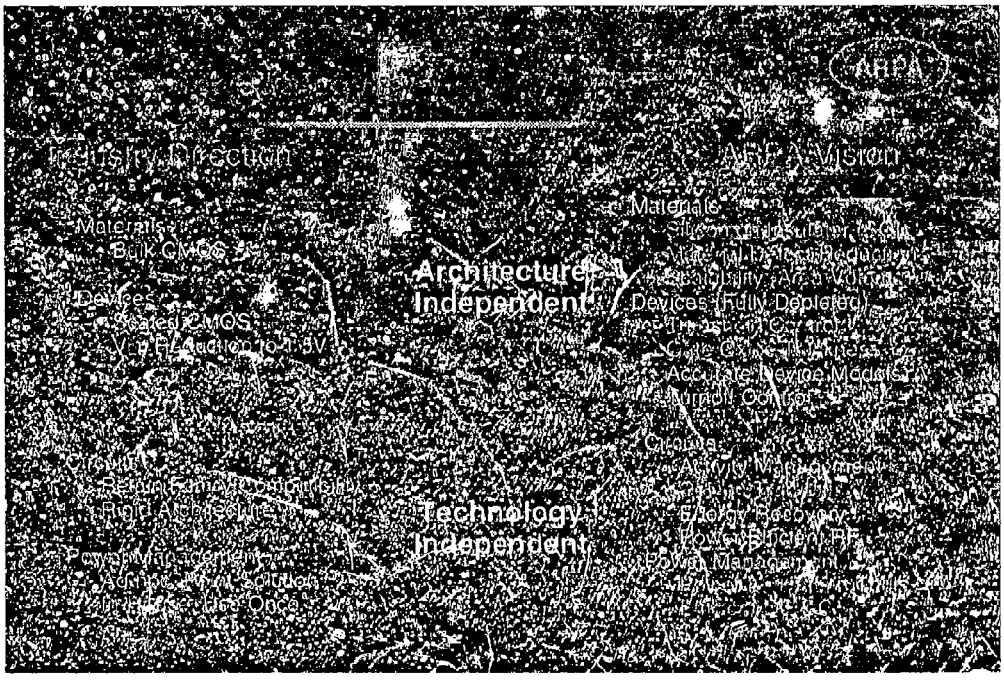
This photograph is a cross-sectional view of a leading-edge microprocessor, the PowerPC RISC chip, illustrating the ever increasing complexities of front-end and back-end processing.

The manufacturing trends are clear as are the challenges to producibility. These challenges include the ability to incorporate 100 million interconnected transistors, 0.1 µm features, 700 cm^2 chips, and perhaps a thousand process steps. All of these requirements must be met within the manufacturing cost constraint of several dollars per square centimeter.



The trends in power dissipation of commercial microprocessors illustrate the drivers for the ARPA Low Power Electronics program. Power dissipation has nearly tripled every 3 years as a result of increased integration.

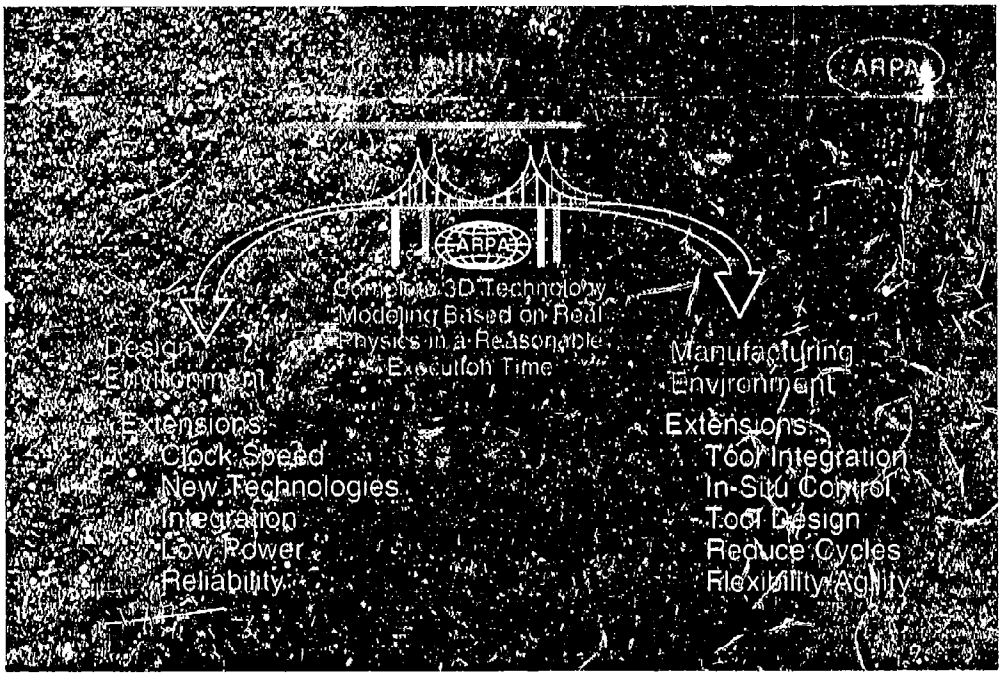
There are two lower dissipation limits which impose barriers for hand held commercial electronic products as well as computational driven scaleable computing systems. In the portable-limit, it becomes difficult to carry energy for systems which dissipate more than about 5 watts. In the package limit, it is difficult and expensive to package electronics that dissipate over 30 watts. These electronics require external cooling, heat sinks, and special packaging technologies. These barriers apply to scaleable computing and desk-top systems.



Low Power Electronics is perhaps the fastest growing electronics segment and the one which offers the greatest potential. Industry has identified this and is following a strategy to meet the demands of the portable market. For example, there is a trend of decreasing power supply voltages as device channel lengths decrease. Scaling for constant channel electric fields can preserve device performance and may also serve to reduce power, although this is totally dependent on the number and functionality of the devices within an IC, which will increase as linewidths decrease.

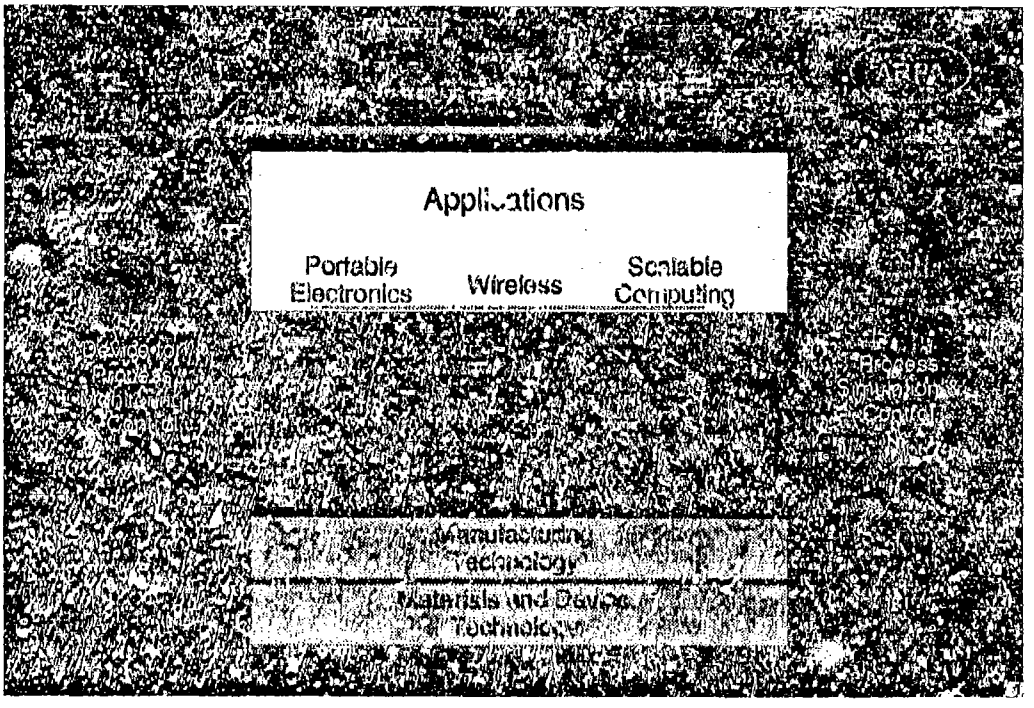
In developing an investment strategy for low power electronics, areas of major development activity may be classified into two categories: architecture independent and technology independent. The first category concentrates on the material and physical implementation of a circuit design. In this area, industry is already following a trend toward decreasing power supply voltages with conventional CMOS. The Semiconductor Industry Association technology roadmap predicts 1.5V operation will be needed by the year 2001 for portable products. It is possible that integrated circuits with 1.5 volt supplies may be developed in a scaled CMOS technology. For a number of reasons however, it is unlikely that CMOS can be extended much below 1.5V. Here, fully depleted SOI materials and device structures will have a dramatic effect, allowing power supply reductions to at least 1V and probably lower. SOI is still a high-risk technology, so industry has not yet totally embraced the approach. Material defects must be reduced to improve the material to a point of maturity. Furthermore, a robust material supplier infrastructure is required for industry to seamlessly transition to a new technology. Process control for threshold voltages and gate oxide thicknesses must be demonstrated in thin films that support fully depleted devices. Modeling tools to predict SOI device behavior and reliability will be needed also.

In the technology independent area, industry has developed some techniques to prolong battery lifetimes, largely through activity management of functional blocks. These techniques are often ad-hoc, point solutions that have little application to new generations. Circuit designs are also rarely optimized for low power. Key elements of the Low Power Electronics Program are to develop CAD tools to answer power/performance trade-off issues and optimize designs. Power management techniques that are rigorous and include efficient and accurate power dissipation calculations are likely to be developed.

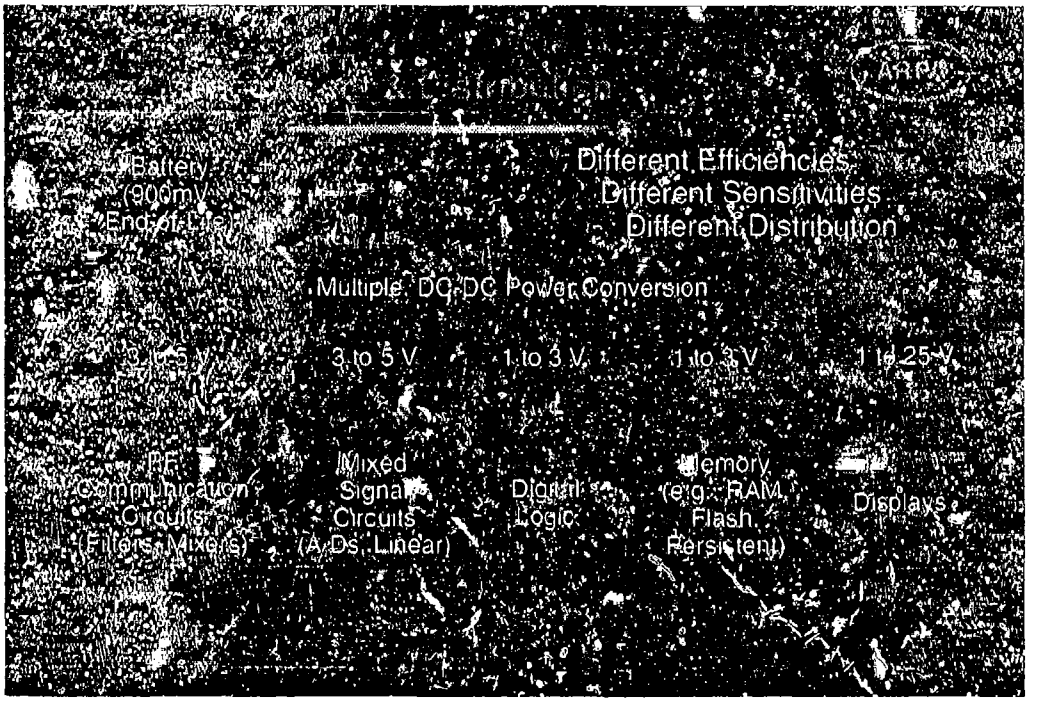


The strategy to meeting commercial producibility demands is two-pronged. On the design side, extensions of CAD tools must be developed that support high speed circuits, higher integration levels, low-power, reliability/manufacturability, and new technologies. Currently, CAD tool developments are mainly driven by ASIC products. In the future, these tools must be extended to random logic and analog, as well as monolithic integration of novel technologies. On the manufacturing side, software and CIM tools are needed to allow faster integration of process equipment, in-situ control, reduced process development times, and increased factory flexibility.

Advanced simulation capabilities is one of the key technologies here. A complete capability to accurately and rapidly model the performance, parametric sensitivity, functionality, reliability, and manufacturability of an electronic component is critical. A powerful design environment such as this might support all phases of electronic design and production in a hierarchical fashion, from manufacturing tool design, to unit process, to process integration, to factory modeling, to product performance modeling.

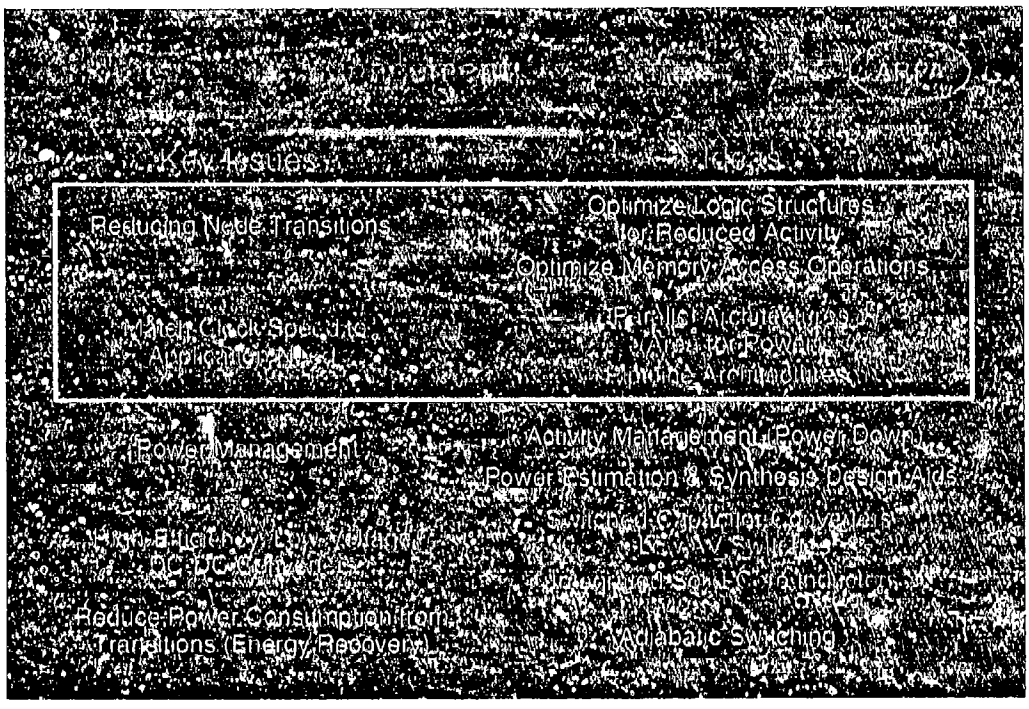


Materials and process technology are the foundation of the ARPA electronics programs. Applications are emerging that will drive low power semiconductor technology from the top down, producing an infrastructure and knowledge base to design and produce electronics with orders of magnitude of lower power and higher performance.



A systems approach to power distribution and management will be needed to integrate multiple functions and technologies. Portable systems will consist of a battery and a number of subsystems, digital, analog, and mixed signal, that may require multiple power supply voltages and currents. An advanced energy-dense battery of the future may have terminal voltage of around 1V. Efficient, well regulated dc-dc converters are required to convert the battery voltage to the level needed by various ICs in the system. Switched capacitor converters are an attractive approach, but their effects on sensitive low voltage ICs must be studied.

Power management must be implemented in both active and passive forms for maximum impact. Passive techniques are useful and are used frequently in present products. Examples are software extensions that stop spinning up hard drives after no drive access has occurred in a given time interval, or monitor dimmers that do the same. Active management is an approach that could have a much more drastic effect on system power draw, but the implementation is very difficult. Active management refers to shutting off power to parts of a sub-system or even parts of an IC dynamically to achieve the largest possible power savings. Of course, the impact of additional hardware or software necessary to implement these functions must be traded with the power gains. It is possible that certain material technologies and circuit architectures are better suited for active power management than others and must be considered during system design trade-off studies. This also underscores the need to develop rapid and accurate power estimation tools.

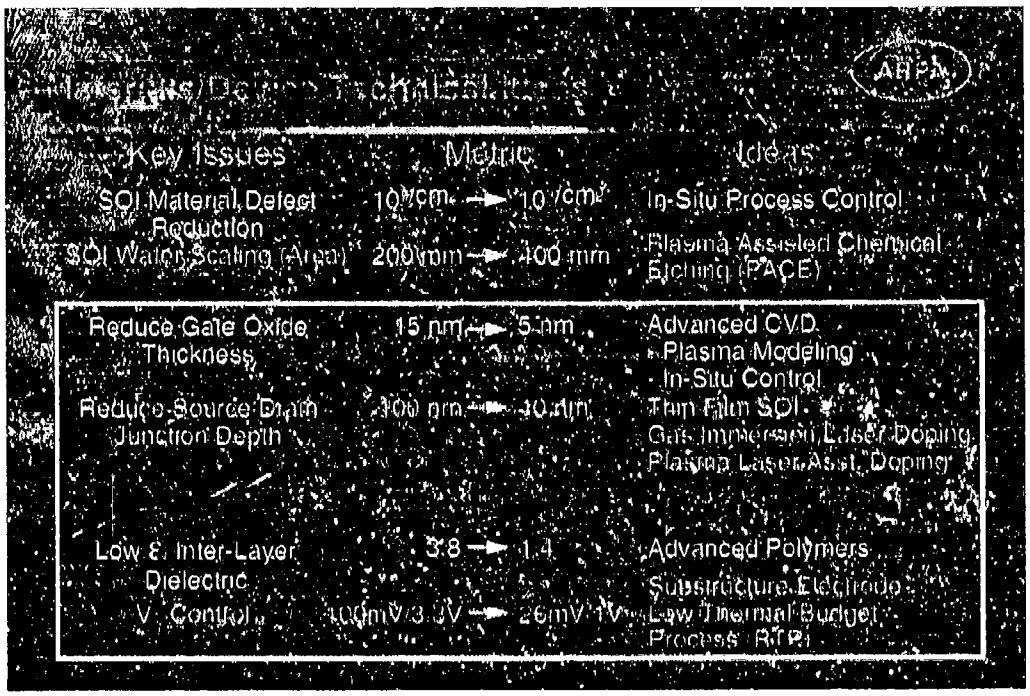


Mobile and portable information systems will continue to be the primary drivers for significant reductions in power consumption. Mobile and portable applications will also provide the framework within which the design approaches are expected to be developed. For example, many of the computation and communication applications in mobile/portable information systems (e.g., voice/video compression, location/navigation processing, wireless communication) are self-limiting in terms of processing speed and throughput. With no computational advantage to be gained in these applications by additional increases in processing speed, power consumption can be dramatically reduced with circuit architectures that maintain a fixed performance and are optimized for low power consumption.

A number of generic circuits and architecture based approaches have been identified which may result in significant power reductions. Since power dissipation is directly related to node transitions, attractive approaches might include optimizing logic structures for reduced activity and optimizing memory access operations. Dynamic clock frequency management may be used to supply computational throughput that exactly matches demand. Parallel and pipelined architectures may be utilized in some instances to substantially reduce power without any negative impact on performance.

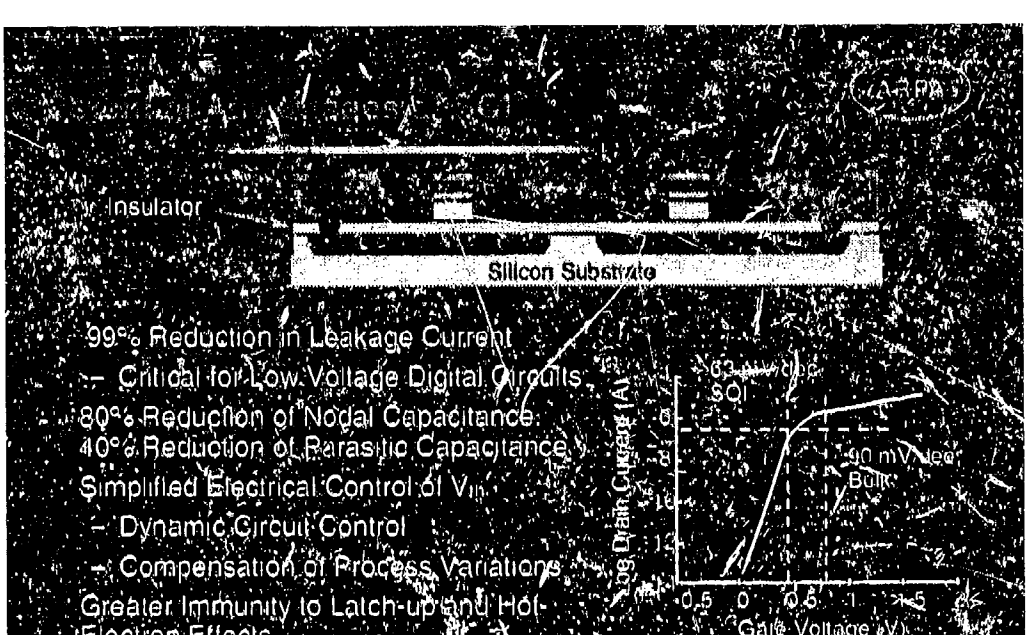
Dynamic activity management techniques may provide the capabilities to shut off portions of sub-systems or ICs that are not needed in current or impending operations. To avoid impacting system response and ergonomics, this approach may require additional hardware and software, but it has a tremendous potential to reduce system power and is totally independent of implementation technology at a certain level of granularity. Rapid and accurate power estimation tools and synthesis design aids are required for unambiguous design trade-off studies. Efficient low voltage, dc-dc converters are also required. Some novel ideas to recover energy from node transitions such as adiabatic switching may be attractive and could be used to reduce system power consumption.

The ARPA Low Power Electronics program will consider these approaches and the development risks which may inhibit productization and widespread implementation.



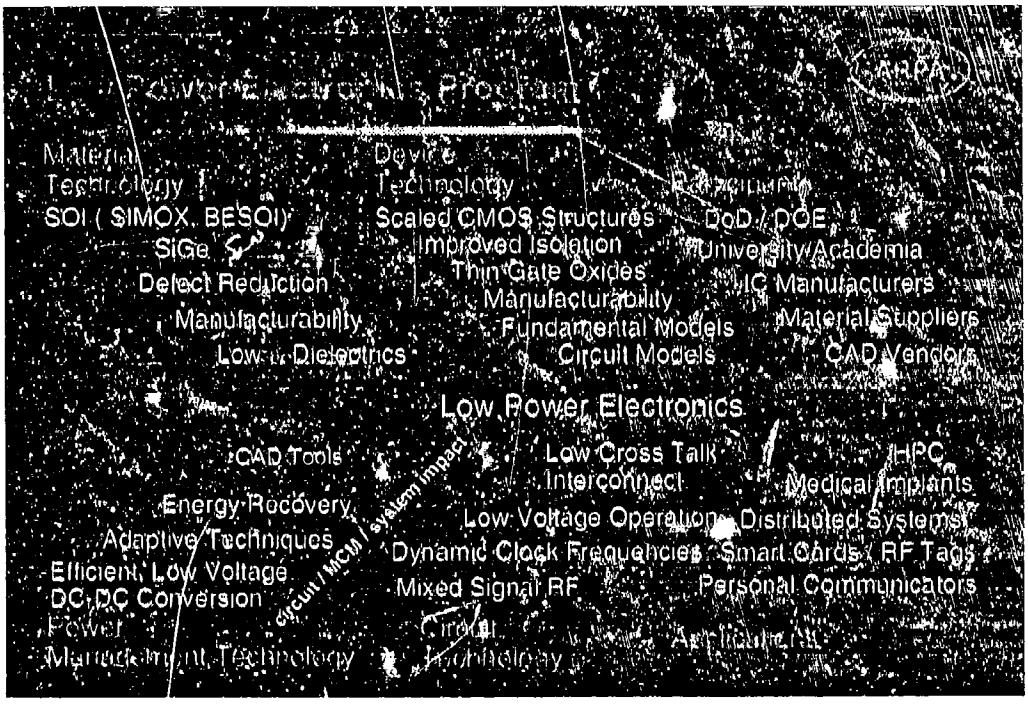
The Low Power Electronics program will significantly accelerate low power materials and device technology. The mainstream materials technology for this program will be based upon fully depleted silicon on insulator (SOI) technology for reduced power dissipation. The advanced materials development will include advances in material preparation and qualification and will result in a mainstream technology base which supports 1Gbit DRAM integration levels. The materials technology goal is to be scaleable in both production volume (up to one million wafers per month across the industry) and wafer size (up to 400 mm diameter wafers).

The resulting device technology will focus on the development of manufacturable scaled silicon CMOS structures at integration levels of greater than 5,000,000 usable gates which demonstrate subthreshold leakage current less than 90mV/decade. The program goal is to develop a low power device technology which can be seamlessly inserted into conventional bulk CMOS fabrication facilities. This developed device technology will include the demonstration of a viable manufacturing strategy with the appropriate process controls to achieve competitive wafer processing costs to bulk CMOS.

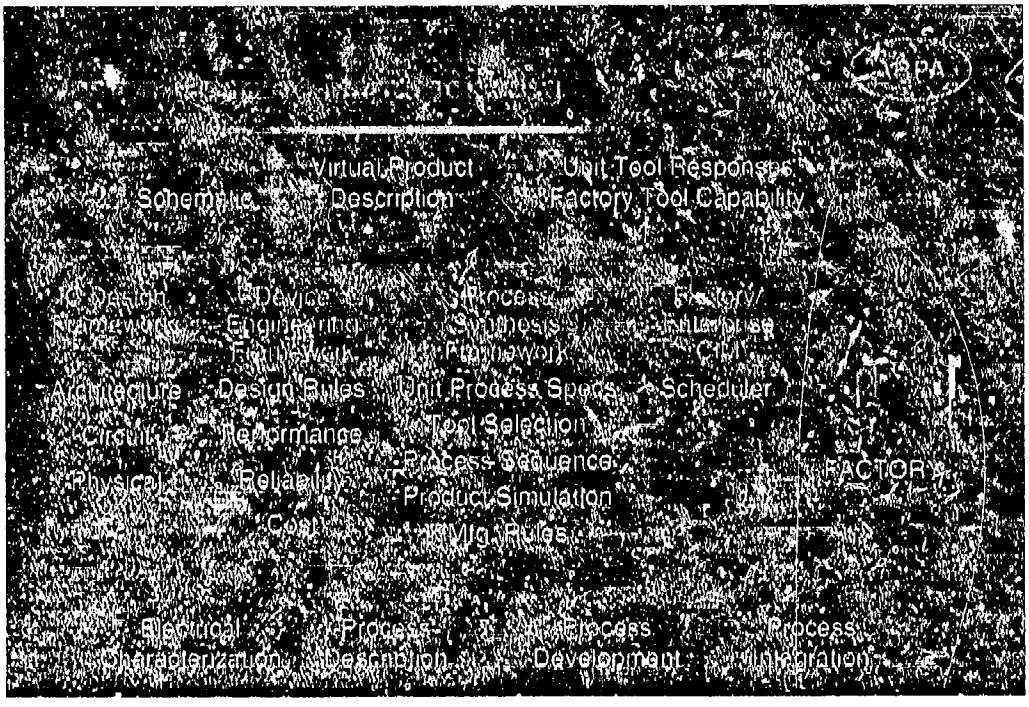


Silicon-on-insulator (SOI) material technology has several compelling advantages over engineered-channel scaled CMOS structures. By making the silicon thickness very thin, under 600Å or so, the depletion layer extends entirely through the active area (fully depleted) and drastically improves the electrical characteristics, as compared to conventional CMOS or even thick film (partially-depleted) SOI. This resulting performance is best demonstrated by the subthreshold leakage current.

The best CMOS devices have subthreshold slopes of about 90mV/decade of drain current. Fully depleted SOI devices have subthreshold slopes under 65mV/decade, approaching the theoretical limit. The smaller the subthreshold slope, the greater the difference is between the drain current just above and just below the threshold. The sharper the transition, the better, especially for low supply voltages where the dynamic range is limited. The resulting SOI device clearly can operate with lower threshold voltages than the conventional CMOS device. Below threshold, in the "off" state, the SOI device can conduct two orders of magnitude less leakage current than CMOS. On the other hand, CMOS channels may be engineered to reduce threshold, but this often results in greater subthreshold leakage, reducing the advantages. Alternate gate metallurgy may ameliorate some of these issues, but there are difficulties in integrating these exotic processes with the mainstream.

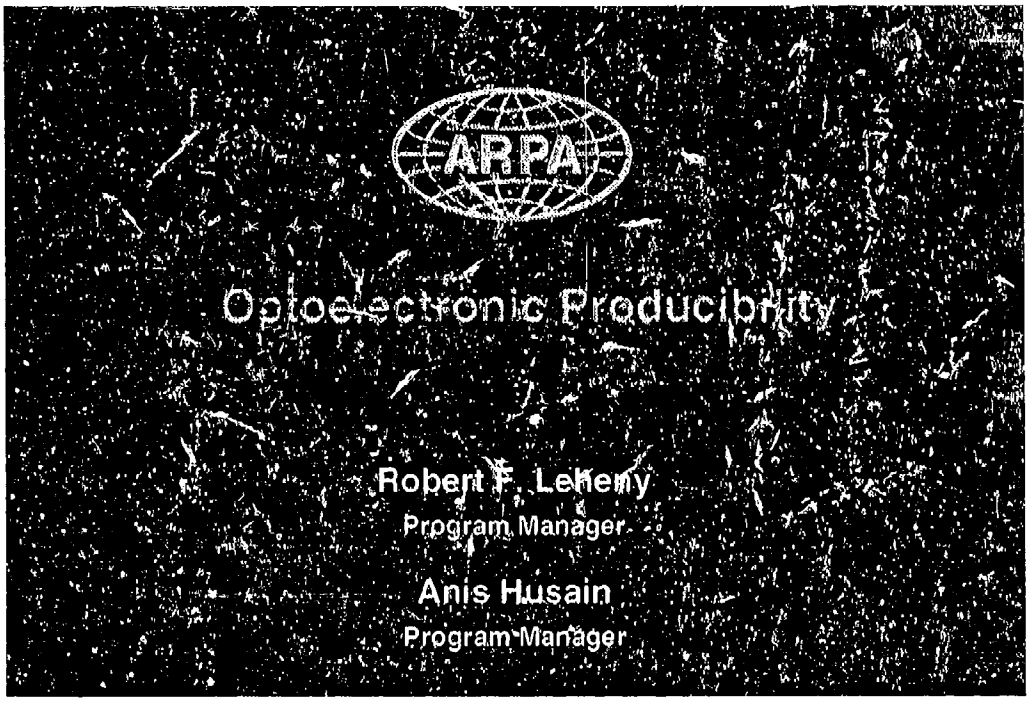


The ARPA Low Power Electronics program is planned to impact four main areas: materials, devices, circuits, and power management. A number of applications are initially planned to drive technology development and quickly begin the transition to manufacturing. It is hoped that the program will involve participants from all areas. It is clear that both customers and suppliers must be involved and they must support the technology development effort in order to create a demand. A number of subtopics are shown under each technology area. The list is by no means exhaustive, but it is an indication of the critical areas that have been identified. This program will develop and support the critical technologies necessary to enable leading-edge manufacture of semiconductor integrated circuits, exhibiting high integration levels, great functionality, high performance, and extremely low power dissipation.

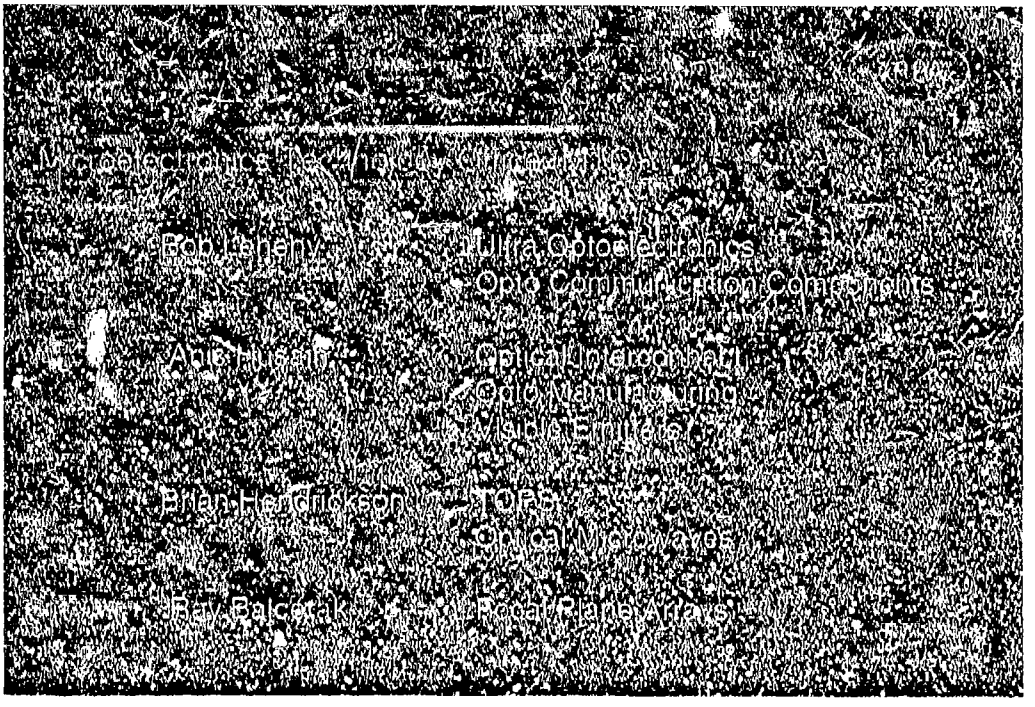


The Low Power Electronics program will require effective coupling to a design-coupled manufacturing environment. Seamless, efficient information exchange between powerful frameworks and the manufacturing CIM system will enable this new paradigm. Specific IC designs may be compiled from reusable libraries, then passed to a device engineering framework that checks design rules against physics-based constraints, simulates performance and functionality, and also provides guidance on manufacturability and reliability. These simulations may then be used to update the libraries and also be imported to technology development tools, where processes and recipes are determined. These recipes may then be stored in libraries and reused. The CIM system integrates and coordinates all activities associated with the factory and works to ensure that each wafer lot is processed in an optimal manner with no mistakes in the recipes. The factory in turn provides a manageable set of data back to the technology, process, and device development frameworks to update models and assist in parameter control.

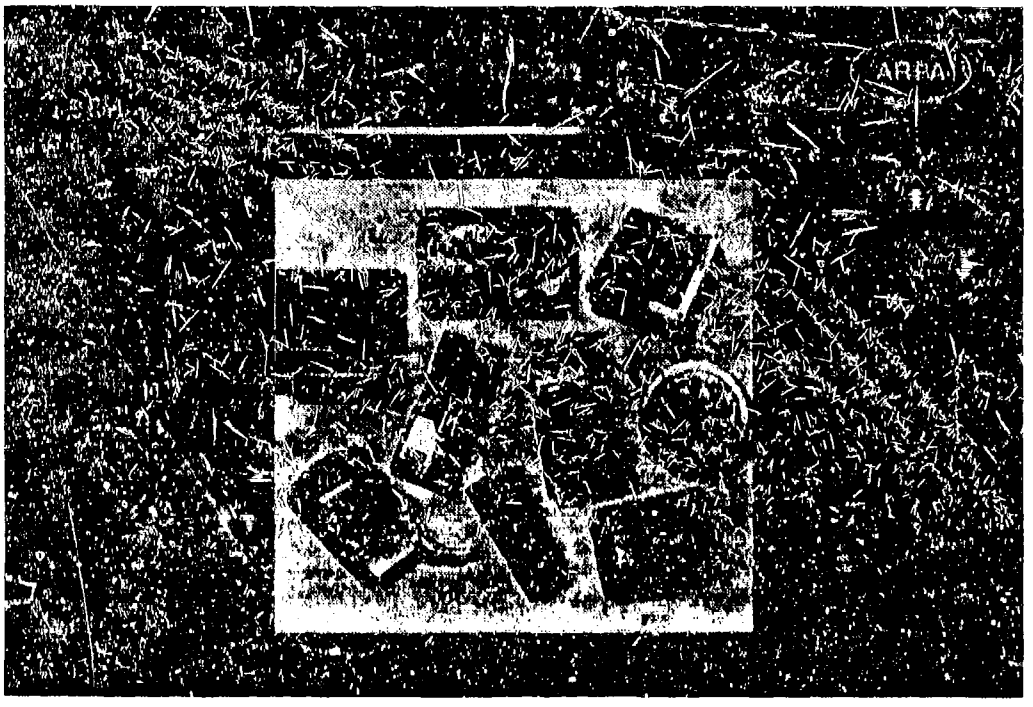
This is a very powerful environment for future manufacturing. It is structured to meet the needs of both commercial and military markets. It represents a key paradigm shift toward optimizing the cycle time necessary to produce a high mix of products on a single manufacturing line. This ability will serve to minimize the risks in construction of new fabrication facilities and will allow much higher equipment utilizations and longer factory lifetimes.



Good morning. My name is Bob Leheny. I am one of ARPA's program managers for Optoelectronics. My objective this morning is to provide you with an understanding of the vision and direction of ARPA's program on Optoelectronic Producibility. This program is managed principally by Anis Husain, who could not be here this morning, so I'm standing in for him. I hope to provide you with a summary of our planned, near term opportunities for industry participation in ARPA's Optoelectronic Producibility program.

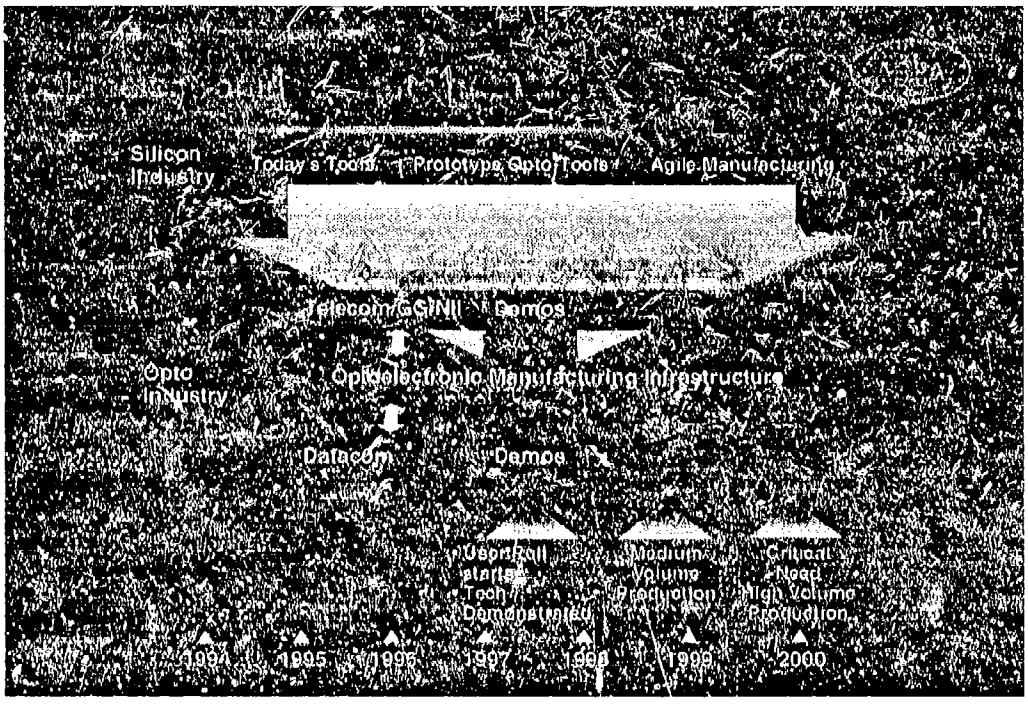


The optoelectronics program at ARPA spans three offices. Those within the Microelectronics Technology Office (MTO) are listed here. Anis Husain's program for the most part has a near term focus which is the subject of this morning's presentation. My programs span from longer term research, which I'll be discussing this afternoon, to a joint program supporting Broadband Communications Infrastructure Technology discussed by Bert Hui in Tuesday morning's session. Brian Hendrickson is responsible for the Transitioning Optical Processors into Systems (TOPS) program, the focus of which is self explanatory, and, microwave and other analog applications of optical technology. Ray Balcerak is responsible for the infrared sensor programs and will be discussing these in greater detail this afternoon.

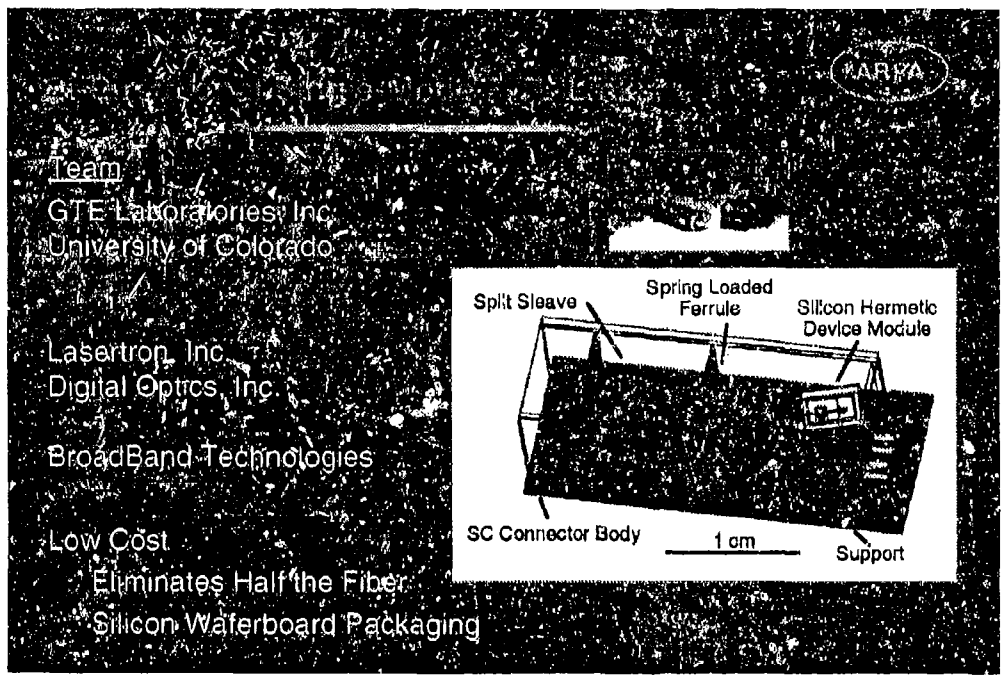


Examples of the first wave of advanced, portable electronic products are now beginning to reach the marketplace. These examples include: a world-phone, a combination pager and e-mail reader, a digital assistant, and a personal navigator. A combination of these devices have recently been prototyped or placed on the market. Advancements in key technologies have enabled such functionality. However, as innovative as these products are, each is ultimately limited by power dissipation.

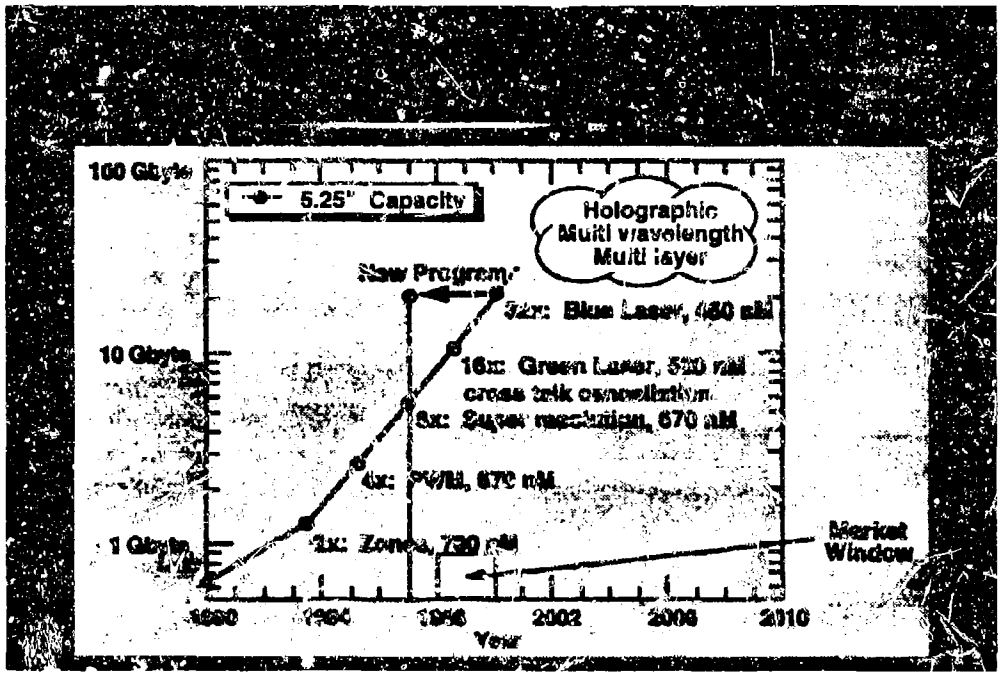
In the near future, vast new markets will emerge for this industry. They will be driven by continuing advances in process technology and an emerging generation of low-power integrated circuits and device technologies. The ARPA Low Power Electronics Program, coupled with management of manufacturing complexities, will drive the leading-edge technology development and deployment for these new markets.



Responding to market predictions, the optoelectronic components industry is ready to gear up to meet the needs of the various applications including Telecom and Datacom as shown here. ARPA programs are in place aimed at demonstrating how opto-technology can enhance performance for these applications that are expected to create significant demand by the end of this decade. It is therefore important to begin investing in the necessary infrastructure required to support this industry today. One approach being explored is to adapt the tools already developed to meet the needs of silicon IC manufacturers to opto-manufacturing. Examples include CAD/CAM, precision assembly, wafer level testing, complete module testing, etc.



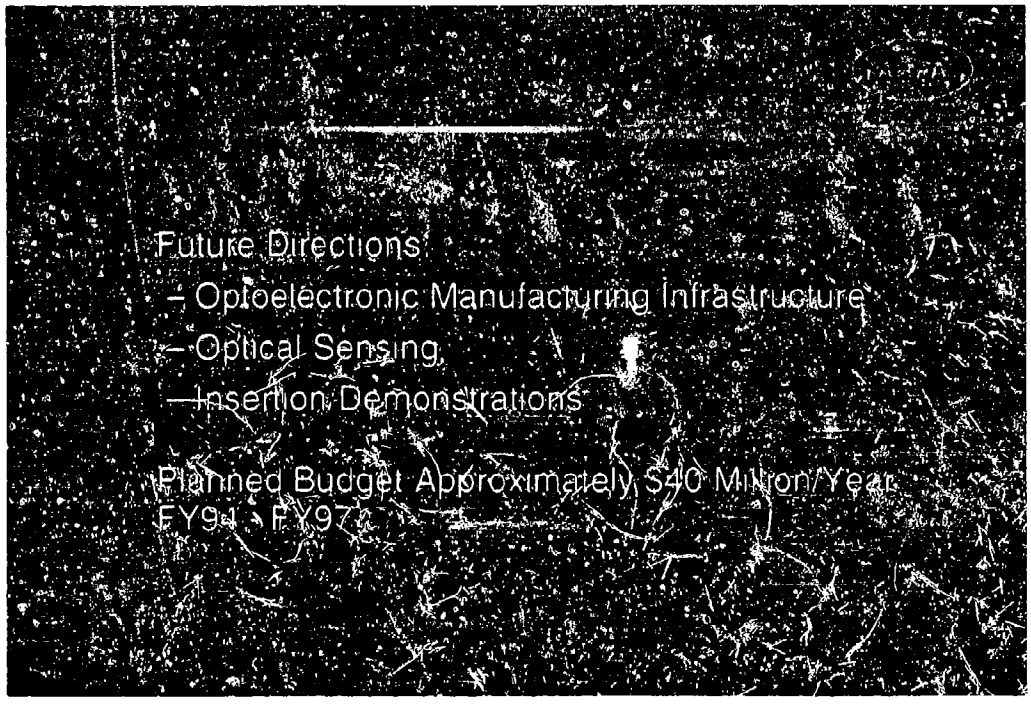
This ARPA project illustrates the strategy of building a team of suppliers and users of technology for low cost-to-manufacture fiber in the loop (FITL) transmitter/receiver modules. GTE and the University of Colorado are providing novel packaging technology, Lasertron and Digital Optics are providing component technologies, AMP is the program manager and systems integrator, and BroadBand Technologies is providing system requirement experience.



The Optoelectronic Industry Development Association Roadmap shown here, illustrates the need to reduce the wavelength of data access lasers in order to satisfy anticipated future demand for increased capacity optical memory systems. This roadmap focuses on a critical need and illustrates the case for investing in short wavelength (blue) laser technology to speed up the introduction of these devices for high density optical recording applications.

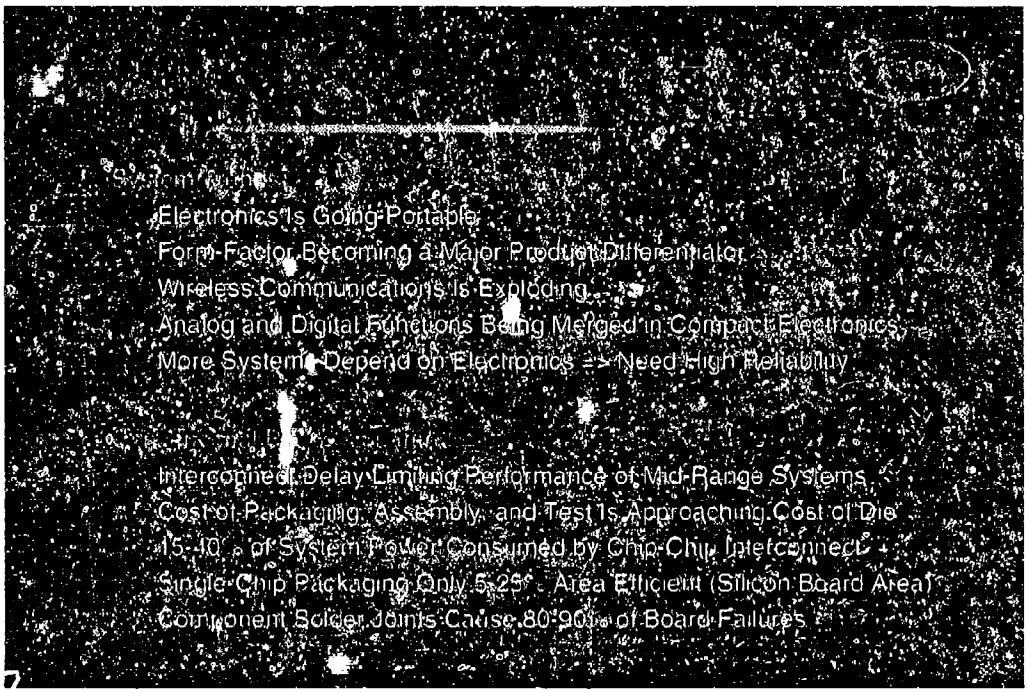


The program directions outlined in this talk are summarized here. The major near term focus is on serial and parallel links and short wavelength sources for optical memory access.

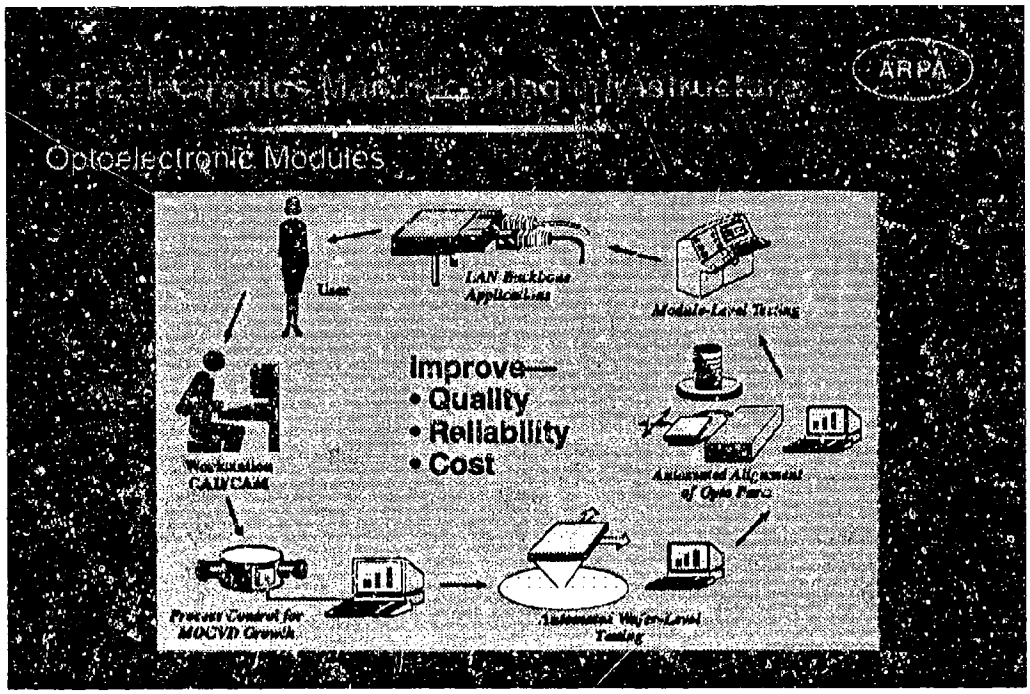


ARPA continues to make significant investments in optoelectronic technology for information processing at about $40 million/year.

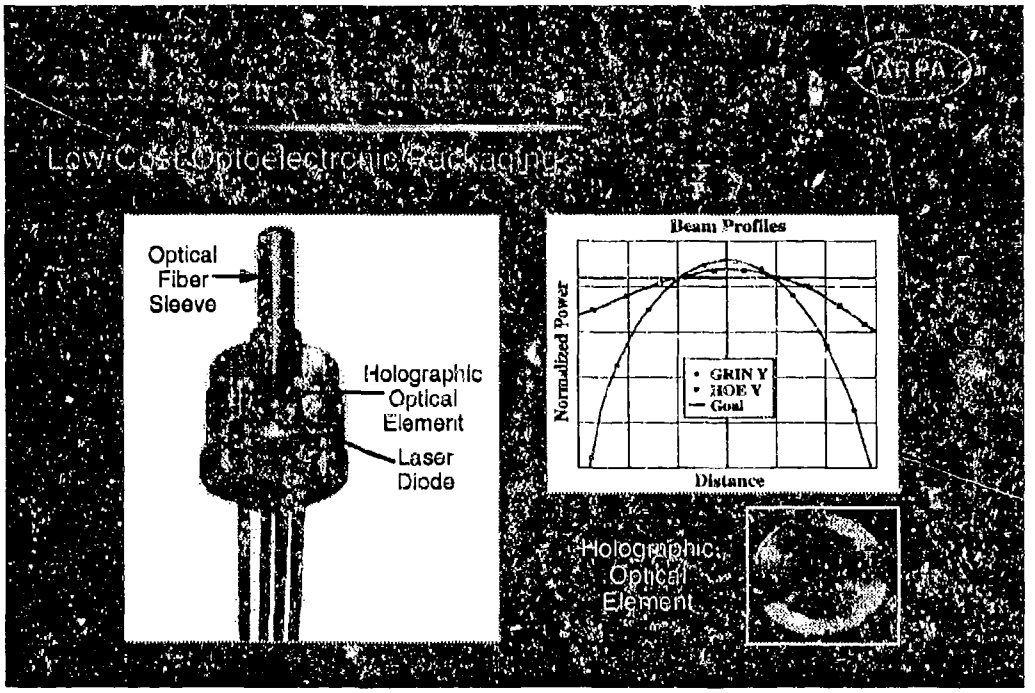

ARPA
Electronic Packaging
and
Interconnect
Lance Glasser
Director, Electronic Systems Technology Office
Advanced Research Projects Agency



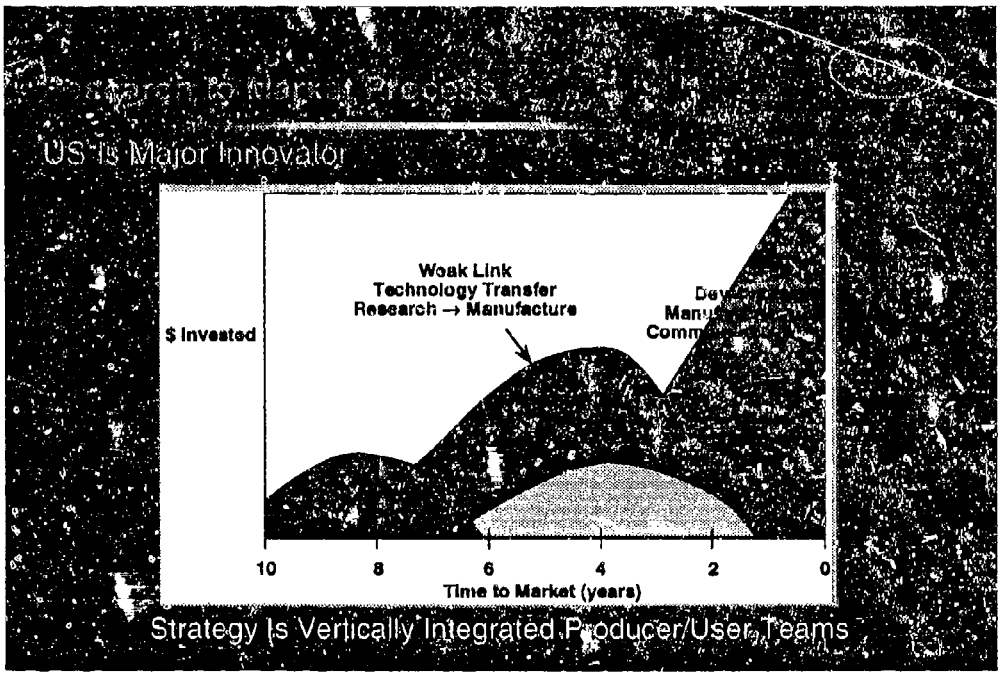
There are a number of system trends which will increase the importance of packaging. Conventional single-chip packaging is not keeping up with these trends.



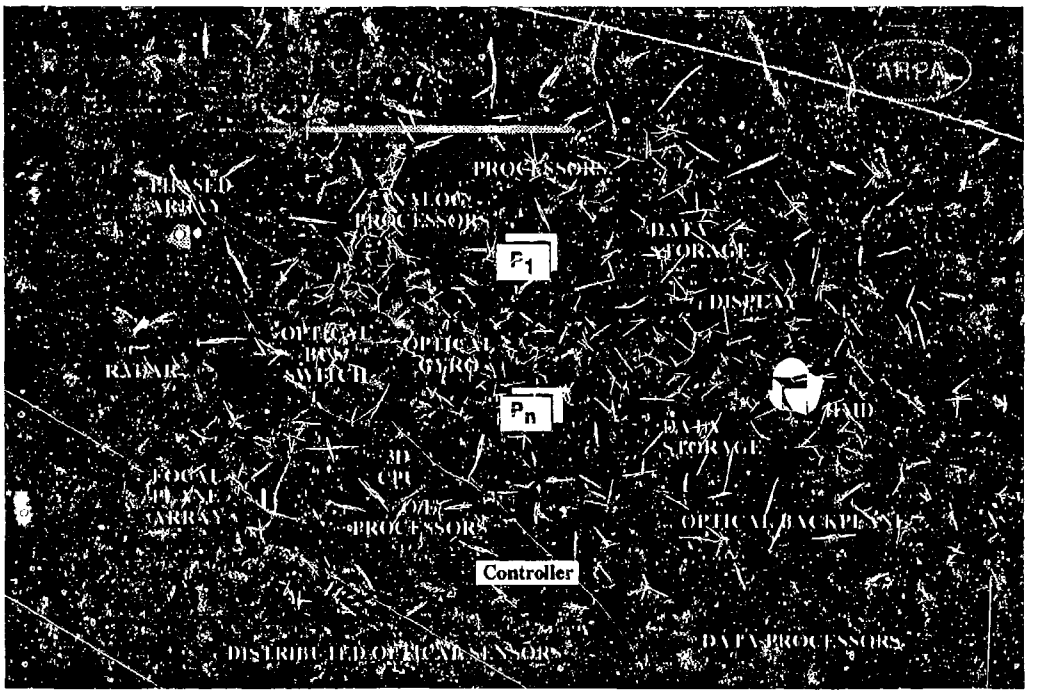
The design cycle for development of optoelectronic modules is illustrated here. It begins with the initial device concept, through CADmodeling and layout of device structure, through manufacture of the starting material for fabricating the device, through on-wafer testing, through packaging, to final module testing. At any point a bad result can lead to redesign. It is tools of the type illustrated here that need to be developed to establish a manufacturing infrastructure to support optoelectronic module manufacture.



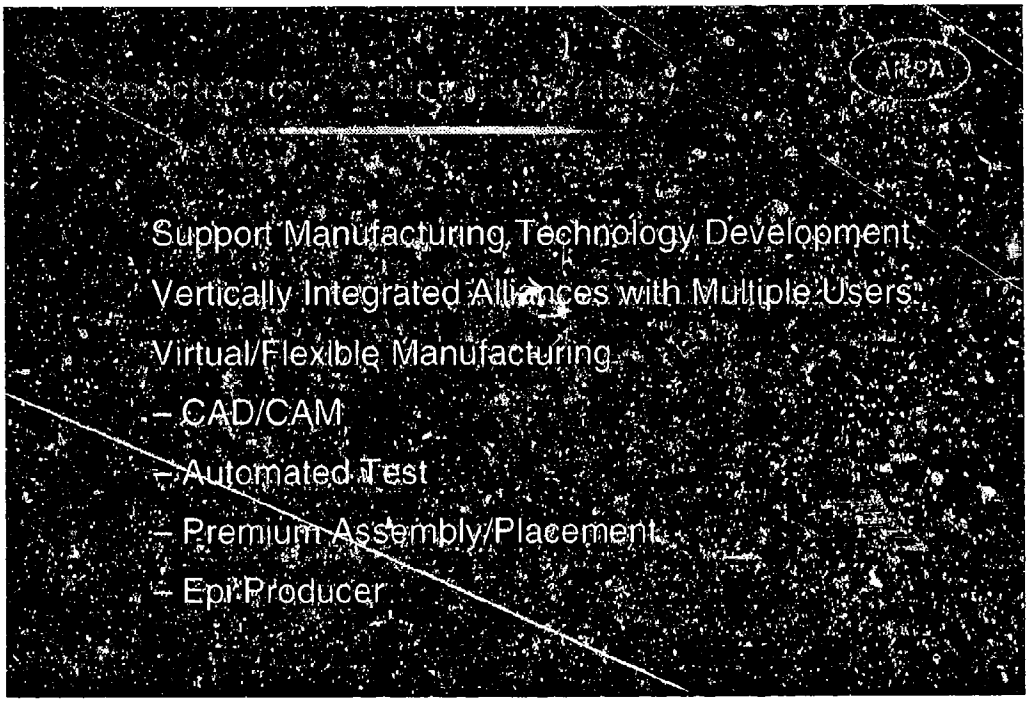
One innovation for low cost packaging is through the use of the holographic optical element illustrated here. As a low cost and easy to align lens, this holographic optical element relaxes the sensitivity to relative positioning of the fiber and laser when coupling the output of a laser to the input of an optical fiber. The chart illustrates the benefit that can be obtained when the holographic optical element is used.



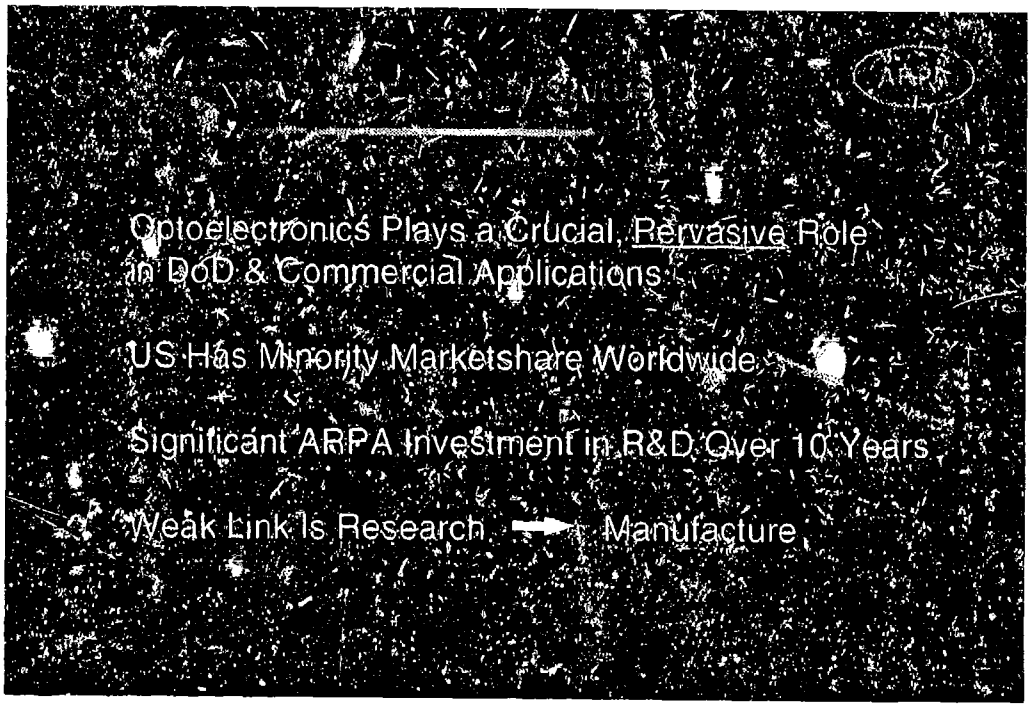
It is widely recognized that the US is a major innovator in optoelectronics technology. The challenge is to increase investment in exploratory development and market research to link the transfer of research results to manufacturing. Programs that link university and national lab researchers with industrial labs provide one means to transfer research to industry. What is critical to complete the process are programs aimed at demonstrating the advantages of optotechnology that link producers with users. These programs offer the means to create real market demand for optical components.



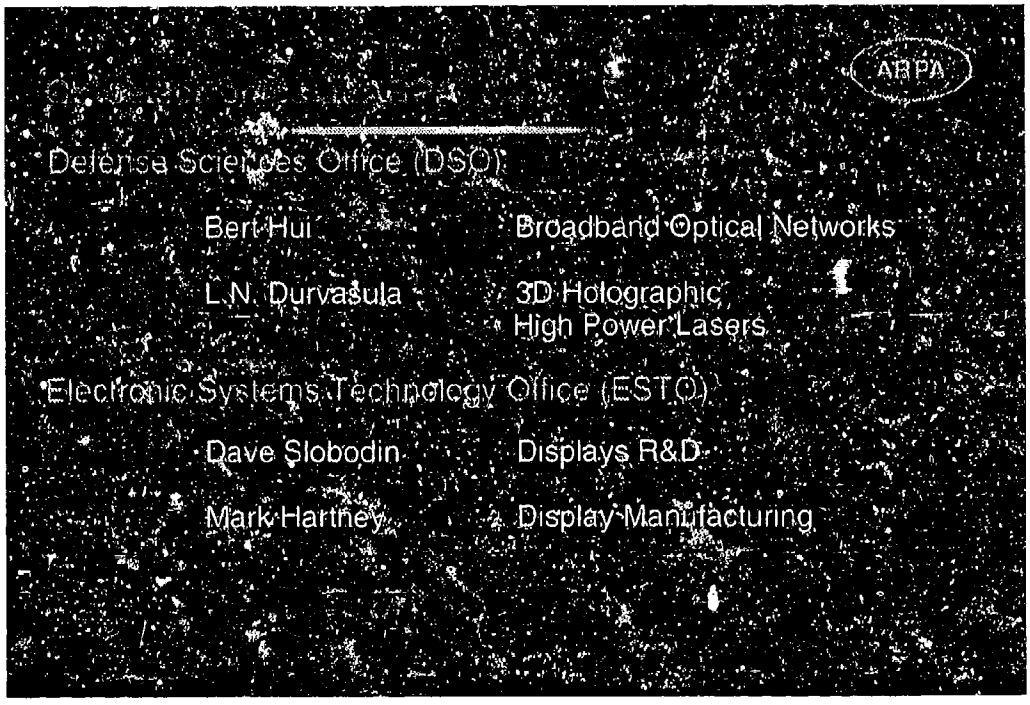
Here we illustrate the range of DoD specific applications of optoelectronics technology: Efficient low loss, light weight analog microwave and radio links to optoelectronic sensors; From high speed optoelectronic signal processors to low loss, low dispersion fiber links, to digital processors and data bases; and from optical links across processor backplanes to the final display system, either a traditional terminal or an advanced helmet display system.



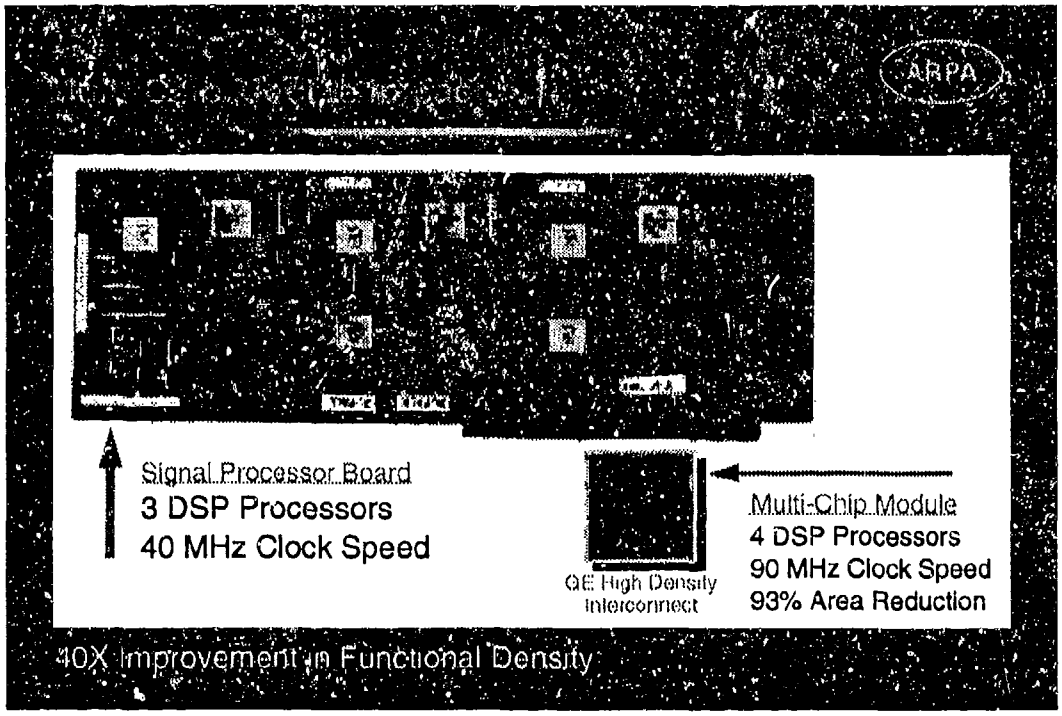
The ARPA Optoelectronics Producibility Program is aimed at addressing the tech transfer weakness previously mentioned . The strategy is to create vertically integrated teams allying Producers with Users. The objective is to create User awareness of optoelectronics capabilities, and in the process, generate market pull for technology while it is still in the research and development phase. Specifically, the goal is to create flexible manufacturing capabilities and develop the infrastructure required for a healthy optoelectronics industry, including tools like Opto-specific CAD/CAM, merchant epitaxy, precision alignment, and automated test equipment.



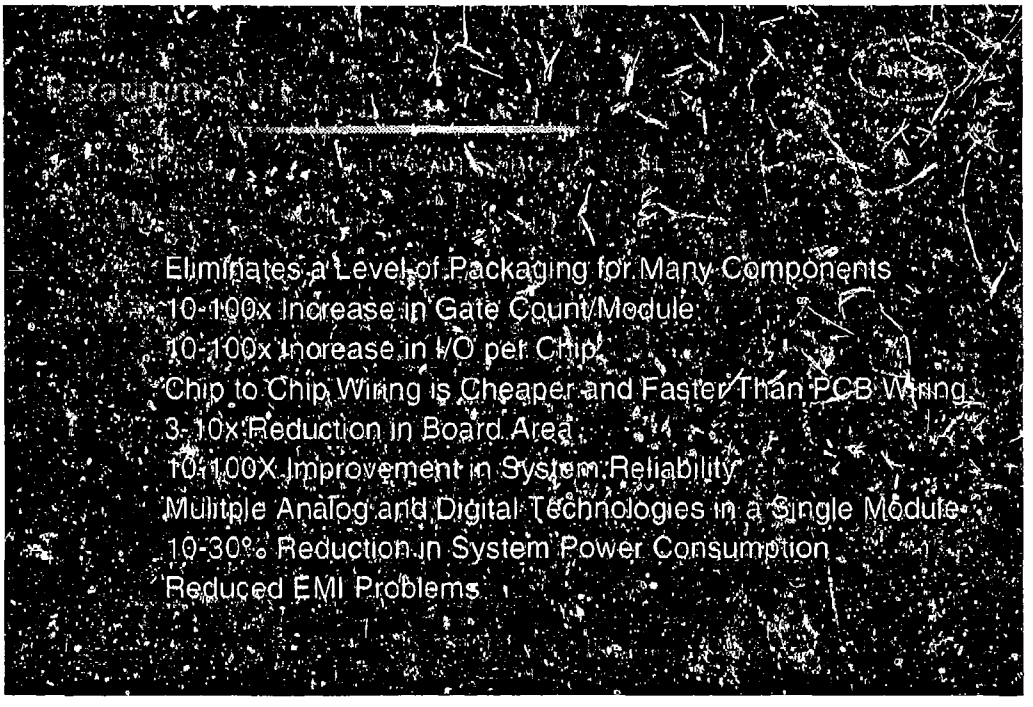
Optoelectronics, the science and technology of light generation, modulation, transmission and detection, plays a crucial and pervasive role in many DoD and commercial applications. Yet, after a decade of decline relative to the Pacific Rim countries, the US has only a minority share of the world market in this technology. During this period, ARPA has invested significantly in research and development of optoelectronic components and in supporting system field trials aimed at demonstrating the advantages of optoelectronics. These efforts by ARPA are widely recognized. Yet the weak link in reaping commercial reward from this investment is the transitioning of research results to manufacturing. This tech transfer problem is not unique to the optoelectronics industry and a major thrust of our optoelectronics producibility program is to overcome this problem.



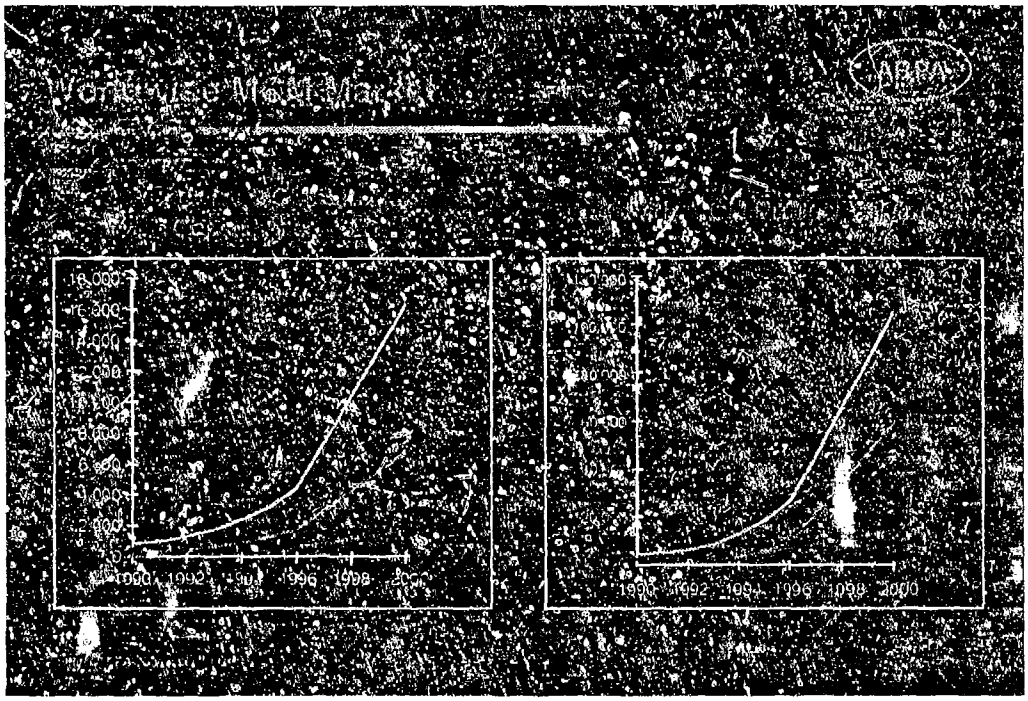
The Defense Sciences Office (DSO) and the Electronic Systems Technology Office (ESTO) are the two other ARPA offices with significant optoelectronics activity. The topics of their programs are listed here. The principal DSO programs are Broadband Optical Networks (Bert Hui), discussed in Tuesday morning's session, and three dimensional holographic memory systems (L. N. Durvasula). Programs focused on display technology reside in the ESTO office at ARPA and there is obvious interest in optoelectronics as it applies to display applications. Dave Slobodin and Mark Hartney are the responsible program managers and Mark will be discussing some aspects of their programs later in this session.



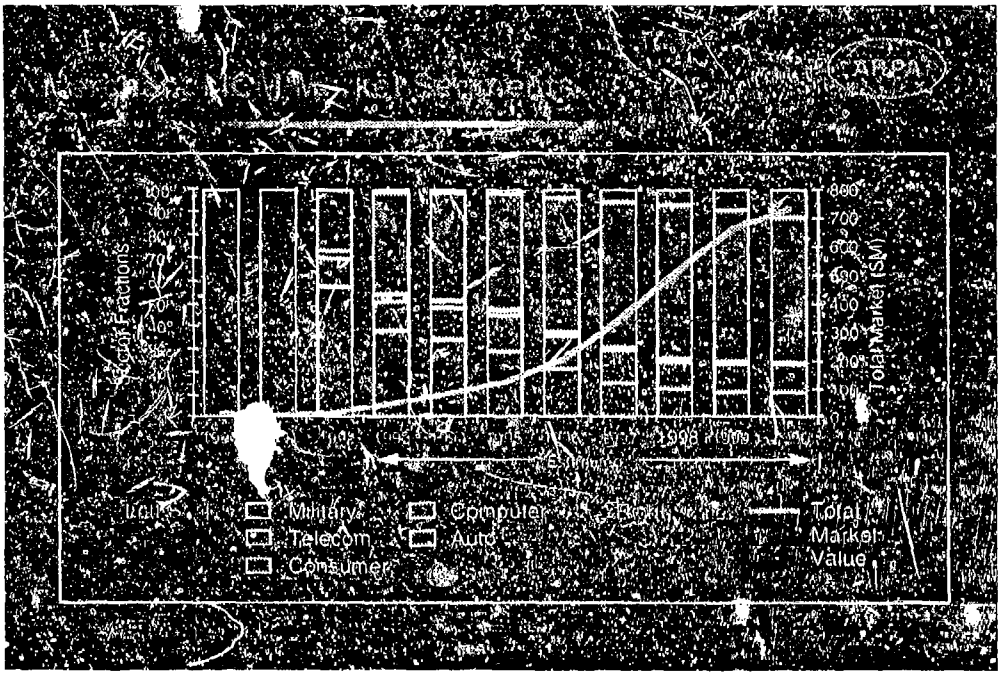
Multi-chip module technology offers a new paradigm for interconnecting components with minimum overhead in terms of area, volume, weight, signal propagation delay, and opportunities for failure. In the example shown, the conventional circuit board (top) contains three digital signal processor subsystems. The multi-chip module (bottom) contains four of the same circuits in 7% of the original area. By shortening the path delays between the ICs, the clock speed can be more than doubled using the same chips. The result is a 40 fold increase in functional density.



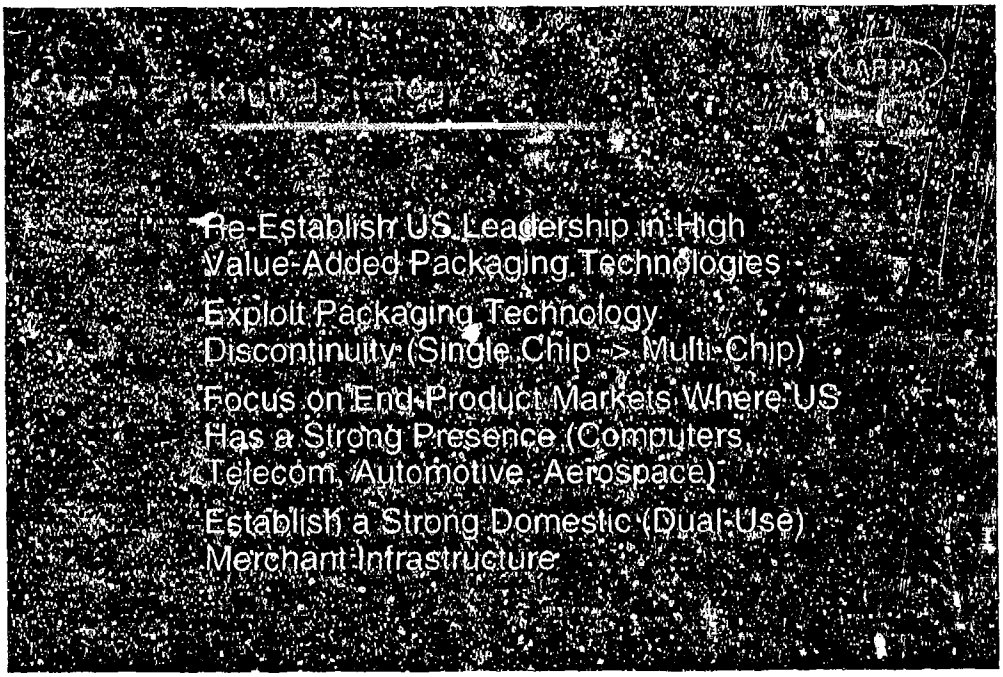
Multi-chip modules can eliminate a level of assembly and the associated costs and dramatically increase the amount of functionality in a given sized module. New assembly technologies that allow electrical connections over the entire surface of a chip, rather than just around the perimeter, can yield a an order of magnitude increase in the number of signal connections to each chip. The reduction in the number of solder connections directly translates into a proportional increase in reliability. The shorter, more ideal, signal paths also reduce power consumption and electro-magnetic interference (EMI) emissions.



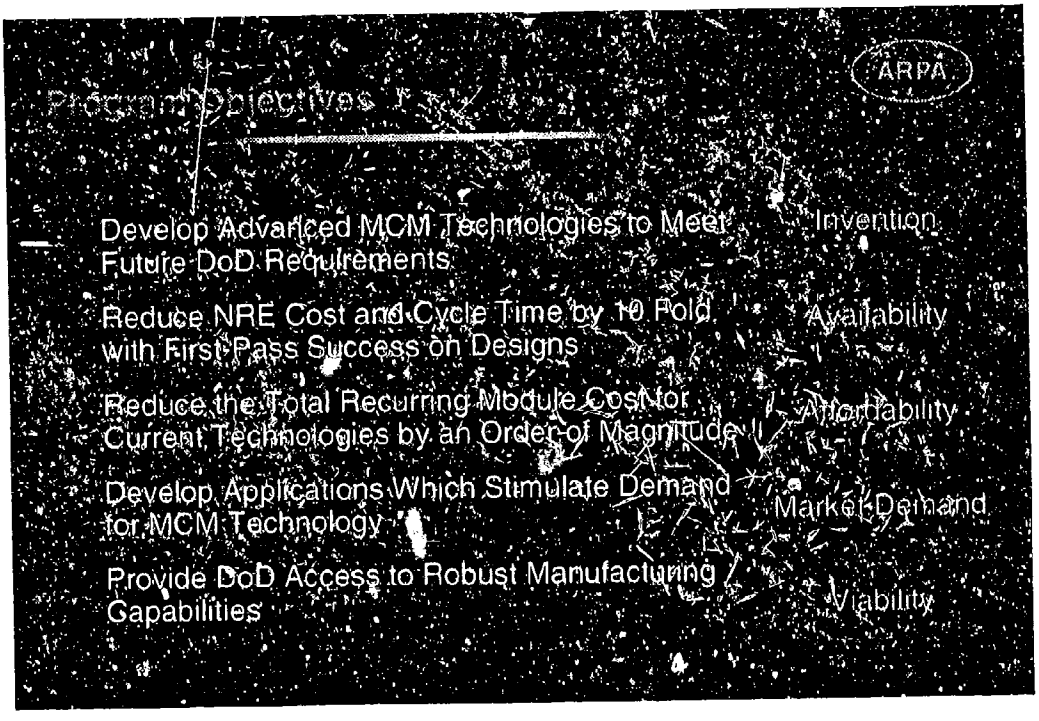
The potential market for this new technology is projected to exceed $10 billion before the end of the decade. More importantly, some estimates of the market for products enabled by this technology is projected to exceed $100 billion.



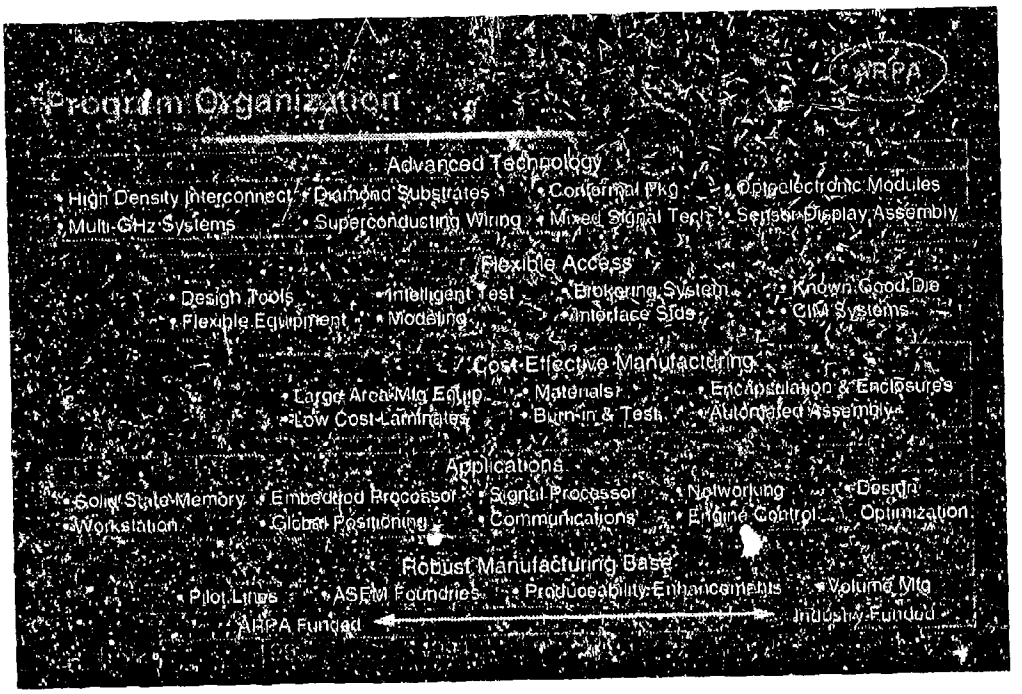
Initially, the market driver for MCM technology was military applications which could afford to pay a premium for performance enhancement or size/ weight reduction. However, commercial markets such as computers and telecommunications, are growing much faster than the military market and by the end of the decade are projected to account for about 90% of consumption. If the DoD is to fully benefit form the economies of scale brought about by the large commercial markets, it is essential that there be an integrated domestic production base.



ARPA's packaging strategy is designed to re-establish US leadership in the packaging technologies that will make make a critical difference in military and commercial products. This will be possible by exploiting the paradigm shift to multi-chip module technology and leveraging the common requirements of our computer, telecommunications, automotive, and aerospace industries to establish an integrated domestic production base.



The objectives of the ARPA thrust in electronic packaging range from the initial invention of new packaging approaches, to the infrastructure to make them widely available to systems designers, to the manufacturing technologies necessary to make them affordable for a wide range of applications. In parallel, we are developing innovative applications which exploit the new capabilities of the technology and working with industry to create the production base necessary to supply military and commercial users.

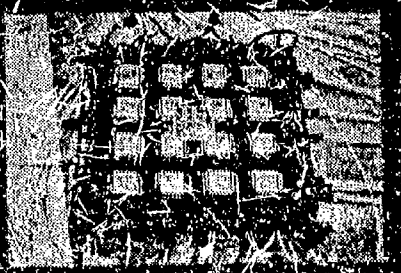


This chart shows the range of projects included in the ARPA program.

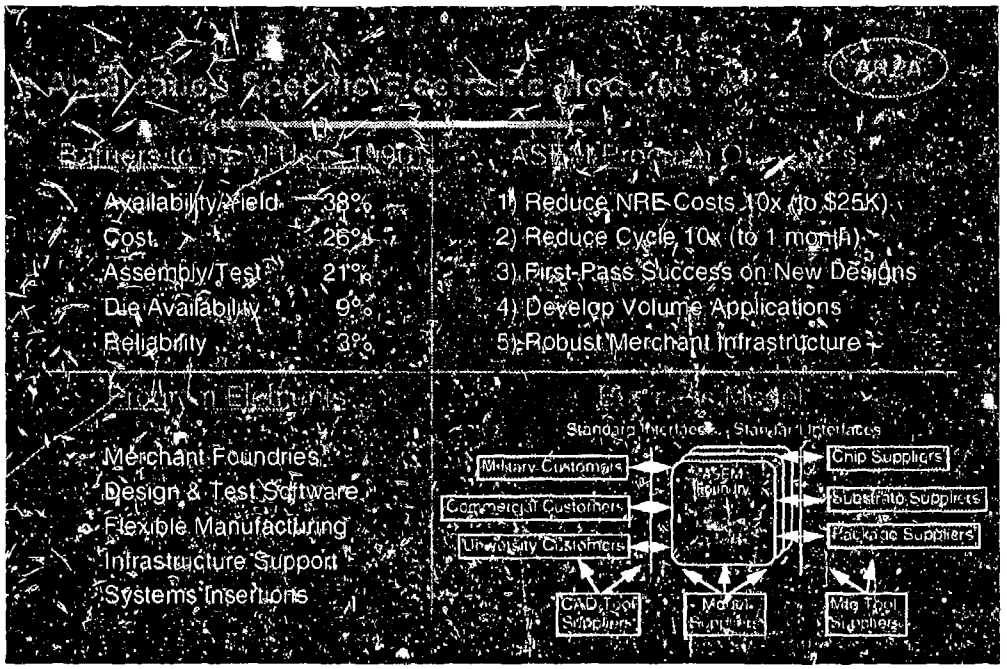
High Speed MCM Technology

ARPA

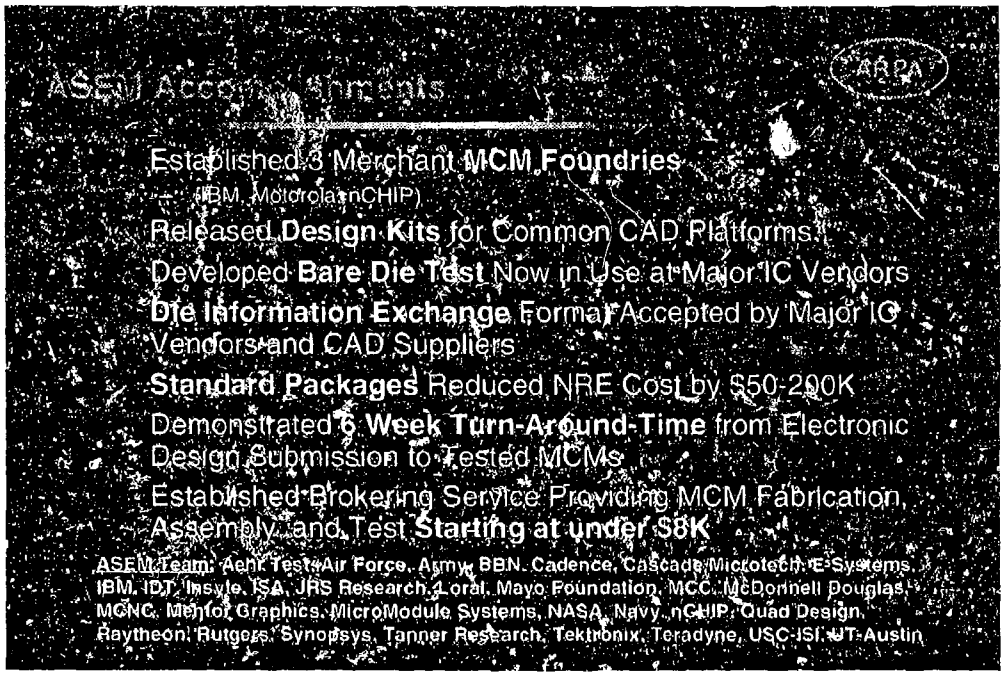
- nCHIP NC3000 Process
  - 5u Thick Copper Signal Lines
  - Aluminum Power and Ground Planes
  - Integral Decoupling Capacitors
- Mayo Foundation Test Vehicle
  - 16 Vitesse GaAs Gate Array
  - 520 I/O Pads per Chip
  - Demonstrated 1 GHz Operation



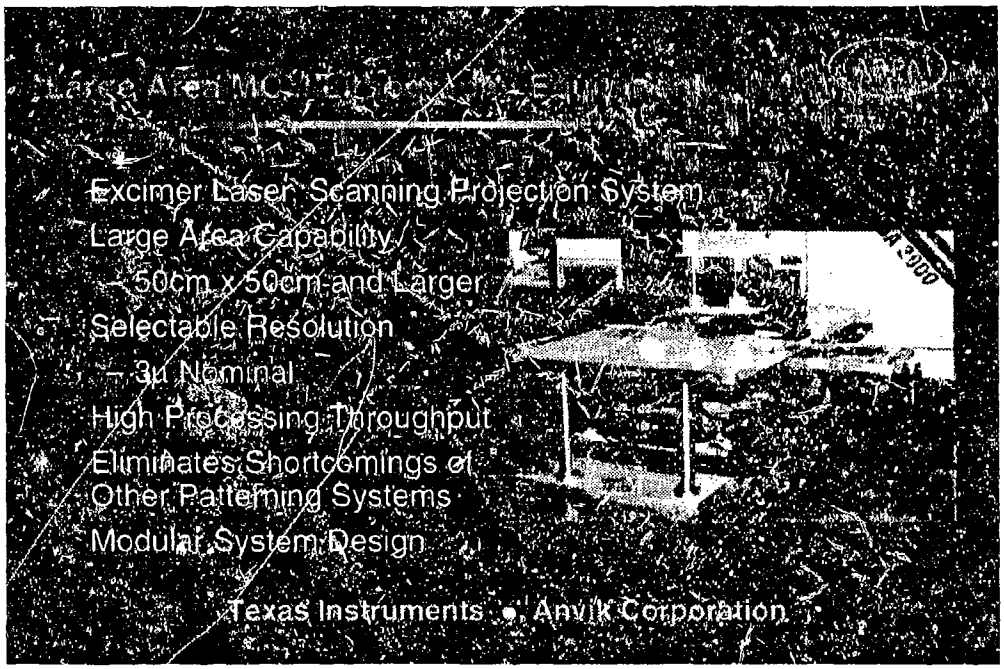
Mayo Test Vehicle



In 1990, the primary barriers to the use of multi-chip module technology were availability, cost, and compatibility with next level assembly and test. The Application Specific Electronic Module (ASEM) programs objectives are to reduce the non-recurring engineering cost and time to design a dozen chip MCM by an order of magnitude to $25,000 and one month respectively and have it work the first time. The program includes merchant foundries, design and test software, flexible manufacturing equipment, infrastructure, and systems insertions.

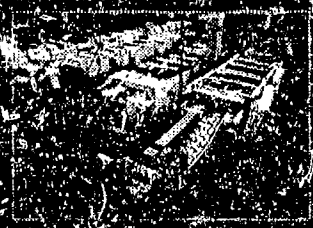


This chart shows the structure of the merchant Application Specific Electronic Module (ASEM) industry and the participants in the ARPA ASEM program. The organization is modeled after the structure of the Application Specific Integrated Circuit (ASIC) industry.

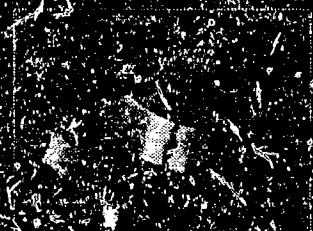

Excimer Laser Scanning Projection System
Large Area Capability
– 50cm x 50cm and Larger
Selectable Resolution
– 3μ Nominal
High Processing Throughput
Eliminates Shortcomings of
Other Patterning Systems
Modular System Design
Texas Instruments • Anvik Corporation

ARPA

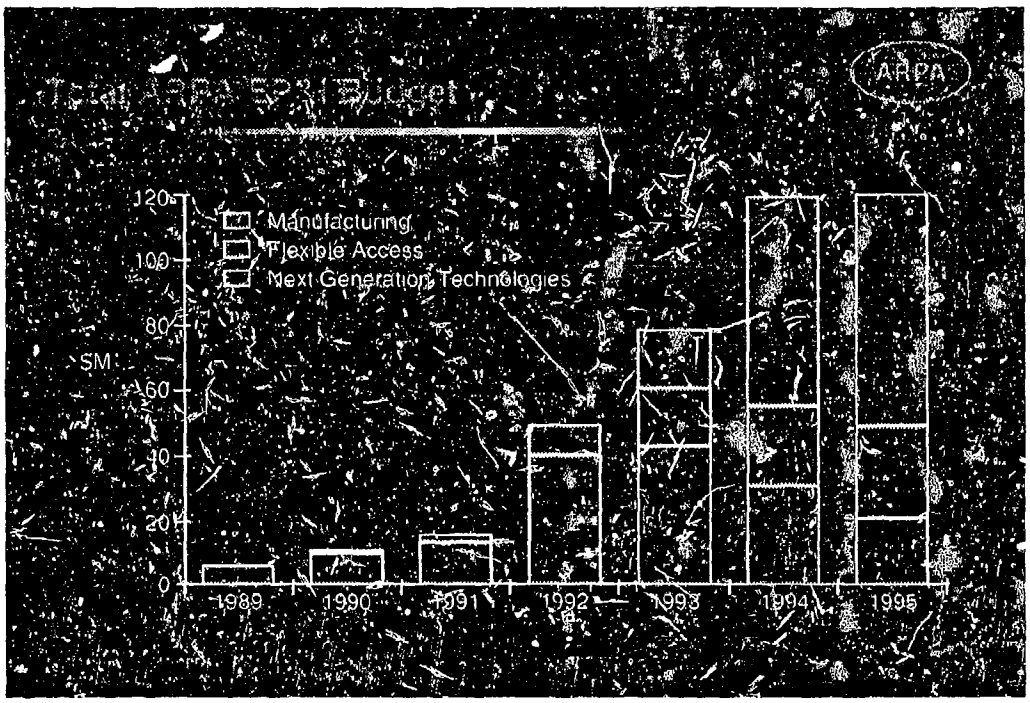
- Objective
  - Low Cost, High Density Substrate Technology for MCM-L, COB and PCMCIA Cards
- Approach
  - Continuous Reel-to-Reel Process
  - Laser Drilled Vias
  - Adhesiveless Metalization
  - Parallel Fab and Test of Wiring Plane Pairs
  - Multi-Layer Capability with Anisotropic Adhesive Lamination
- Status
  - Pilot Production Line
  - Demonstrated 1 Mil Lines and Spaces and 1 Mil Vias



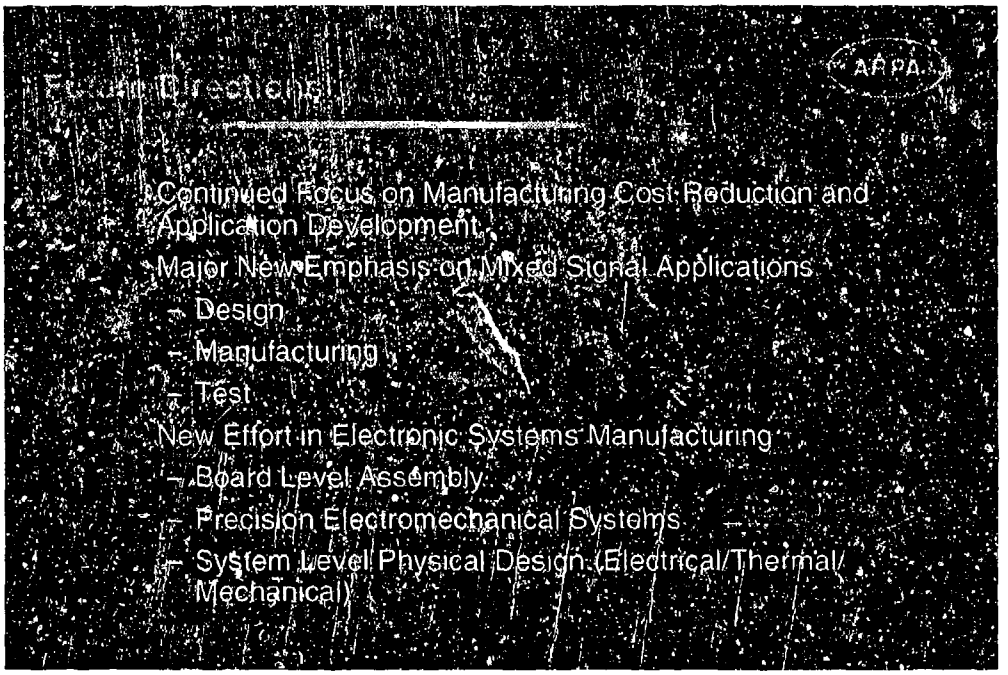
Reel-to-Reel Manufacturing Line



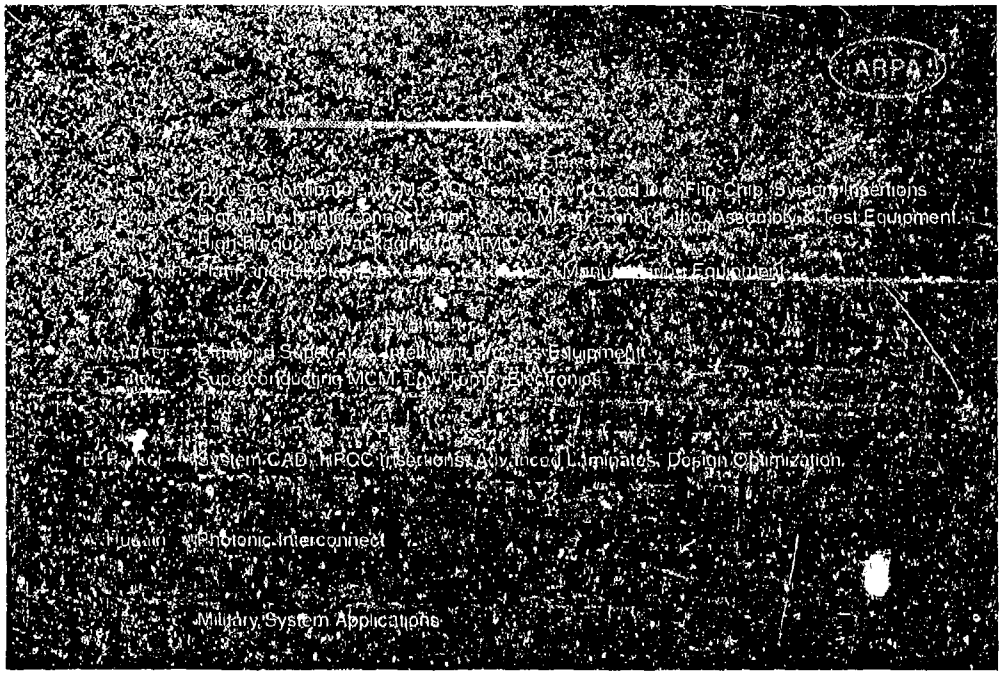
Typical Product Application



The total ARPA budget for Electronic Packaging & Interconnect has grown from less than $20 million in fiscal year 1991 to over $100 million in fiscal 1995 including funding from the Technology reinvestment Project. As the technology matures, the nature of the ARPA investment has shifted from being focused almost exclusively on new technology development to being balanced across new technology development, flexible access, manufacturing , and application with the biggest share going to manufacturing cost reduction and application development.



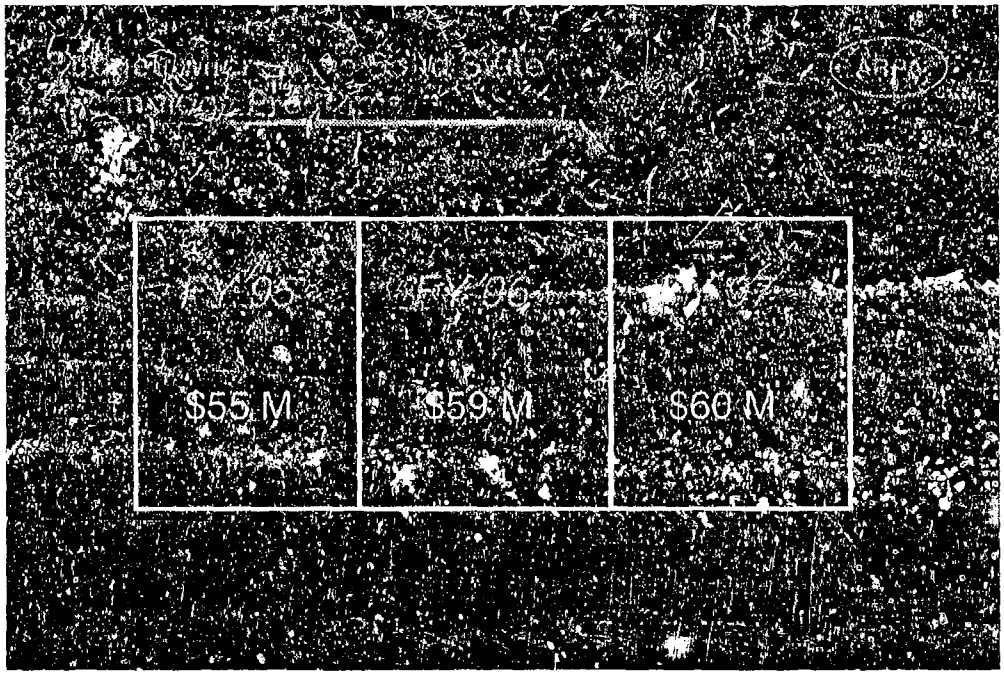
In fiscal 1995, ARPA's packaging thrust will continue to emphasize low-cost manufacturing and the application of advanced packaging to new applications. As the technology matures, we will be taking on the challenge of integrating analog and digital circuits in the same module such as needed for wireless digital communications. In a related program, the Electronic Systems Office will be starting a new effort on Electronic Systems Manufacturing. This effort builds on technologies developed under the Electronic Packaging and Interconnect Program to address higher levels of system assembly. The primary areas of interest include board level assembly, precision electromechanical systems, and system level physical design such as needed to manufacture hand-held computing and communications devices.



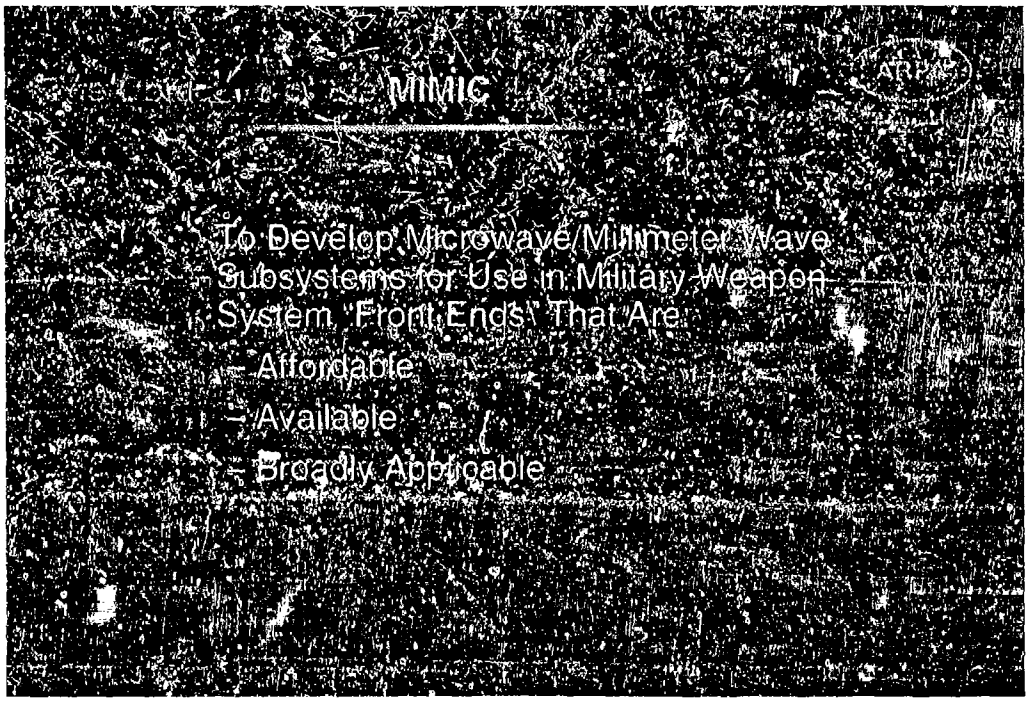
The ARPA packaging thrust involves supported by program managers from across ARPA. Dr Nick Naclerio in ESTO coordinates the overall effort. The roles of other ARPA offices and program managers are shown on the chart.



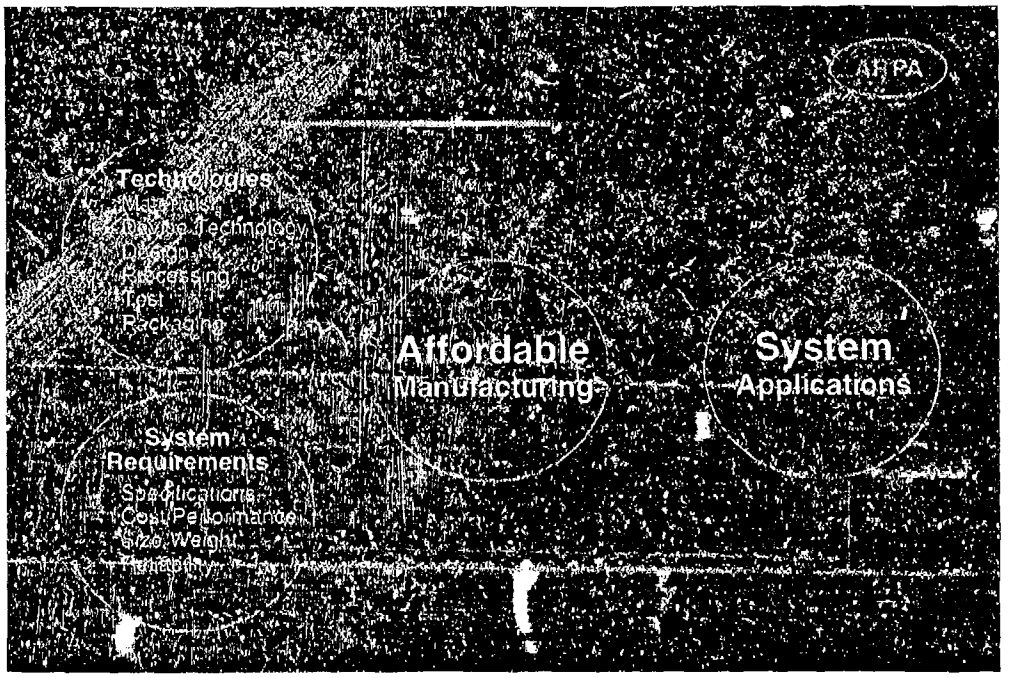
Good morning. In the next 20 minutes, I will discuss the three ARPA microwave and millimeter wave solid state technology programs. Two of these are in progress: the Microwave and Millimeter Wave Monolithic Integrated Circuits (MIMIC) program and the High Density Microwave Packaging (HDMP) program. The third is a new program that we will be starting this year called the Microwave and Analog Front End Technology (MAFET) program. ARPA works with the Army, Navy and Air Force in the management of all of these programs. The programs share the common goal of making microwave solid state products, especially microwave monolithic integrated circuits (MMICs) and modules containing them, available at an affordable cost for use in a wide variety of military and commercial systems applications.



This chart shows the approximate ARPA budget allocated for microwave and millimeter wave solid state technology over the next three years. MIMIC will end in FY 95, HDMP will continue through FY 97 and MAFET through FY 99.



First I'll say a few words about the MIMIC program. The MIMIC program is now entering its final year. Since its beginning, its primary objective has been and continues to be the development of high performance, affordable, and available microwave and millimeter wave technology for building electronic systems. Program products and processes continue to find increasing acceptance and use in a wide variety of both military and commercial applications.



The MIMIC program has established a solid infrastructure for microwave monolithic integrated circuit (MMIC) technology. It is comprehensive in nature in that it has focused upon putting into place required technology and manufacturing capabilities in the six technical areas that have the most critical impact upon cost effectively producing, testing, and packaging MMICs that meet DoD system requirements. These technology areas are: materials (principally gallium arsenide and other 3-5 compound materials), device technology, computer-aided-design (CAD), manufacturing, test and packaging. All of the work undertaken under program sponsorship in these areas is oriented toward affordable manufacturing of MMIC products for use in as many RF system applications as possible. For this reason, system requirements such as changes in specifications for performance, cost, size, weight, and reliability are constantly monitored and, if necessary, appropriate design modifications are made rapidly and inexpensively.

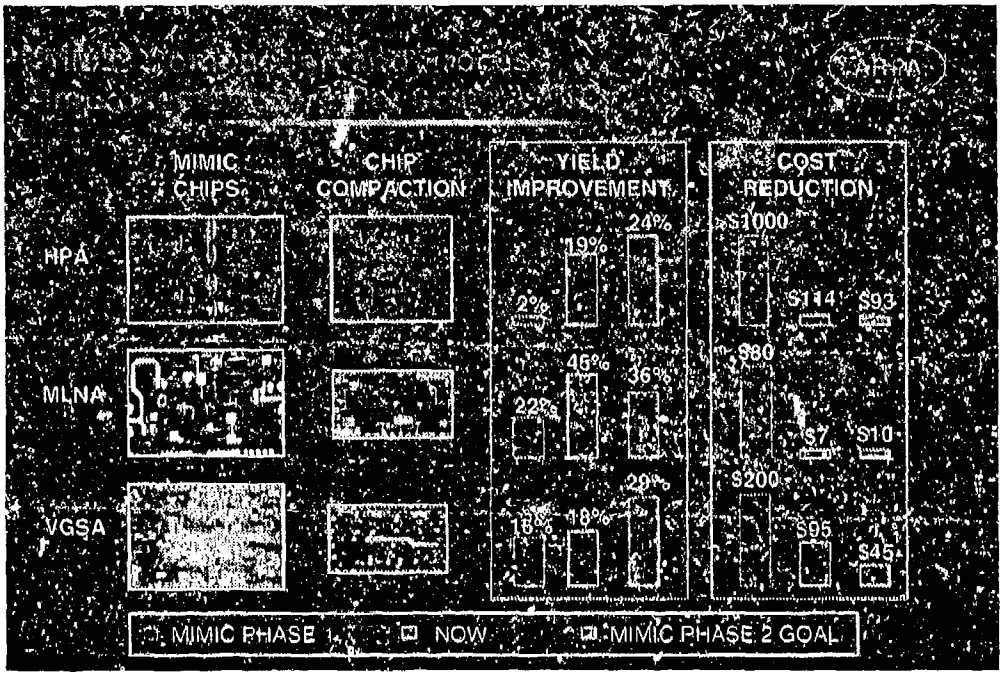
In the substrate materials area, overall crystal sizes have become much larger over the course of the program . Gallium arsenide wafer diameters have increased from 2 inches to 4 inches at many contractors. In addition, the number of wafers from each crystal or boule is over 100 instead of 20 to 40. Six inch diameter material is now becoming available in limited quantities. Even more important, wafer characteristics and uniformity have dramatically improved during the past few years.

Another major focus of the MIMIC program has been upon the development of advanced computer aided design (CAD) capabilities. This effort has yielded enhanced design tools and improved circuit models. Software libraries of design microcells developed under the MIMIC program at many participating contractors have become available for use in computer aided design systems. These new, expanded microwave circuit libraries make it possible to achieve further significant savings in the cost and time of developing MMIC circuits.

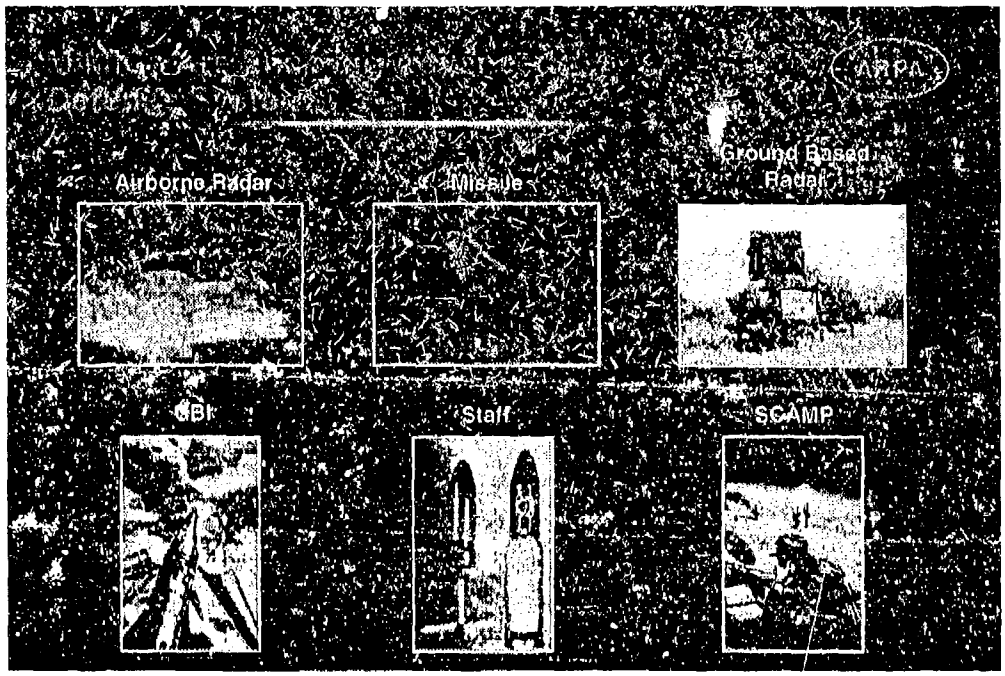
A variety of process improvements have been instituted since the beginning of the MIMIC program. These include improved passivation, improved wafer backside processing, implementation of statistical process control, adoption of optical stepper and E-beam lithography and greatly increased line automation.

Testing time has been reduced by a factor of 50-100 compared to the time required at the start of the MIMIC program and it is now possible to test devices with power up to 8 times as great as previously.

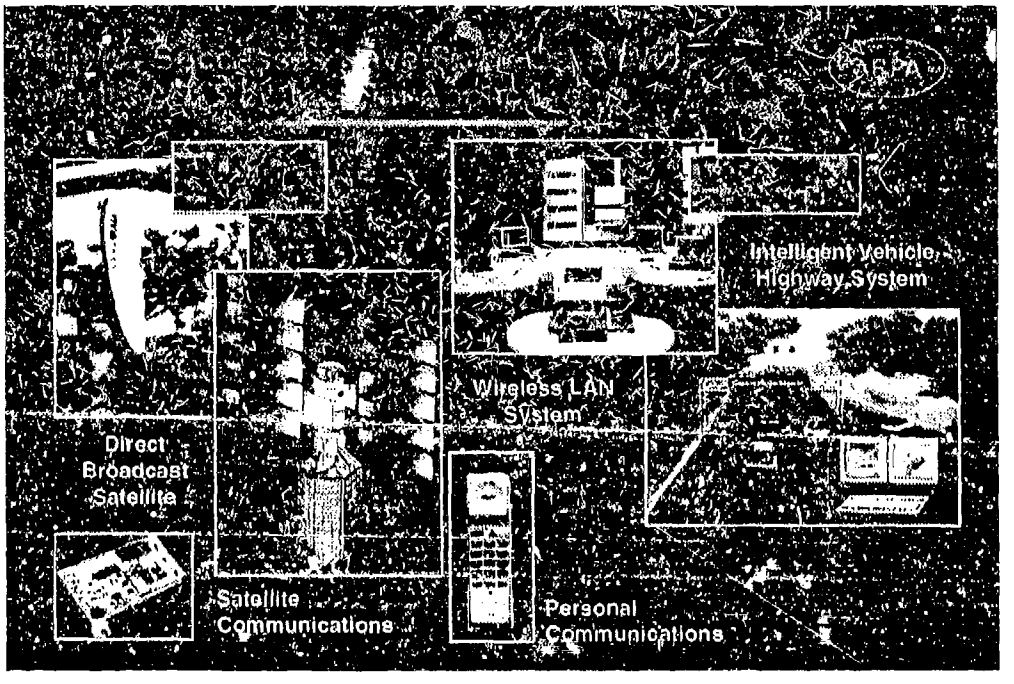
The cost of microwave packaging is continuing to decrease. This year, under MIMIC program funding, the cost of metal matrix composite AlSiC packages, including feedthroughs, has dropped to below $30 even for relatively small quantities (approximately 1000). This compares with packaging costs of over $1000 in 1987-88.



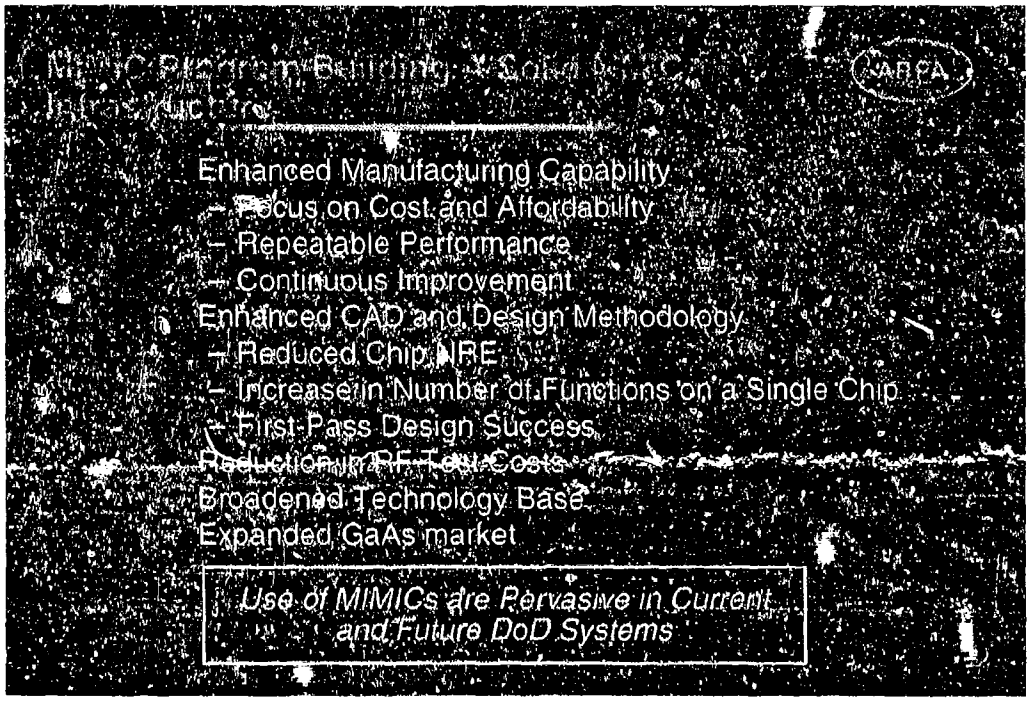
This chart shows how advances in CAD that allow better use of gallium arsenide "real estate" coupled with improvements in the manufacturing yield of MMICs are dramatically driving the cost of MMICs down. Notice that the cost of the multi-function low noise amplifier or MLNA has dropped from $80 to $7 in about 2 1/2 years, more than an order of magnitude reduction. The cost of the high power amplifier has also dropped by about a factor of 10 and the cost of the variable gain switched amplifier (VGSA) is less than half of what it was 2 1/2 years ago. This level of chip cost reduction coupled with similar or larger drops in the cost of testing and packages has made the difference--MMICs are being used in an increasing number of DoD and commercial applications.



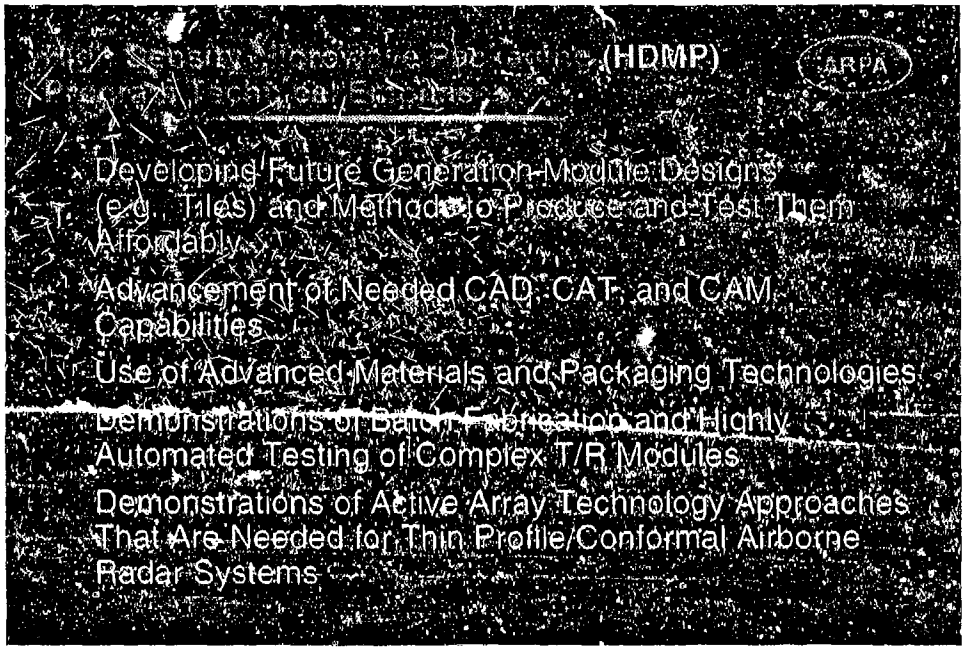
These are some of the types of military systems in which the MIMIC program is playing a role. They include the Ground Based Radar (GBR) system, the first full scale active electronically scanned radar to use MMICs, and a system that will use hundreds of thousands of MMICs in 68000 modules being built at Raytheon and TI, airborne radar systems, advanced portable communication systems (SCAMP) and several types of missiles. Electronic warfare systems have benefitted from MMIC use as well.



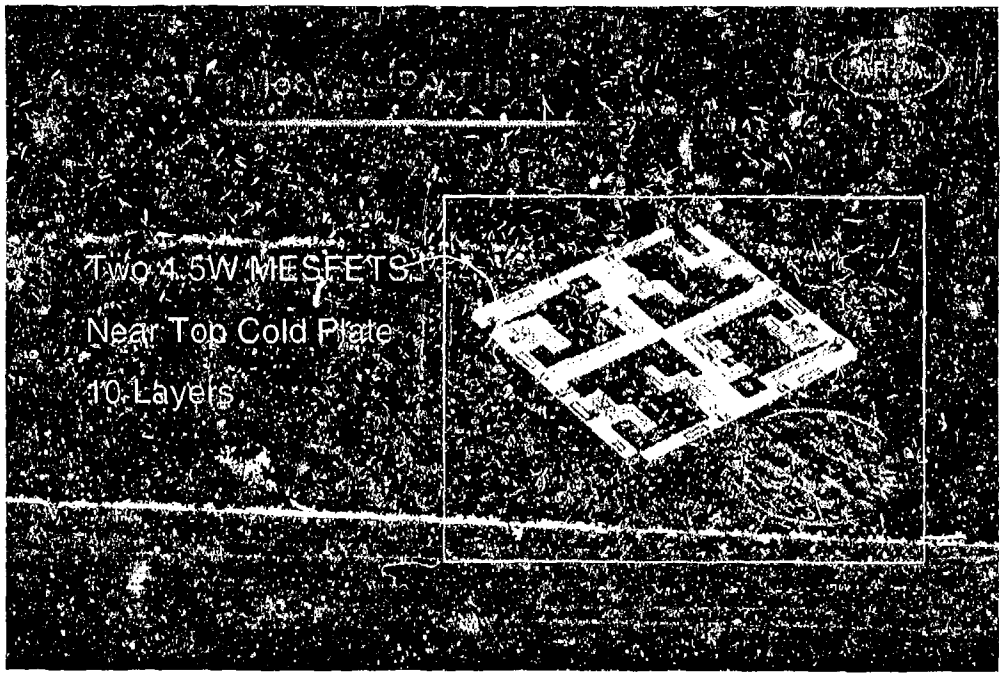
MMICs are also finding increasing use in commercial applications. This chart shows several types of commercial systems that are either using MMICs now or will do so in the next few years. As the need for instant access to information becomes more prevalent, MMIC chips are finding their way into more and more systems. These include cordless and cellular telephones, wireless local area networks, satellite communication systems such as Iridium, radars for automobiles, trucks and school buses, automatic toll collection devices, and tagging systems. It's important to realize that this is one semiconductor area where the U.S. is dominant--we are the exporter of MMICs to Japan, other Pacific Rim countries and Europe.



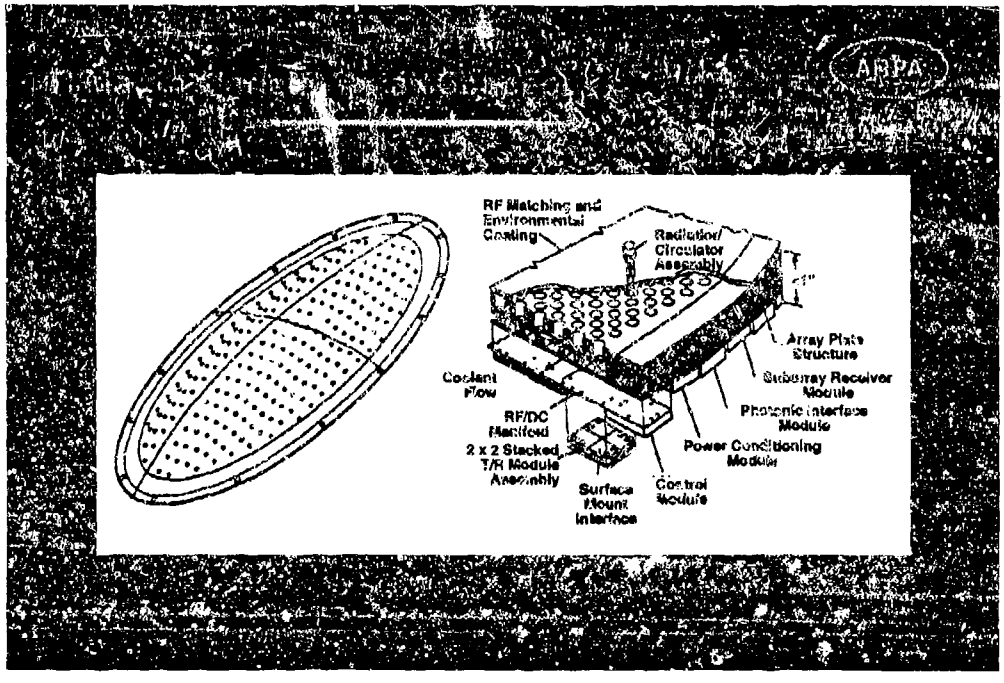
Summing up, the MIMIC program has built a solid infrastructure under which technologies, tools, and processes shown here have been put in place to enable the expanded use of MIMICs in current and future military and commercial systems and products.



The HDMP program will concentrate upon the establishment of techniques to design, produce, and test a new generation of very thin, lightweight radar modules and subarrays affordably. This is a program that will help in making it possible to produce the low cost, very thin active arrays needed for future DoD radar, communication and EW systems. It will include demonstrations of the ability to batch fabricate and test, with a high degree of automation, these types of complex T/R modules and multi-chip assemblies (which are groups of modules). In order to meet cost requirements for producing modules or multi-chip assemblies that meet the electrical, thermal, and mechanical requirements of a wide range of systems, we must improve upon present day computer aided design, test, and manufacturing capabilities. In addition, advanced materials and packaging technologies must and are being developed and used, as needed. A real driver in dramatically lowering costs, and one that particularly lends itself to the type of modules being developed in the HDMP program, is batch fabrication of the module components coupled with highly automated testing of both those components and the final module assemblies. The program will conclude with a demonstration of several types of candidate "tile type" modules and multi-chip assemblies, and a brassboard demonstration of a 96 element active phased array.



This shows a high power amplifier tile being developed by Hughes Aircraft Company under their HDMP contract. The tile contains two 4.5 watt MESFETs and associated circuitry. It consists of 10 layers of interconnections and is mounted near a cold plate for heat removal. Two other tiles form the overall multichip assembly in the Hughes approach: one is a control circuitry tile, and the other a low noise amplifier tile. The whole multi-chip assembly is about 1 square inch in area and about a 1/4 of an inch thick. This approach is typical of ones being pursued by a number of companies as part of their efforts to develop a new generation of T/R modules.

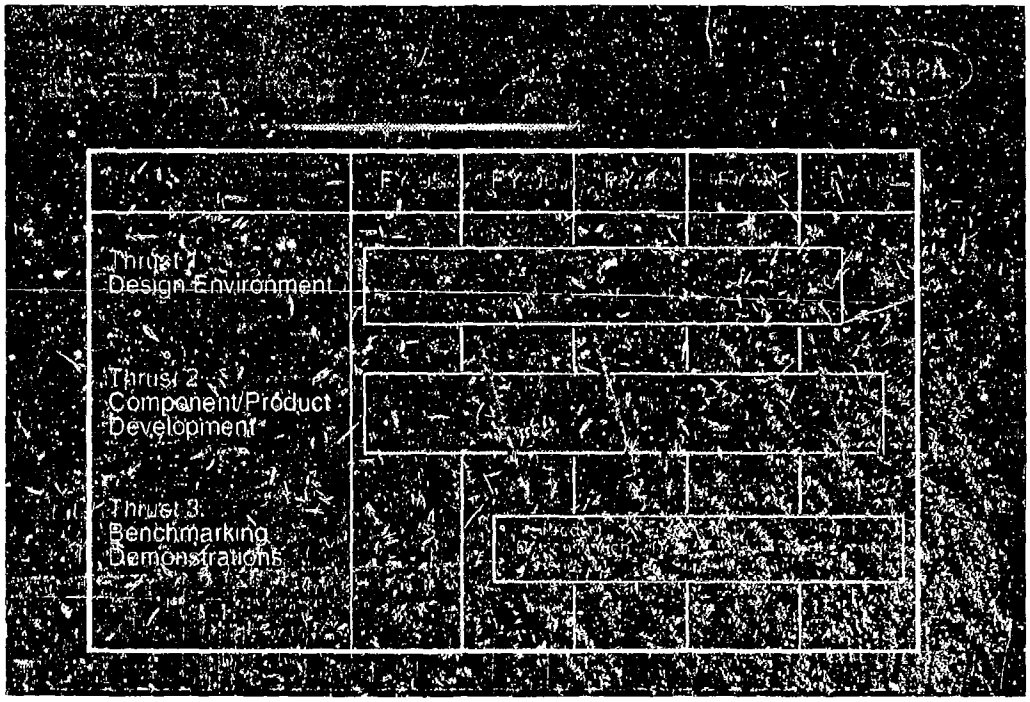


The array shown on the left is an artist's conception of a conformal array of the future that is expected to result from the Texas Instruments/Martin-Marietta team's work under the High Density Microwave Packaging Program. The thickness of the array will be only about 1 inch. A number of 2 x 2 stacked T/R module assemblies will be connected as shown in the drawing on the right to a manifold to form the overall array. Each 2x2 T/R module is approximately 1" x 1" x 0.25". An array utilizing brick T/R modules instead of tiles would be 5 to 10 times thicker. This team will demonstrate a 96 element brassboard of this design at the conclusion of their HDMP contract.



I want to spend the remainder of my time discusing the new Microwave and Analog Front End Technology or MAFET program, a planned FY 95 start. MAFET will focus upon the development of the technologies and capabilities needed to produce the RF systems and system upgrades of the future that are affordable, are highly portable, and gather, process, and transmit information quickly, accurately, and reliably. The program will address technology and products for use across the entire microwave and millimeter-wave frequency spectrum.

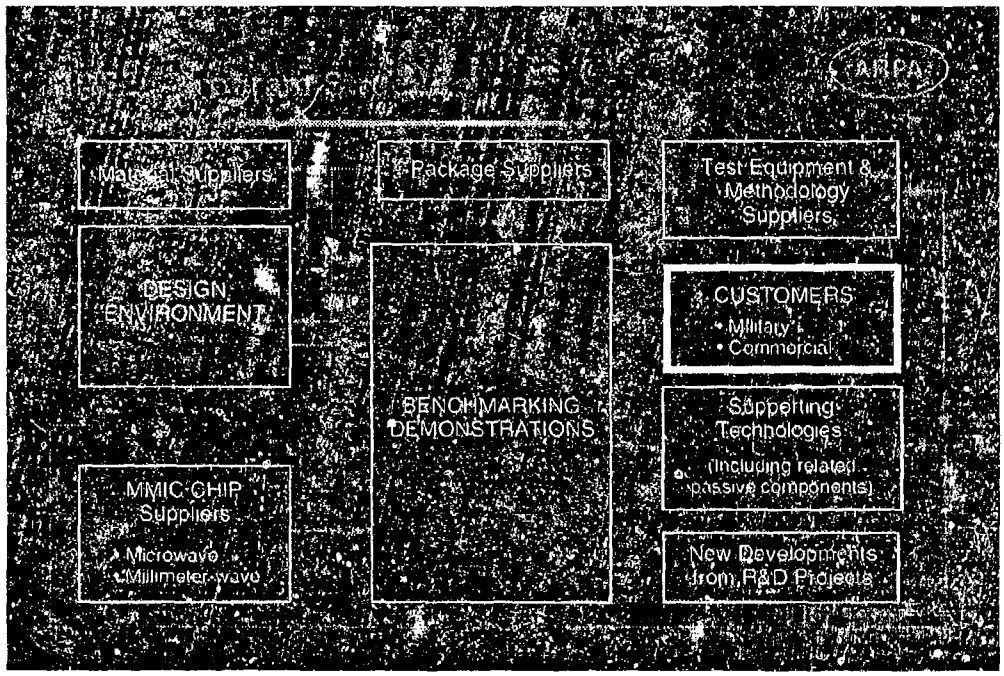
The program seeks to achieve major reductions in the cost of and time for designing microwave and millimeter wave monolithic integrated circuits (MMICs), other components, interconnections, subsystems, and systems; continuously improve the infrastructure development begun under the Microwave and Millimeter Wave Monolithic Integrated Circuits (MIMIC) program including establishment of the capabilities to rapidly and inexpensively manufacture and assemble needed microwave and millimeter wave frequency products for the widest possible range of system applications; foster increased circuit functionality within a given MMIC chip area; and develop new cost effective circuits, related components, and methods for interconnection and housing these elements in order to establish a self-sustaining, economically competitive base of MMIC and subsystem product suppliers.



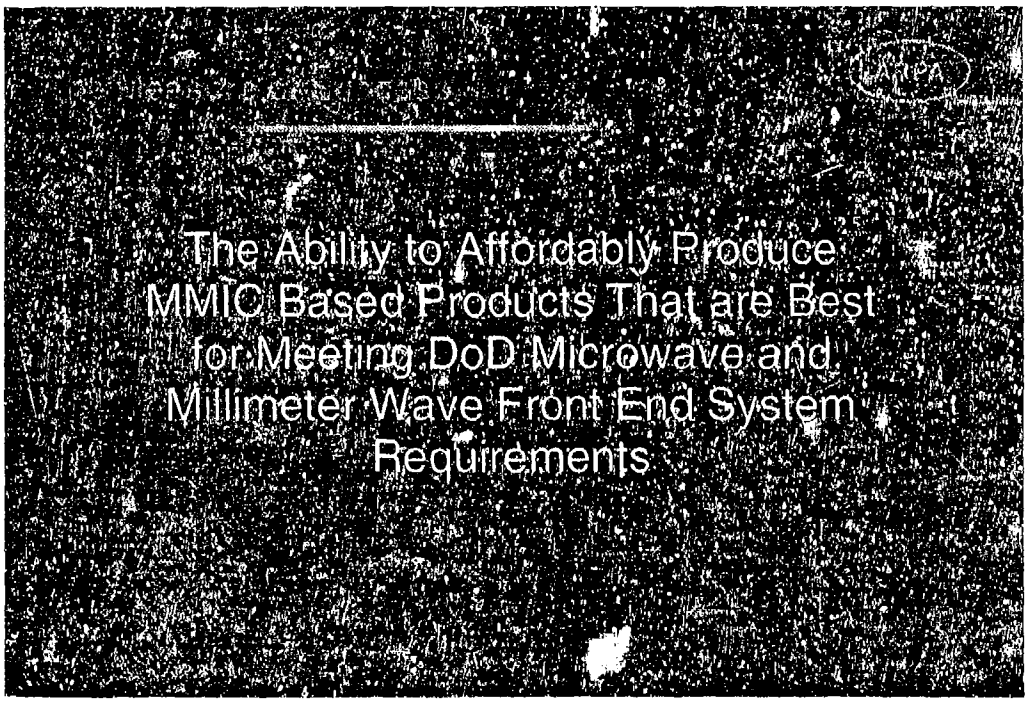
MAFET will include three major thrusts. The first of these is the development of a comprehensive design environment that will include the ability to use a "system down" design approach as well as a "component up" approach. The MAFET vision for an improved computer aided design environment centers upon providing the capability to process and display information in a way that allows designers at all levels (system, sub-system, circuit, and device) to easily exchange needed electrical, mechanical, and thermal data. The CAD system to be developed will build upon the very substantial base of CAD tools and information that already exists. It will extend this base to provide additional capabilities and establish the needed interfaces that allow many types of tools, programs, and models from many vendors to interact effectively with each other.

The second thrust is directed toward the development of improved, more affordable components and products for many microwave and millimeter-wave system areas. These include advanced materials such as indium phosphide, completion and implementation of advanced, robust, versatile, efficient MMIC fabrication processes, improved MMICs including lower cost, more capable circuits for millimeter-wave frequency operation and advanced microwave frequency circuits, improved passive components such as circulators, filters, capacitors, and inductors, lower cost packages particularly ones for multi-chip use at millimeter-wave frequencies, advancement of effective low cost test methodologies and promising new developments from various R&D projects including ones at universities. The overall objective is to satisfy the widest possible range of military system applications, quickly and affordably. The final thrust will include a number of benchmarking demonstrations. The benchmarking demonstrations are intended to provide proof that the effective use of a comprehensive design environment, coupled with robust processing and efficient manufacturing and assembly of MMIC based products is the best approach for achieving low cost, high performance microwave and millimeter-wave products for all system applications, military and commercial.

This slide shows a proposed "roadmap" for meeting MAFET program objectives. Note that there will be a number of benchmarking demonstrations over the course of the program and that at least two benchmarking demonstration solicitations are planned. Although the solicitations for the benchmarking demonstrations will follow that for the design environment and component/product development thrust areas, interactions between design environment contractors, component/product suppliers and prospective benchmarking demonstration contractors must begin at the start of the MAFET program.



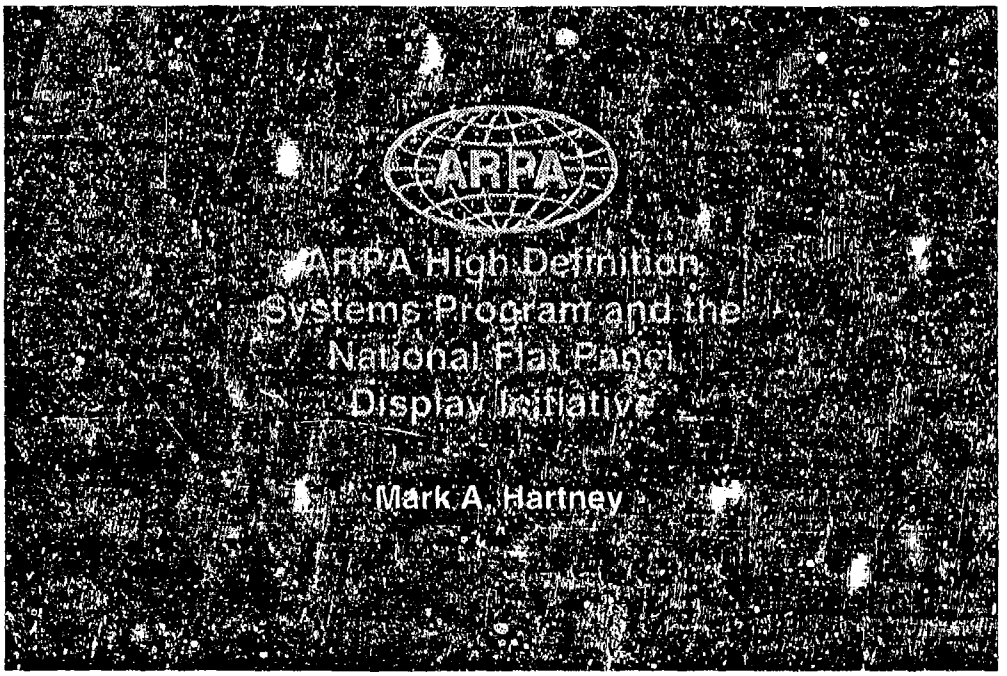
This shows how the various thrusts of the MAFET program structure tie together to meet the overall program objectives. There are four color codes, one for each of the three thrusts and the final one for the program's customers, military and commercial. Thrust 1 is the Design Environment. Note that as it matures, it will reduce the cost and time of designing MMIC chips, related passive components, packages, and testing procedures as well as those of overall sub-systems and systems. The color coded blocks around the periphery of the block diagram are all parts of Thrust 2. All of the work done under Thrust 2 is oriented toward development of components and products for widespread applications in DoD systems and commercial ones. That's why all arrows from these tasks point toward the benchmark demonstrations. The benchmark demonstrations, Thrust 3, will serve as a examples to help system developers understand how they can effectively use MAFET program developments to improve and lower the cost of their systems. The program is expected to include both individual efforts by companies and universities and a number of teams depending on the specific task at hand. However, it is hoped that a very high level of interaction and sharing of information takes place between all program participants.



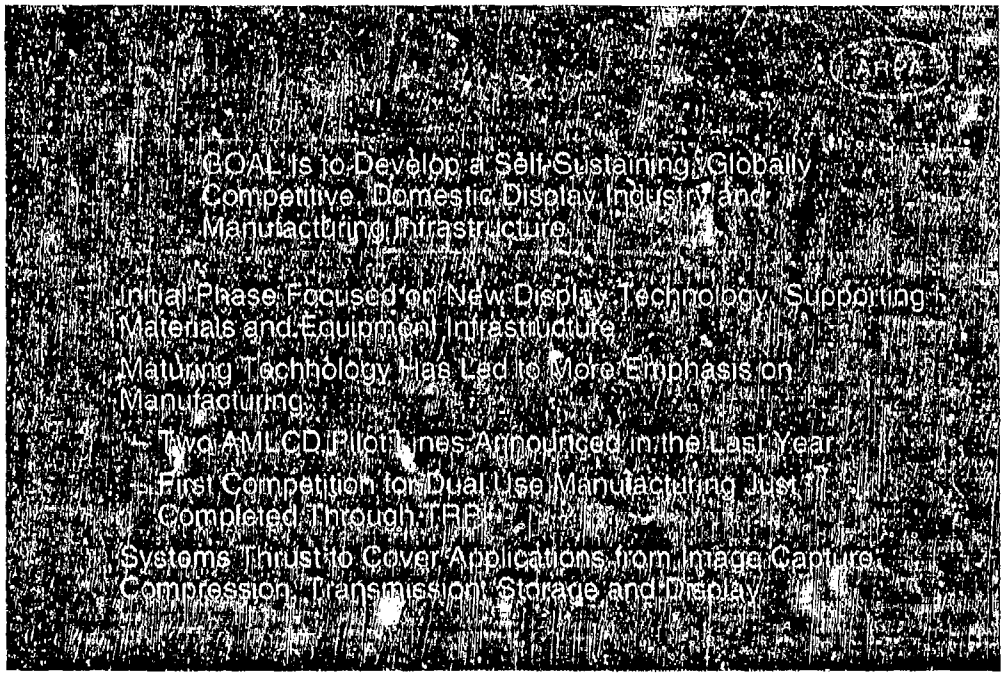
The overall measure of success for ARPAs microwave/millimeter-wave technology programs will be the ability to affordably produce MMIC based products that are best for meeting DoD microwave and millimeter wave front-end system requirements.

The solid technology base developed under the MIMIC program has brought microwave monolithic circuits from experimental proof-of-concept demonstrations carried out in research and development laboratories to the status of the high yield, low cost, readily available products of today that are produced on highly automated fabrication lines. The HDMP program will contribute substantially to establishing the capabilities necessary to produce the next generation of phased array radar systems. Much work remains to be accomplished under the remainder of the MIMIC and HDMP programs and the new MAFET program to drive costs down further, extend product successes to higher frequencies (e.g., millimeter waves) and integrate larger numbers of functions on single chips. This will include development of still more advanced material structures, increased CAD capabilities, better models, more complete circuit libraries, more agile manufacturing lines, cheaper and higher performance multi-chip assemblies, and improved testing methodologies.

Thank you very much for your interest.



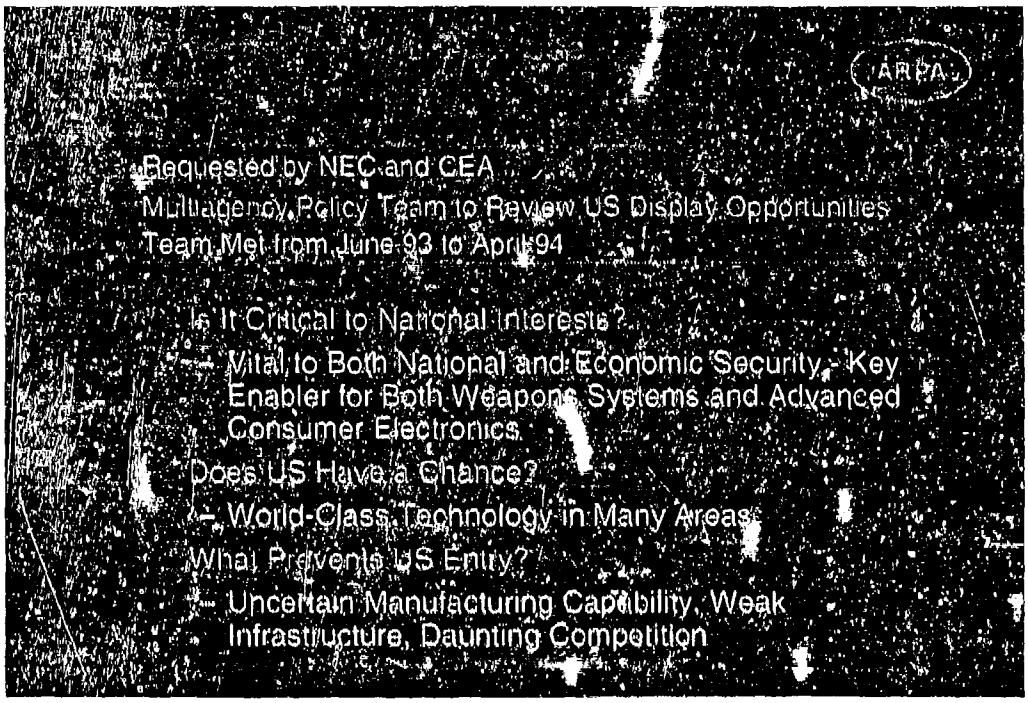
Title Slide for ARPA Symposium presentation on High Definition Systems



The High Definition Systems program, begun in 1989, was initiated to develop improved display technology for military applications. Displays are the primary interface between people an systems and offer tremendous opportunities for conveying information, thus enhancing human performance. Required improvements in displays include making them more power efficient, lighter, thinner, brighter and cheaper.

Displays are inherently dual-use technology, with tremendous commercial applications that drive the industry. The goal of the display program is to provide viable display companies in the U.S. which can provide affordable technology to the military from facilities which primarily serve the commercial market.

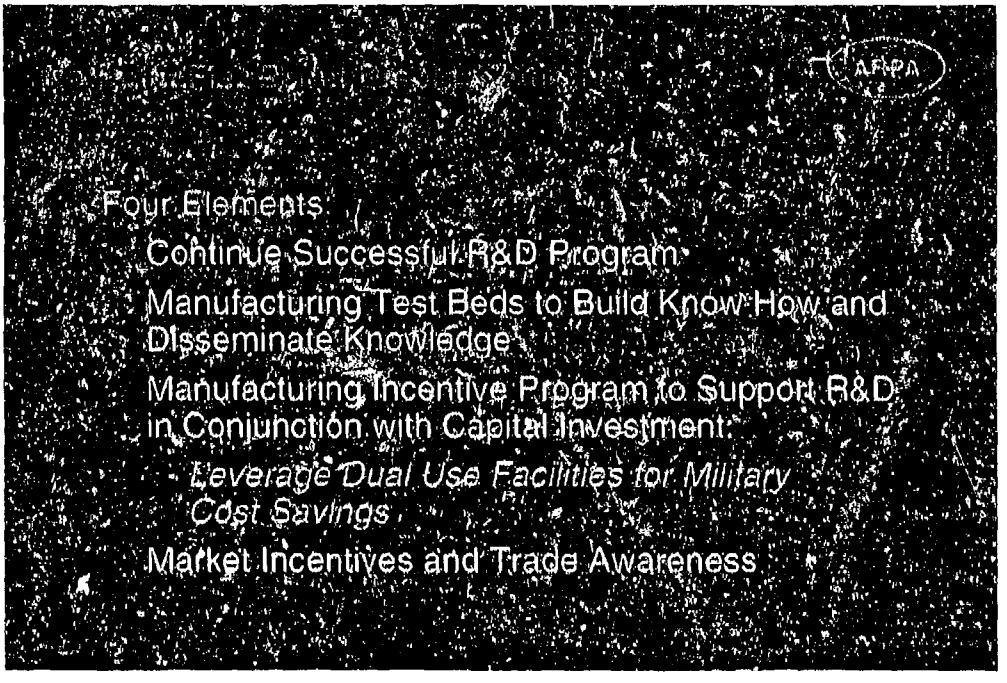
The first phase of the program focused on developing new display technology concepts and demonstrating their functionality. The program has also supported materials and equipment used to produce these new technologies. As this effort has proven fruitful, the next phase of the program focuses on affordable production of these technologies. Finally, a systems level effort capitalizes on new display technology and couples it with information processing to prototype new system capabilities.



Early in the Clinton administration, the National Economic Council and the Council of Economic Advisers requested that an interagency team analyze flat panel displays as a case study for dual use technology development and policy. This team met for nearly a year, with frequent consultation with industry to address a number of key questions and formulate an effective policy solution.

The key questions included whether having a domestic display industry was important to national and/or economic security. The answer to this was clearly yes, since there are an increasing number of weapons systems which rely on displays to convey information to combatants in a concise, readily understood fashion. The display is also a key differentiator of electronics products in commercial technology, ranging from laptop computers to consumer products, and loss of this technology would put U.S. firms at a competitive disadvantage.

While the U.S. has a number of world class display technologies, these reside mostly in laboratories and have not been transitioned to volume manufacturing and commercial products. A number of factors are offered as explanation, including a lack of manufacturing experience, the high capital cost for entry, the presence of established off-shore competition, and a weak infrastructure for materials and equipment.



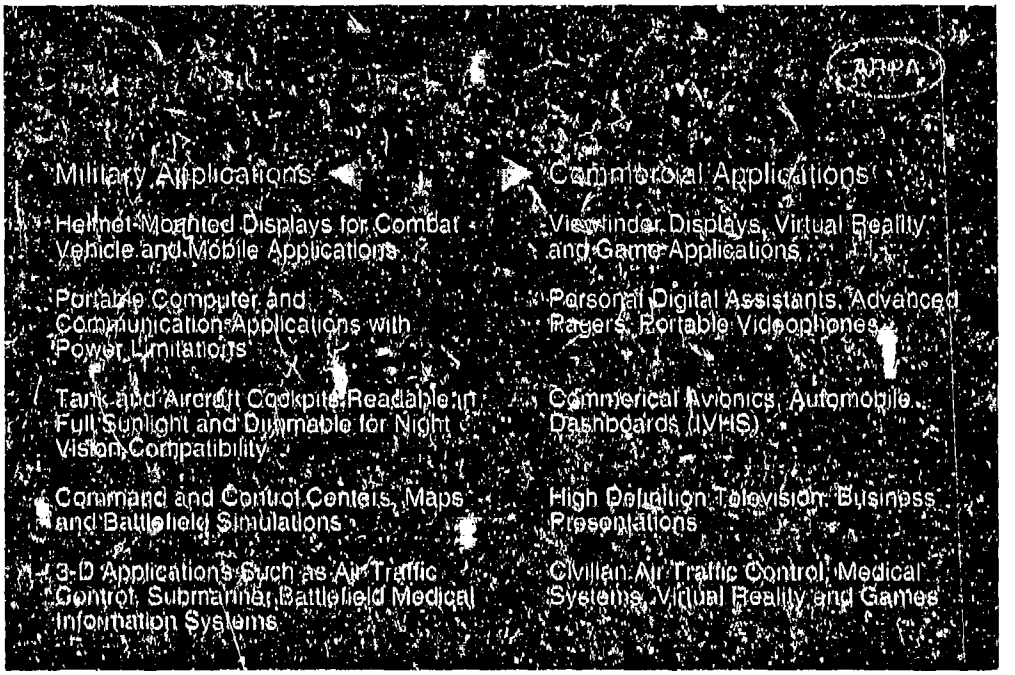
As a remedy to this situation, the National Flat Panel Display Initiative was developed, and announced on April 28, 1994. The Initiative consists of four essential elements:

First, the R&D programs at ARPA, as well as DOE and NIST have sustained a level of technical achievement which provides the U.S. with potential opportunities for future display manufacturing. These programs should be continued, so that the pipeline for future technologies and refinements of existing technologies are maintained.

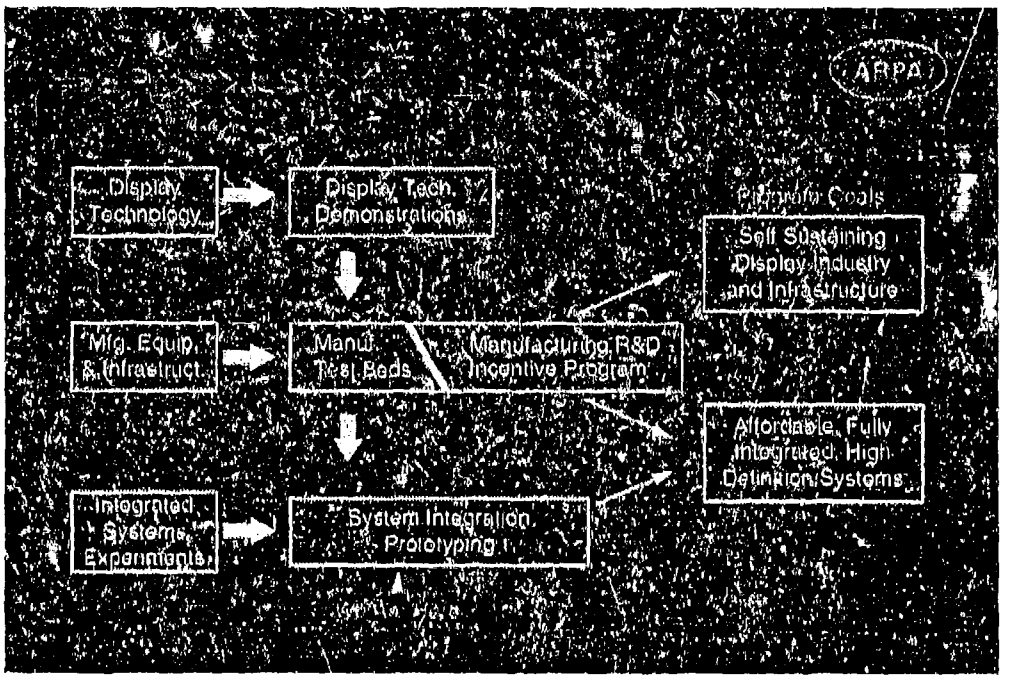
Second, to address the issues of lack of manufacturing knowledge in high volume production, two test beds for AMLCD manufacturing have been established. These programs will develop processes on higher volume manufacturing equipment and provide an industry-wide assessment of process viability for future investment planning. Additionally, these programs will produce a number of displays that can provide early applications testing in military systems as well as commercial product prototypes.

The third element of the initiative is the centerpiece of the effort to create a self-sustaining industry. For this program,the government is soliciting proposals to co-fund R&D on next generation display technology from proposers who have made commitments to produce current generation products. This criteria is established to insure that funding is directed to those companies who will be in the display business now, and in the future, to be able to provide products to the military in a cost effective manner.

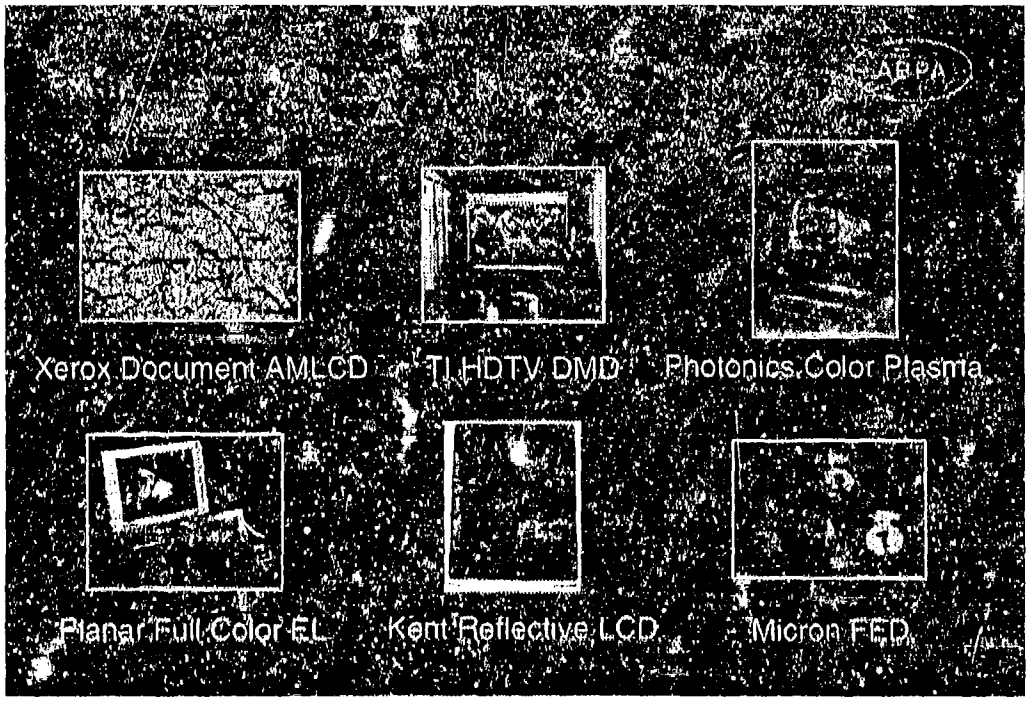
Finally, the fourth element of the initiative is to encourage market development through the use of government as a customer, for both military and civilian applications and through the development of display technology applications for the National Information Infrastructure. An additional component of this element is a vigorous enforcement of trade laws to ensure that domestic producers face fair competition.



This slide compares a number of military applications for different types of display technologies and formats with commercial applications for the same displays. It demonstrates that there is tremendous dual-use synergy between the two market segments, and shows the opportunity to meet military needs by drawing from flexible manufacturing facilities which supply much larger commercial needs.



This slide presents a graphic description of the relationship between different elements of the HDS program. The display technology thrust examines new technology applications which if successful, result in demonstrations of the technology. These new technologies, as well as support for the equipment and infrastructure can lead to the manufacturing programs, either through the testbeds or the R&D incentive program. Production at these higher volumes allows prototypes which can be fed into the integrated systems work to develop new applications of interest. Each of these elements ultimately leads to the program goals of a self sustaining industry and infrastructure and the demonstration of fully integrated high definition systems.



Examples of the successful products from the display technology demonstration are shown in this slide, including:

1. The world's highest resolution AMLCD from Xerox, which has an image quality better than laser printed paper. This display has 6.2 M pixels in a 13" diagonal - more than 16 times the pixel density of common computer displays.

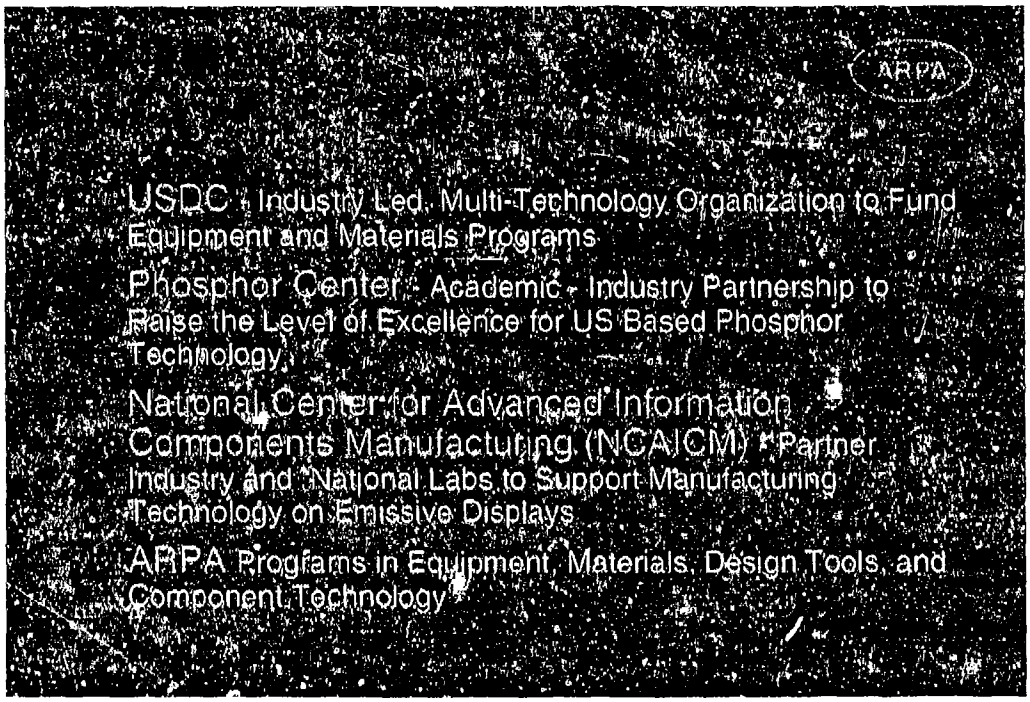
2. The world's largest full color plasma display from Photonics - a 30" diagonal 1024x780 pixel display

3. An HDTV projection system from Texas Instruments based on digital micromirrors which are electronically addressed and controlled to transmit the light.

4. The world's only full color electroluminescent display from Planar, who solved a number of technical and manufacturing problems with blue phosphor materials to achieve full color.

5. A reflective display from Kent Digital Signs which requires very low power to operate and retains the image even after power is turned off.

6. The first U.S. produced full color field emission display from Micron, with the highest resolution of any FED display



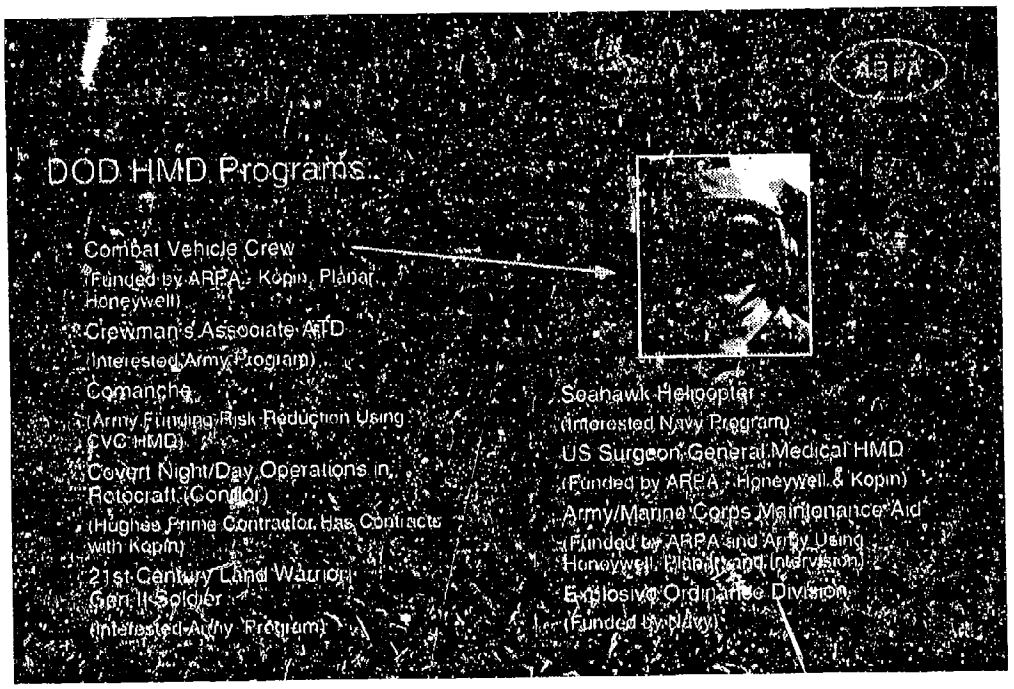
ARPA is also supporting a number of programs in materials and equipment infrastructure through a number of internal and industry partnered organizations begun in the past year.

The US Display consortium, consisting of over 100 display manufacturers, users, and equipment suppliers focuses on funding new equipment and material developments and developing industry standards and benchmarks.

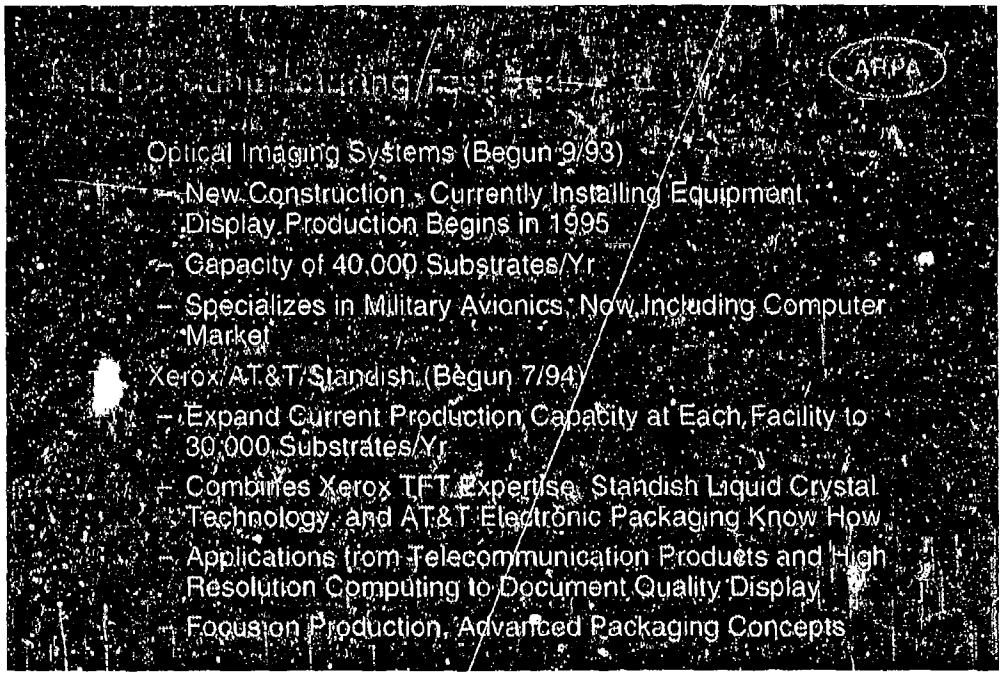
The phosphor center of excellence is organized to develop improved materials for emissive displays and backlights. Improvements in phosphor efficiency will provide improved color, greater efficiency (brighter displays at lower power), and specific materials such as low-voltage phosphors needed for some field emission displays.

The National Center for Advanced Information Components Manufacturing (NCAICM) was established last year to create a partnership between the DOE national laboratories and industry to improve electronics manufacturing, including displays. These programs focus primarily on emissive display manufacturing and core technology.

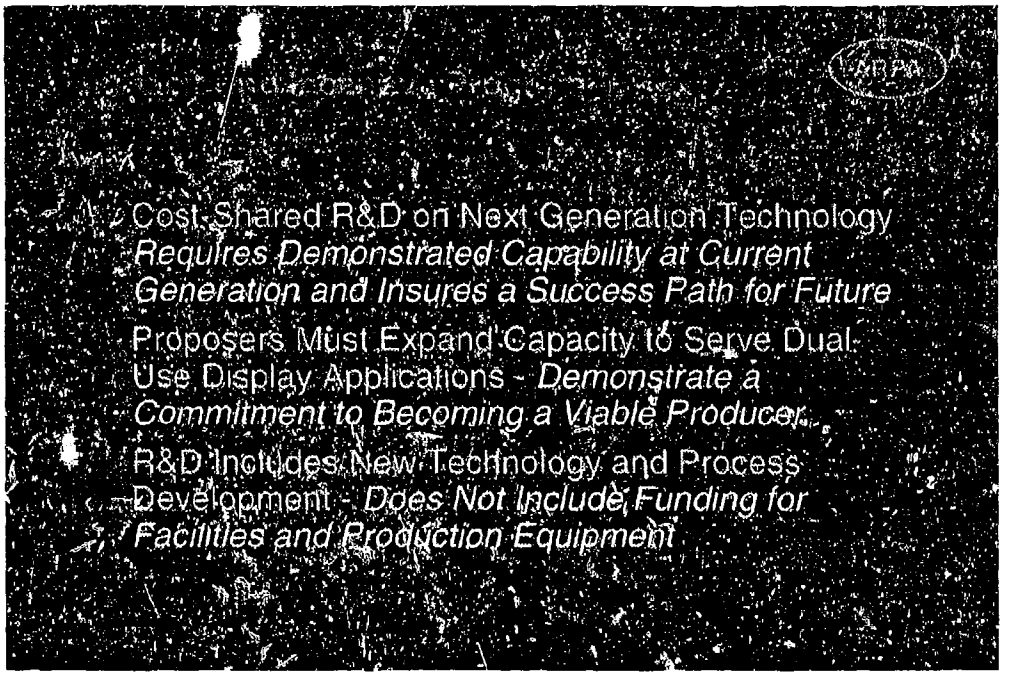
In addition to these multi-faceted efforts, ARPA supports directly a number of individual programs on specific manufacturing equipment and components, underlying technology such as design tools, and university based research.



One of the earliest examples of the transition from display technology demonstrations into systems has been in the headmounted display program. This program has aggressively pushed the technical capability of miniature displays and has found numerous applications now entering the prototyping stages, ranging from the Combat Vehicle Crew helmet, to analagous systems used in the Comanche and Condor helicopter programs. Similar opportunities in the medical field, in maintenance aids and ordnance are being explored. The dual-use nature of these programs is being underscored by a recent Technology Reinvestment Program which is also using these displays to provide a visual template for manufacturing assembly in addition to the military applications described above.



As part of the ARPA program evolution and the new National Display Initiative, two cost-shared awards were made in the last 18 months to establish AMLCD manufacturing test beds that will accelerate the transition from low volume laboratory production to eventual full scale manufacturing. These two programs take a significant step toward that goal by developing technology and processes on equipment that would be utilized in a volume production plant. This information and evaluation is critical to companies planning to enter manufacturing venture and results will be disseminated throughout the industry as appropriate. Additionally, the testbeds will serve to supply enhanced displays to the military for early insertion and development of new system opportunities. Just as importantly, the companies will be able to develop internal prototypes which will help define their new business opportunities in the commercial arena.

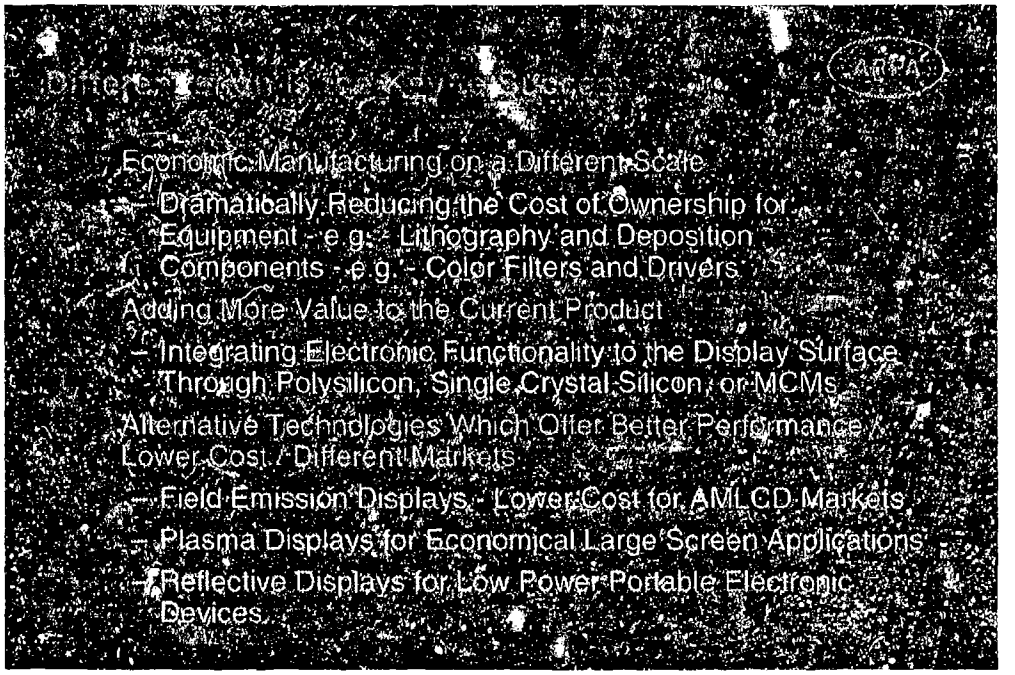


The centerpiece of the Display Initiative is the new program for R&D related to Manufacturing. Like the manufacturing test-beds, these programs will be cost-shared with the participants, however, an additional c. 'eria is a greater commitment to the ultimate manufacturing goal. The program is designed to support R&D, including manufacturing process development on next generation technology. Proposers must have a demonstrated capability on current generation technology and a commitment to utilizing the results of the R&D with expanded production for the next generation.

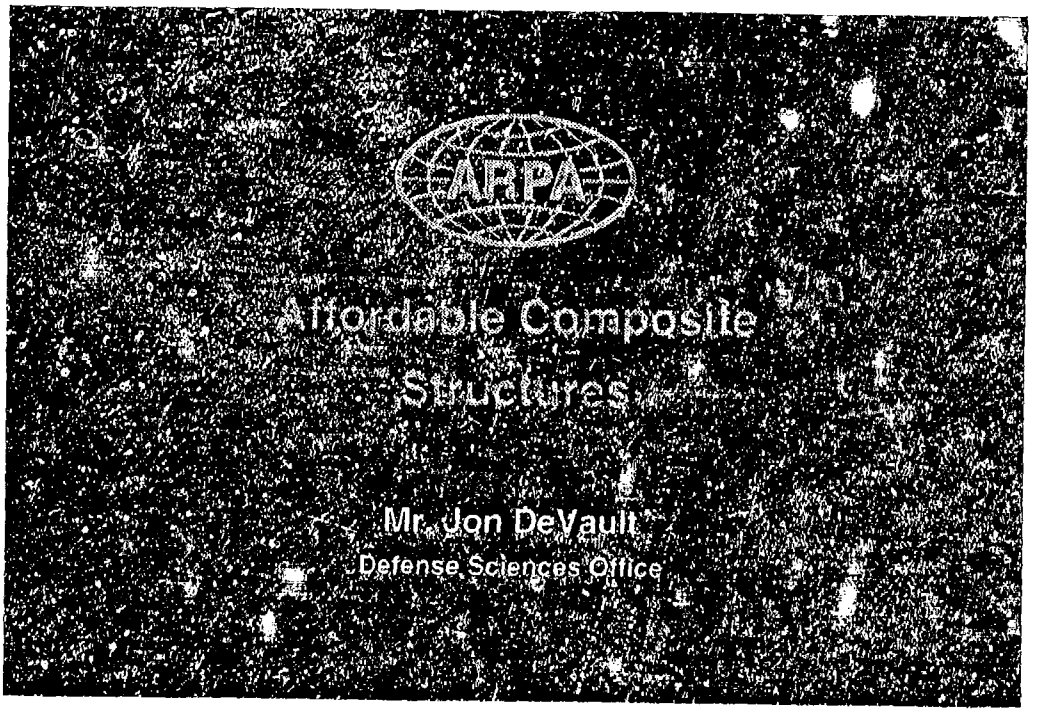
From the government perspective, this insures that the partnership leads to a capacity which can participate in the commercial marketplace, thus reducing costs for acquisition over the foreseeable future. The focus on next generation technology insures that the companies can be competitive not only now, but as the technology continues to advance.



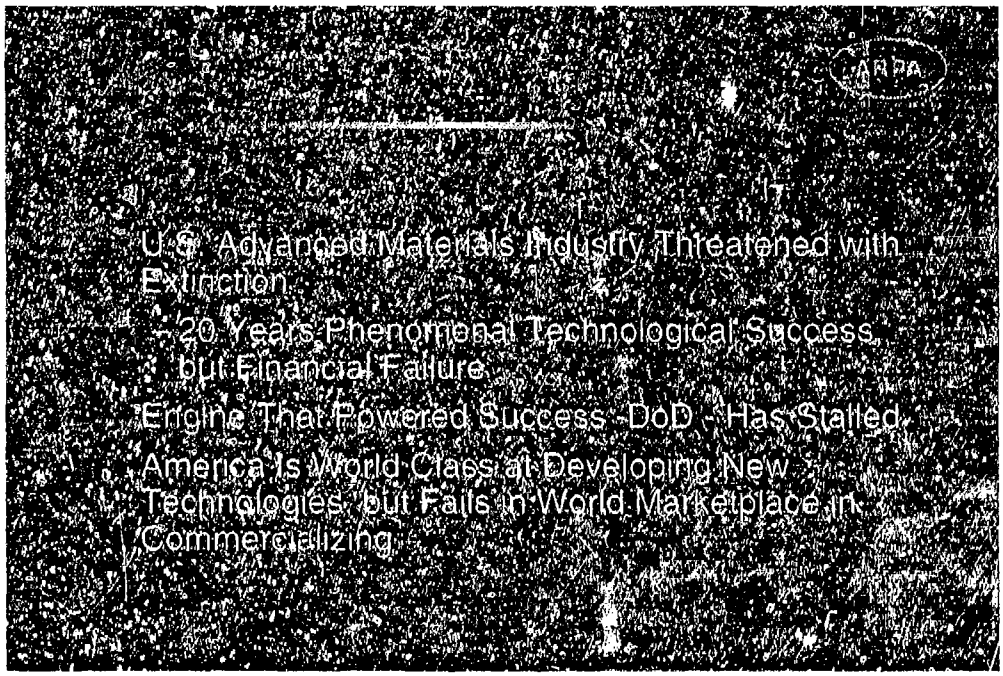
The current market for flat panel displays will be about $4 billion worldwide for 1994, and is expected to exceed $20 billion by the end of this decade. Current production is centered in Japan, who produce nearly 80 % of the world's displays, and over 95% of the world's active matrix displays. Japanese companies have invested nearly $3 billion in production facilities for AMLCD displays over the past four years, and are expected to exceed that number in the next three as demand continues to grow. New investments utilize larger substrates and more efficient equipment, resulting in dramatically higher productivity . Older, less complex technology, such as passive matrix displays are growing elsewhere in Asia, such as Taiwan, Honk Kong and China. Additional developments are expected from Korea and Europe in the AMLCD arena over the next few years.



It is important to note that a strategy of following along the path established by the Japanese manufacturers is not destined for success. It is important to find areas of differentiation which can be exploited to enter the commercial sector and fully exploit the dual use nature of displays. Three of these approaches are (1) to break the paradigm of manufacturing followed for AMLCDs with alternative design, production and component technologies; (2) offer a higher valued product by incorporating additional electronic capacity in the display - a promise enabled by alternative material technologies such as poly or single crystalline silicon; and (3) acceleration of alternative technologies which can offer better price-performance than current technologies, or open entirely different markets than the mainstream approaches of today.



ARPA has a long history in developing advanced composite materials and we refer to materials as one of our three core technologies. In 1993 we initiated a new ARPA thrust in materials and that is in improving the affordability of composite structures. Today I will present the status of that activity.

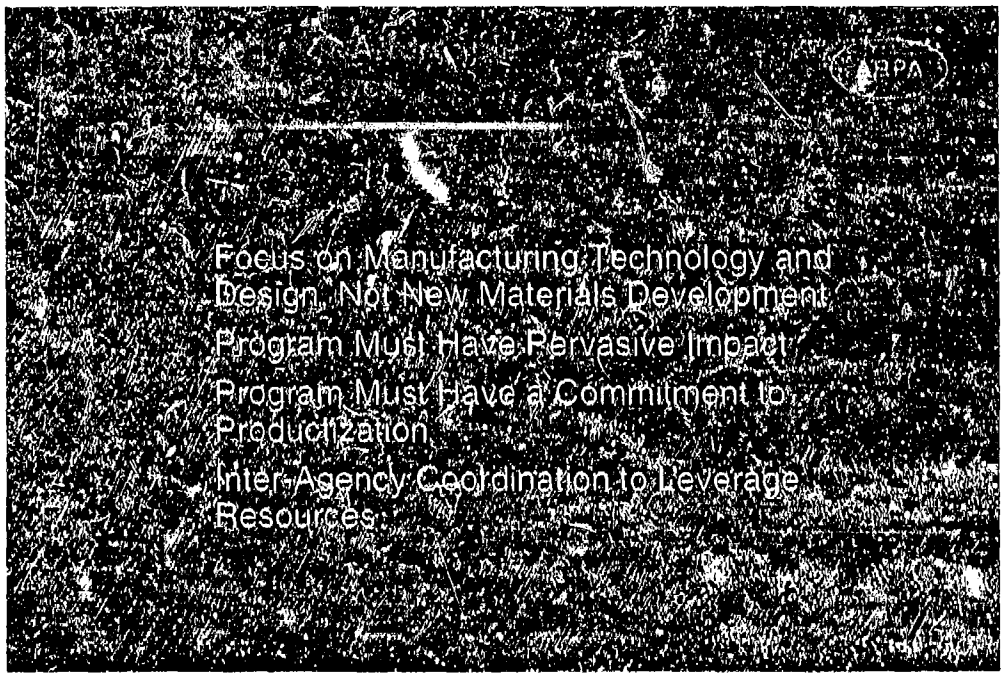


Let me open with my own personal assessment of the advanced materials industry. After 20 years of phenomenal double digit annual growth you have to say that advanced materials are a technological success but a financial failure.

Corporations in the US, Europe, England and even recently Japan are drastically curtailing their activities , trying to sell their interests or in some cases giving up and just shutting them down and walking away. In the United States the engine that powered the success and growth of advanced materials- DOD- has stalled. The reduction in DOD demand for advanced materials, without some compensating growth in civilian demand threatens the existence of the U.S. advanced materials industry. It leaves this crucial technology open to domination by the Japanese who have been more aggressive in developing a range of civilian applications.

This is another example of the US being world class at developing a new technology but failing in commercializing it. Our focus has been on invention, not adoption of advanced materials technology; the emphasis must shift and the key is new and improved component manufacturing technology.

This assessment is what initiated our thrust for affordable polymer composite structures.



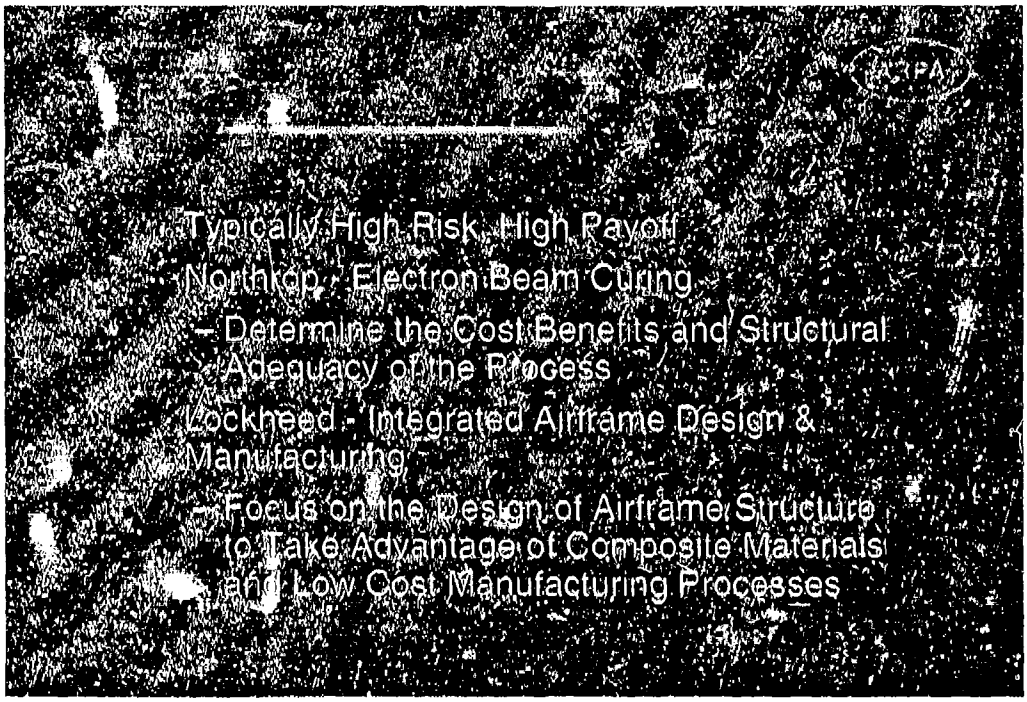
ARPA will therefore focus its efforts on increasing the affordability of utilizing composite materials in both traditional and non- traditional applications. Our affordability strategy hinges on four main points.

We will Focus on Manufacturing Technology and Design, Not New Material Development. If you look at the cost breakdown of aerospace composite structures today, you will see that material costs account for about 10 percent of the cost of the finished structure. Developing and verifying more affordable manufacturing processes and designing structures to take advantage of both the materials and fabrication methods are seen as the key to reducing part cost.

Pervasive impact and commitment to productization are two of the four TRP selection criteria and are at the center of our strategy strategy for composite structures.

Programs must have a pervasive impact. It doesn't make sense to devote resources to solving a problem if the solution results in only a marginal decrease in cost or it doesn't increase the market demand.

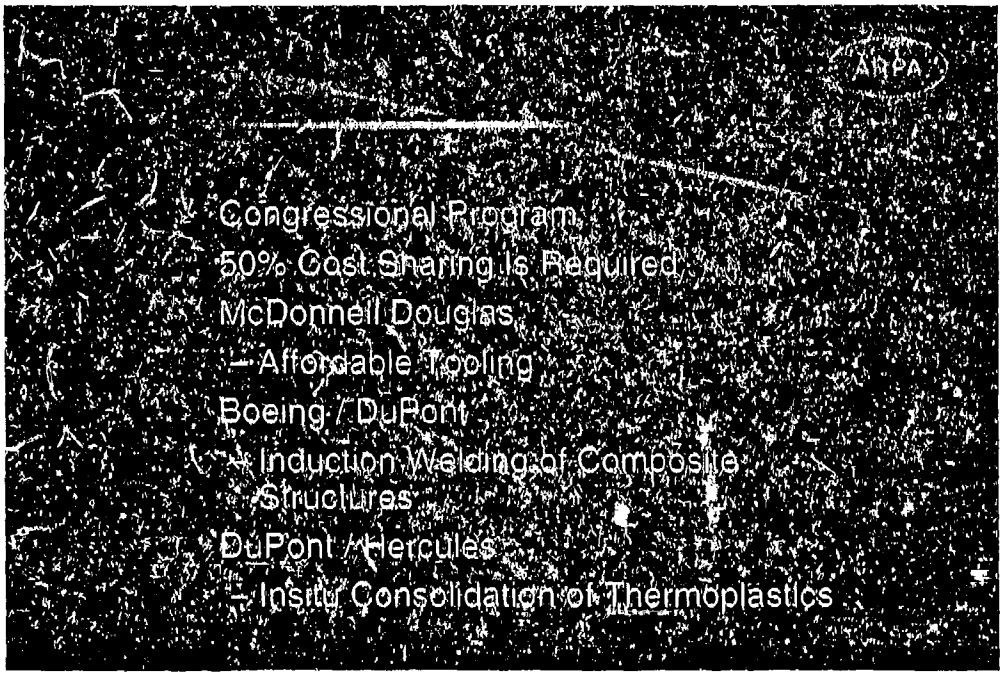
And finally we are striving for better Inter-Agency coordination in order to leverage scarce resources. This includes more open dialogue and joint programs with agencies like DoC-NIST who recently kicked off their own PMC program, the DoT's FHWA and, NASA as well as inter DoD cooperation.



Typically what we refer to as core programs follow ARPA's historical mission of being high risk and high payoff. We have just recently awarded two such programs.

A team led by Northrop Aircraft Division will be working on the Electron Beam Curing process. The goal of the program will be to determine and demonstrate the cost benefits and structural adequacy of the E beam process. The French company Aerospataile who is part of the Northrop team has been using this method to cure composite rocket motor cases for several years. The Northrop program will also be coordinated with an E beam CRADA recently initiated by the Department of Energy's Oak Ridge National Laboratory.

The other program will focus on the design of airframe structure to take advantage of composite materials and low cost manufacturing processes. This team is headed by the Lockheed Advanced Development Company, better known as the Skunk Works. This program is being coordinated with both the ASTOVL and JAST program to leverage results and avoid duplication of effort.



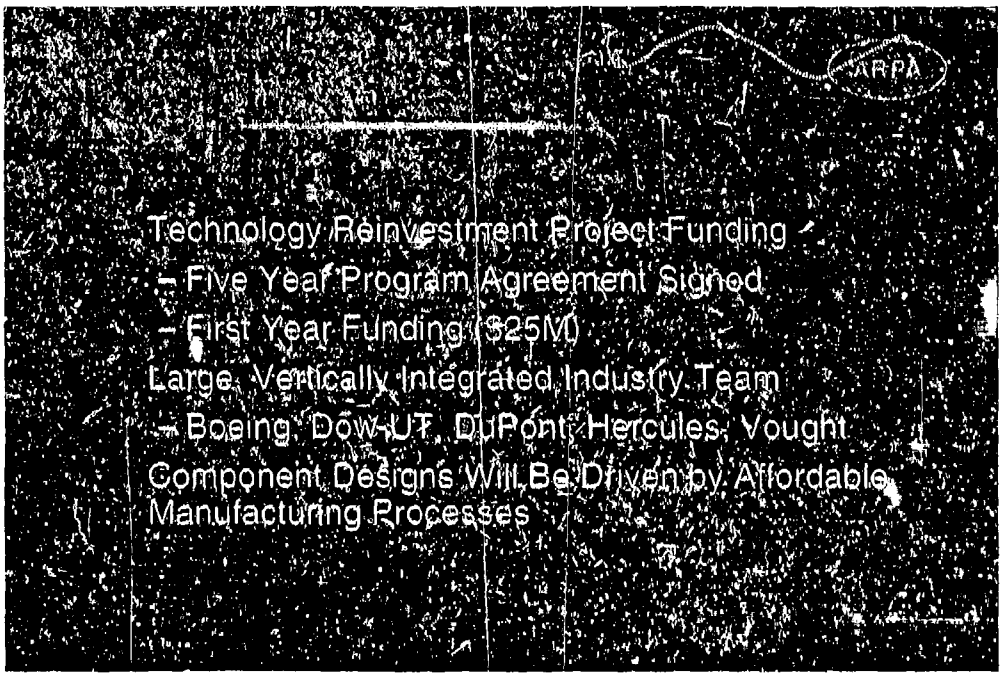
For the last three years, Congress has directed funding for an effort called the Advanced Materials Partnership Program. These programs require teaming and 50 percent cost sharing. Two programs pertinent to affordable PMC's are in the award process and one has already been awarded.

A team led by the McDonnell Douglas Phantom Works will develop and demonstrate low cost tooling for rapid prototyping and limited production Tooling costs are especially important when considering prototype and limited production runs. In fact in such cases they can be as high as 70 percent of the cost.

Another high cost area is in the assembly costs of a structure. This typically involves locating parts, drilling holes, cleaning around the hole, applying sealant, and finally installing fasteners. As you can imagine this not only results in significant costs but also adds weight. A team of Boeing and DuPont will look at the possibility of using induction welding to join structure. The team will develop and demonstrate the process for both thermoset and thermoplastic materials.

The third program, which has already been awarded will further develop the insitu consolidation fiber placement process for thermoplastic materials. The DuPont / Hercules team which successfully proved the feasibility of insitu fiber placement will carry the process forward towards commercialization.

This program is being coordinated with NASA efforts on the HSR program.

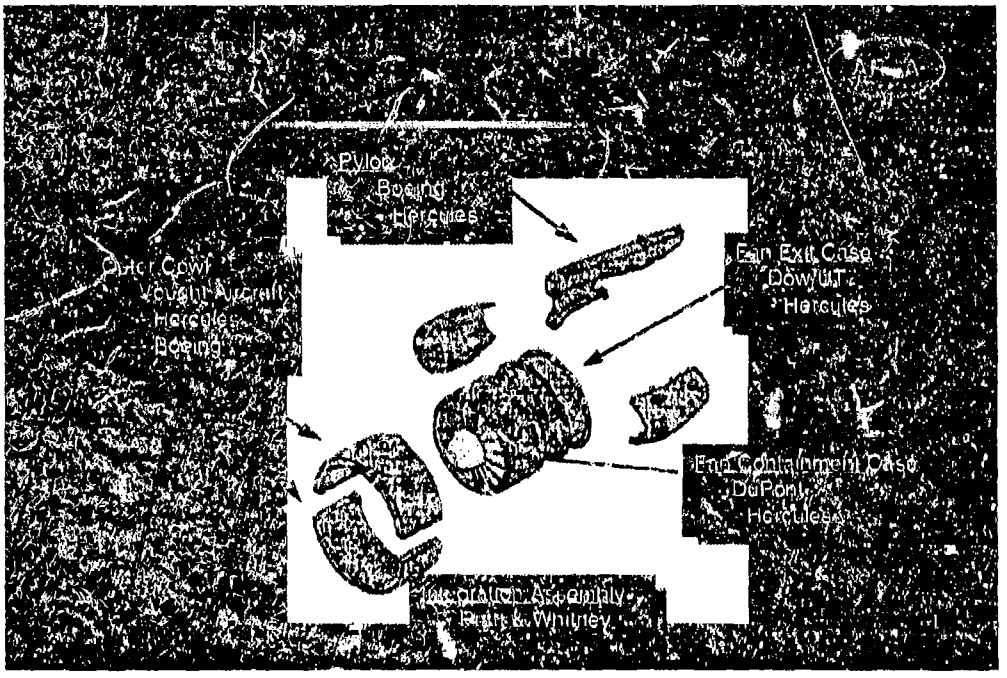


Now I'll discuss two PMC programs that have been funded by the Technology Reinvestment Project which you are all familiar with. They were both first round awards.

The Affordable Composites for Propulsion or ACP program is an effort led by Pratt & Whitney to increase the use of composites on large transport aircraft engines. A five year agreement was signed last May to accomplish this goal. The total amount of the agreement is $370M with $130M coming from TRP funding. The first year TRP funding is $25M.

The ACP team is vertically integrated in that it spans the entire food chain, from material suppliers to commercial airplane builders. Thereforein addition to demonstrating composites for the ADP engine, the program will benefit the subcontractor base which supplies composite materialsand structures to other applications.

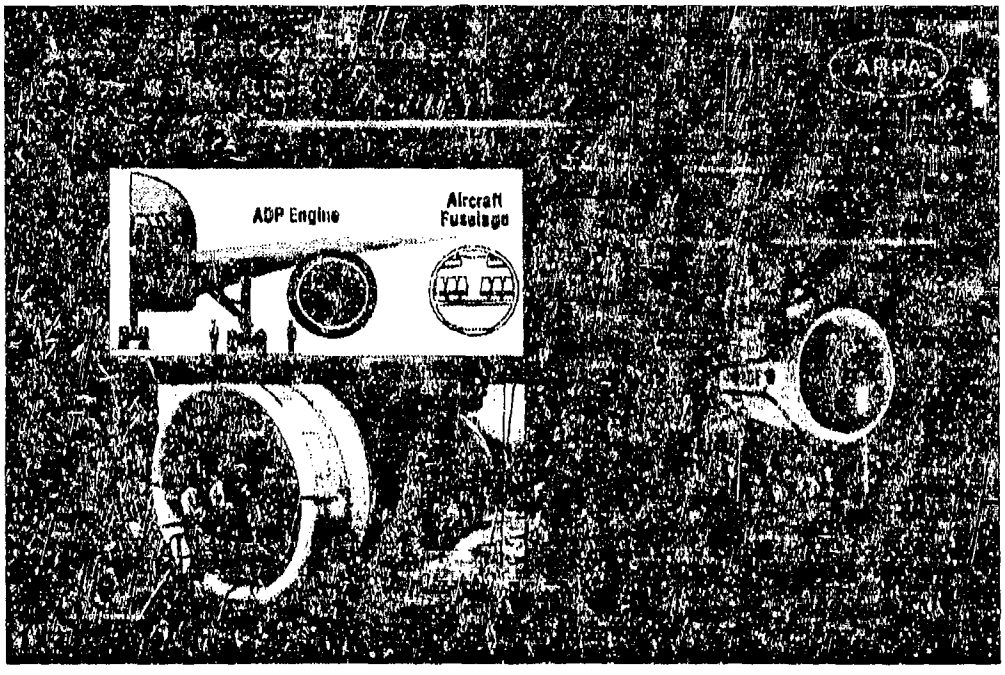
The key to increasing the use of composites is demonstrating their affordability in the desired application. The ACP team's approach is to develop part designs based on low cost manufacturing processes.



This schematic shows the various components of the ADP engine which will be addressed by the team during the ACP program. The fabrication process which are currently being considered for these structures includes fiber placement, filament winding, and resin transfer molding.

In order to determine whether or not you are affordable, you must have a baseline which to measure yourself against. Therefore one of the first tasks for each of the component IPD teams is to establish what the component would cost today using state of the art composite and metallic processes. This cost will become the target to which we will measure our success.

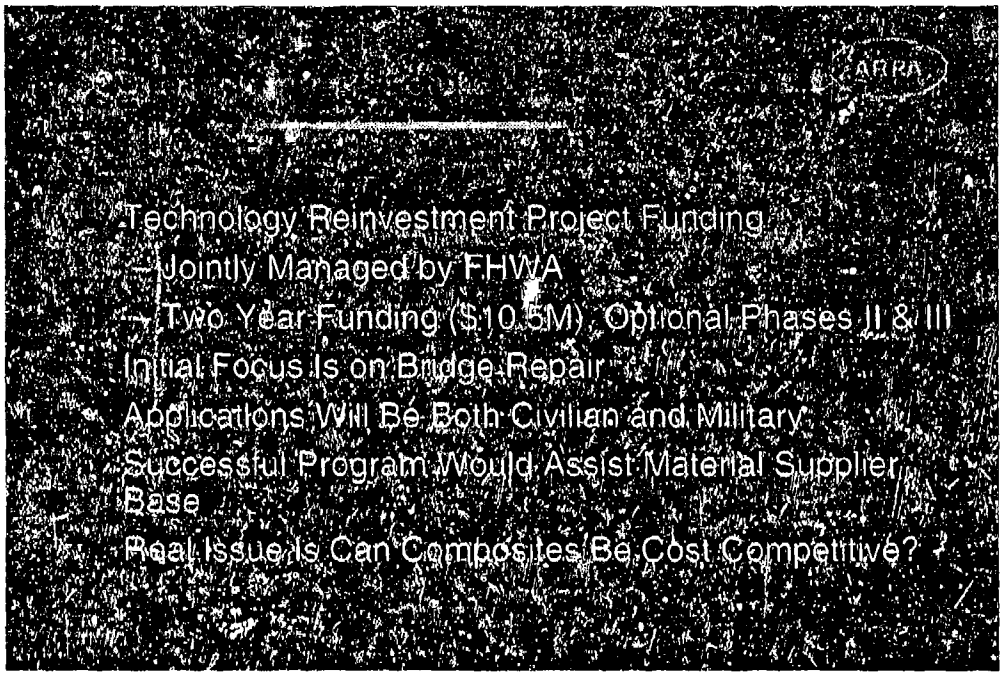
Another key element in demonstrating the affordability of composite structures is building enough articles to have confidence in both the cost of the component as well as the repeatability of the process. The ACP program will address this by building a significant number of components early in the program.



This gives you an idea of the size of the engines we are talking about. The large thrust class version of the ADP engine is as large as a 757 fuselage.

These large ADP engines will improve the operating efficiency of the airlines as well as being more environmentally friendly.

However due to their size, the use of conventional metallic structure would be weight and drag prohibitive. Therefore affordable composites will be key to their ultimate success.



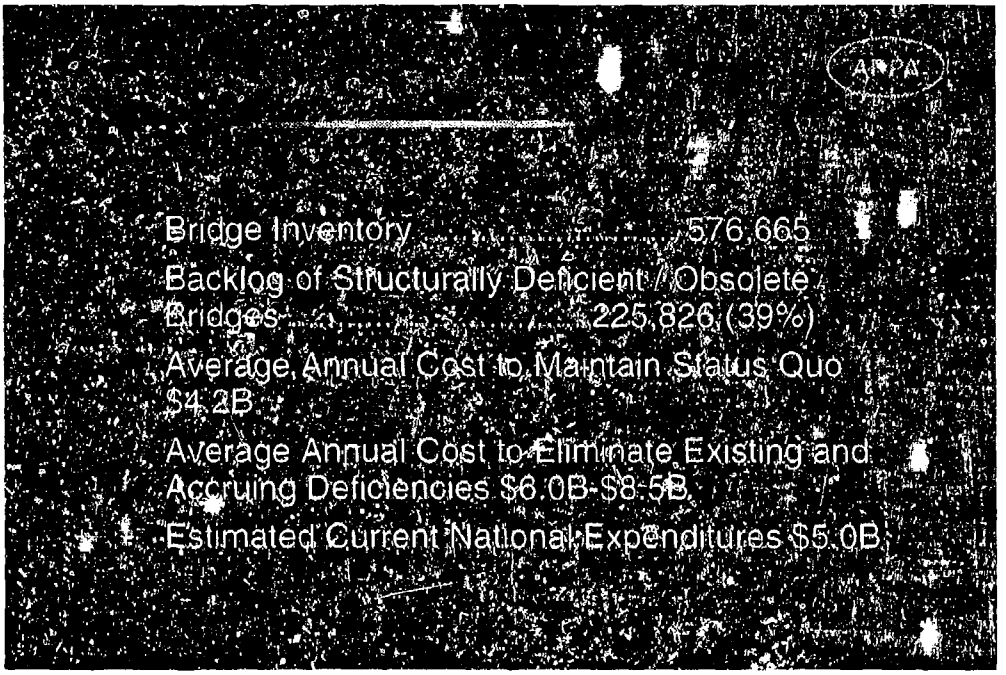
Another TRP program with a PMC emphasis is being led by the University of California, San Diego (UCSD). This program is aimed at developing and demonstrating the application of PMC to help solve the nation's infrastructure problem.

The program agreement for $21M half of which is from TRP funding was signed last June. The program will be jointly managed by the Federal Highway Administration (FHWA).

The initial focus of the program is on bridge repair however the work on the components will be applicable to new construction as well. It will also demonstrate the applicability of composites for Army bridges.

A successful program would greatly assist the PMC material supplier base problem.

As with many PMC applications, the technical feasibility of using these materials is not an issue, their affordability in infrastructure applications is the real issue.

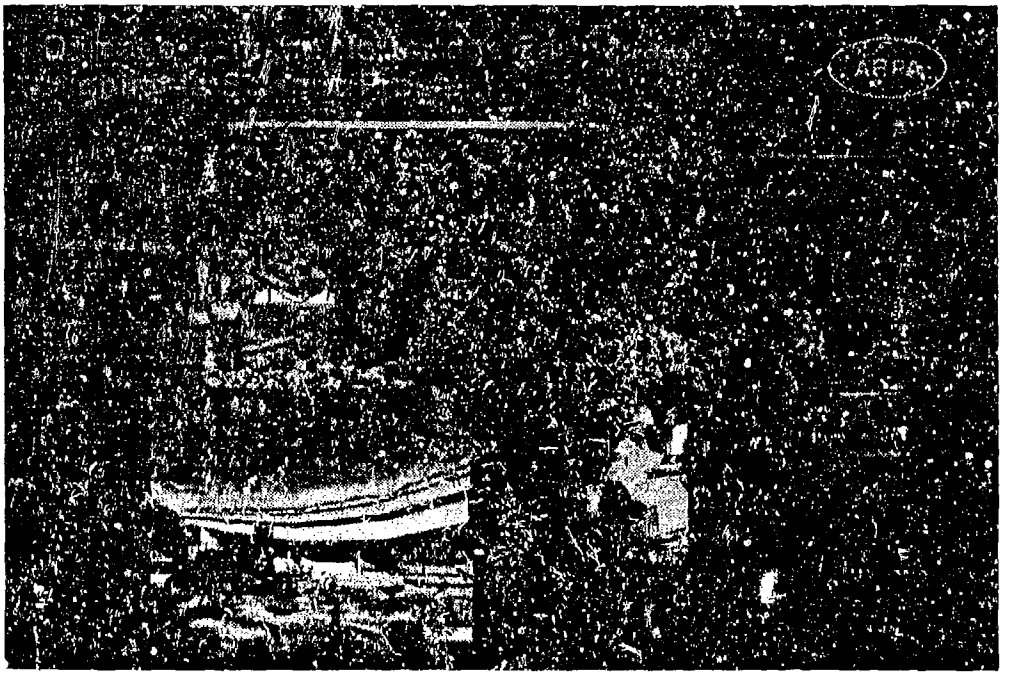


Before discussing the program further, I'd like to show you the status of our nations bridges so can better appreciate why we're doing this. This data comes from a study done by the FHWA and GAO .

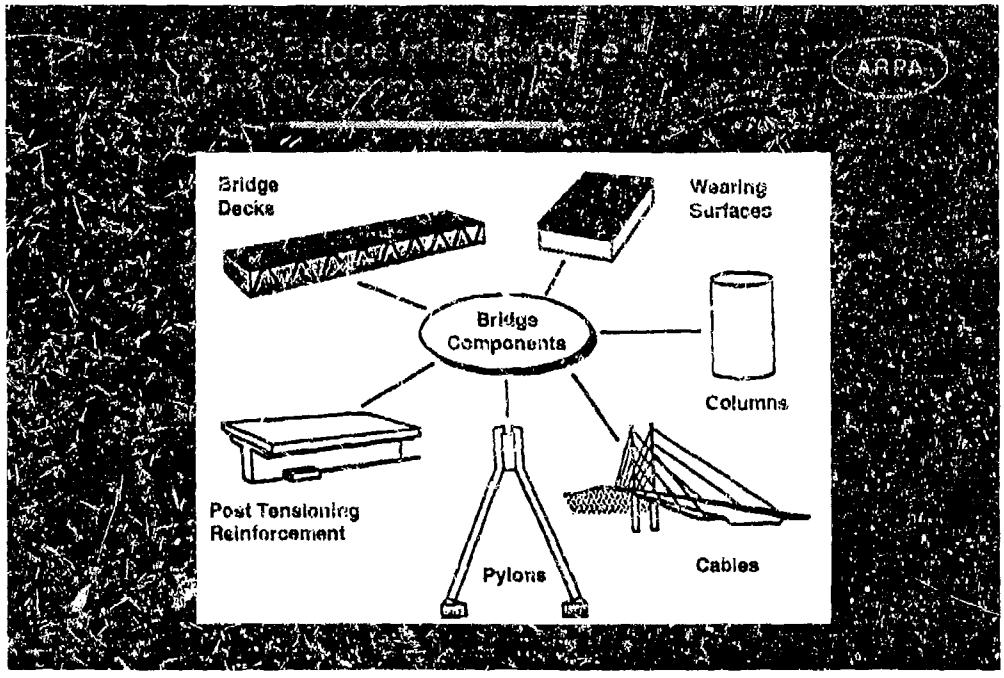
As you can see roughly 39% of our bridges are structurally deficient or functionally obsolete.

The financial figures show that we must clearly find a way to reduce this deficient backlog.

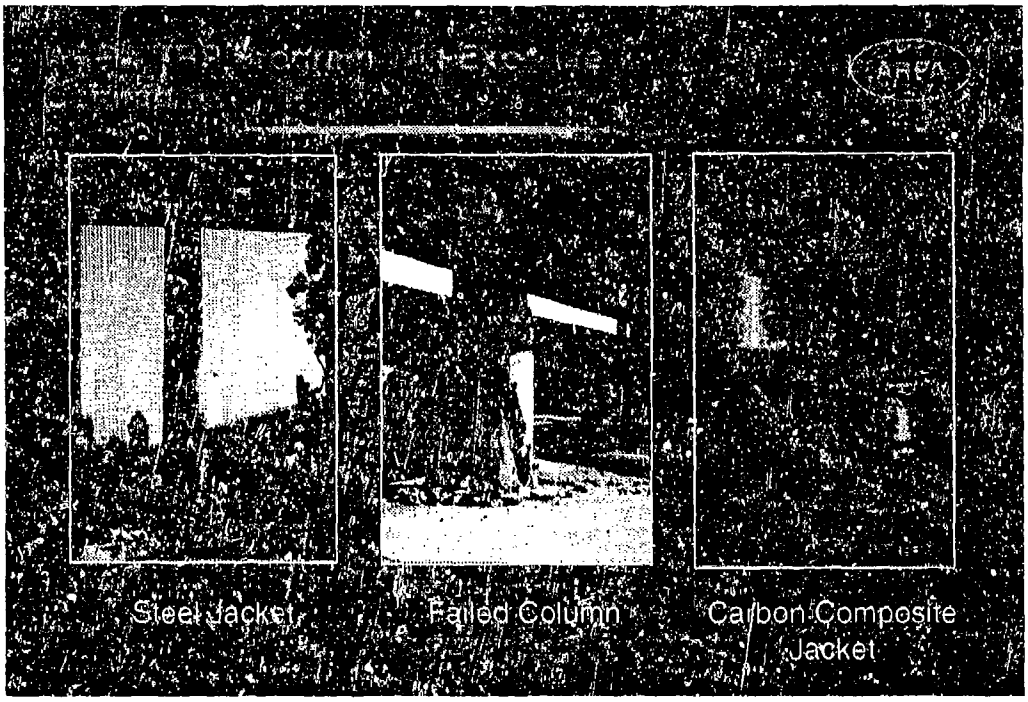
PMC's may offer a way to do that, both in terms of lowering the cost of bridge repair and speeding up the process. PMC's are also expected to lower the maintenance required to maintain the bridge.



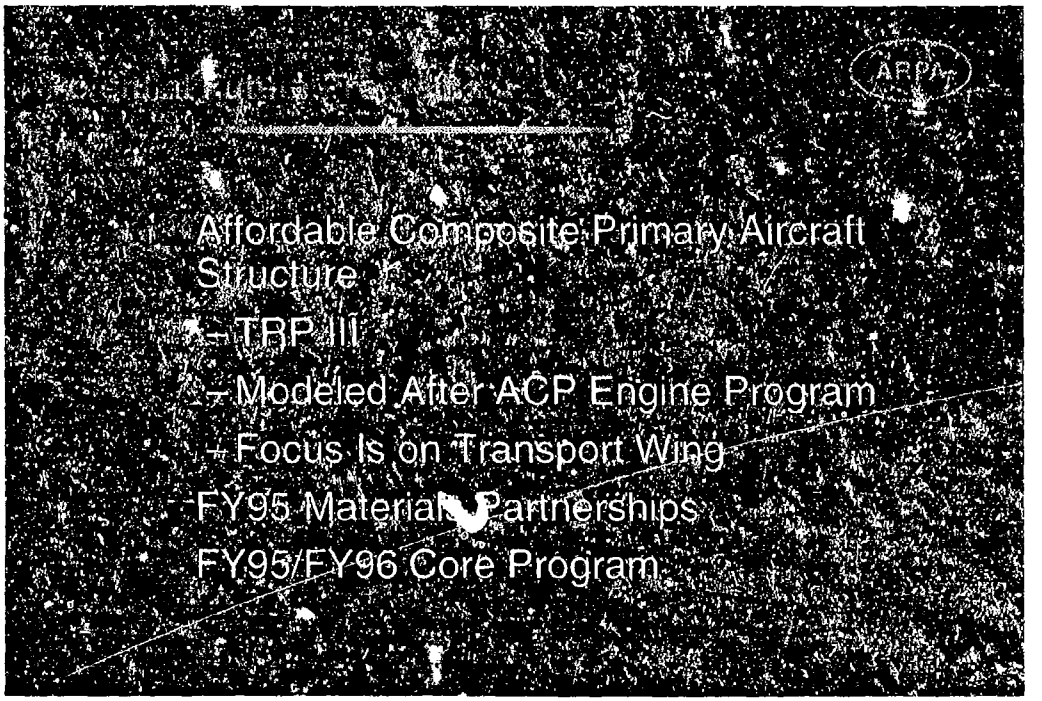
A magnitude 6.8 earthquake occurred in Northridge about 30 km north west of downtown Los Angeles on January 17. The earthquake caused widespread damage to the region north and west of the city. The most dramatic, and most quickly identified damage , occurred to freeway bridges, with nine collapsed structures. The failed columns and deck shown here were on the Santa Monica Freeway or Interstate 10.



Here we show the bridge components that will be studied in Phase 1. Although we will look at all of these the focus will be on columns and bridge decking. A significant amount of full scale hardware will be manufactured and tested in the first 18 months.

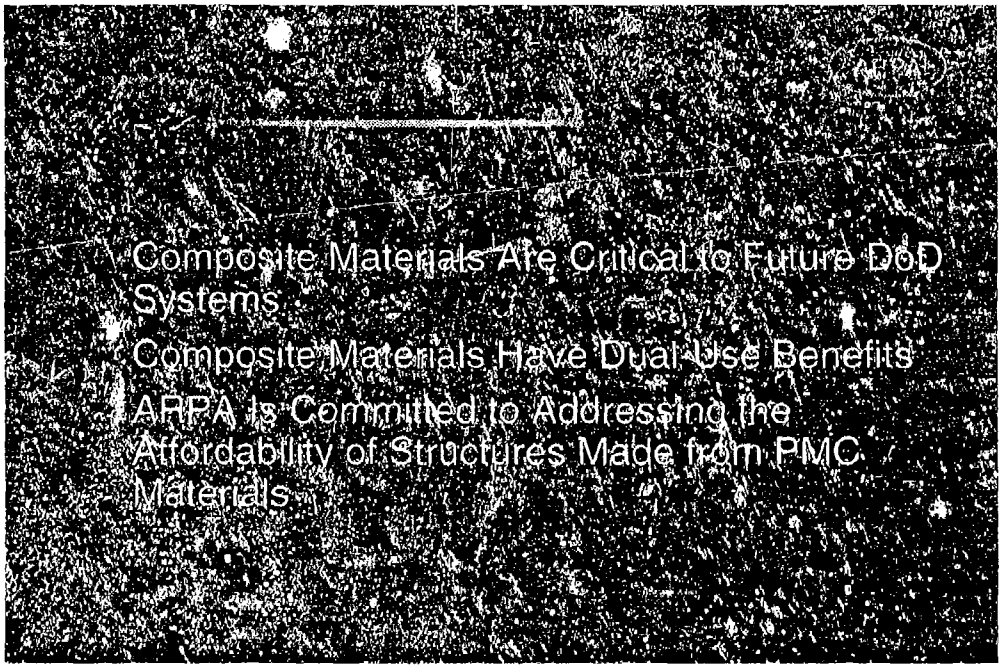


Due to need created by the January 17 earthquake a composite solution to column retrofit will be given a high priority and expedited. The failure during an earthquake is caused by lateral movement in the column and not enough circumferential rebar to keep the concrete from spalling and the the column fails in compression. A repair procedure with steel jackets had been developed and installed on all high risk columns in Los Angeles area. One is shown in the picture on the left. In fact this bridge is just to the west of the two bridges that failed on the Santa Monica Freeway one of which is shown in the center.. We are working on a composite overwrap shown on the right that we believe will have several advantages over the steel jacket including a cost advantage. We plan to have a good assessment of this approach by the end of this year.



Regarding future programs we anticipate a focus area in TRP III on affordable Composite Primary Structure for a transport aircraft . We envision a companion program to the engine program but working on a composite wing for a commercial transport.

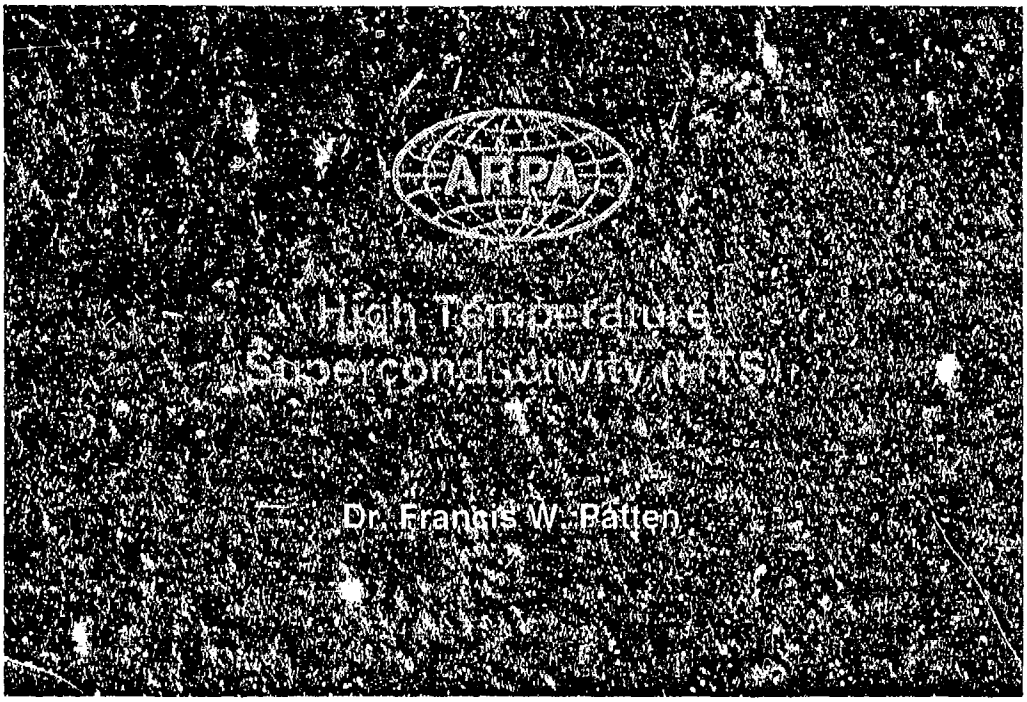
We also will be soliciting ideas for our FY 95 Material Partnership Programs. and we may be expanding our core programs in FY 95 .

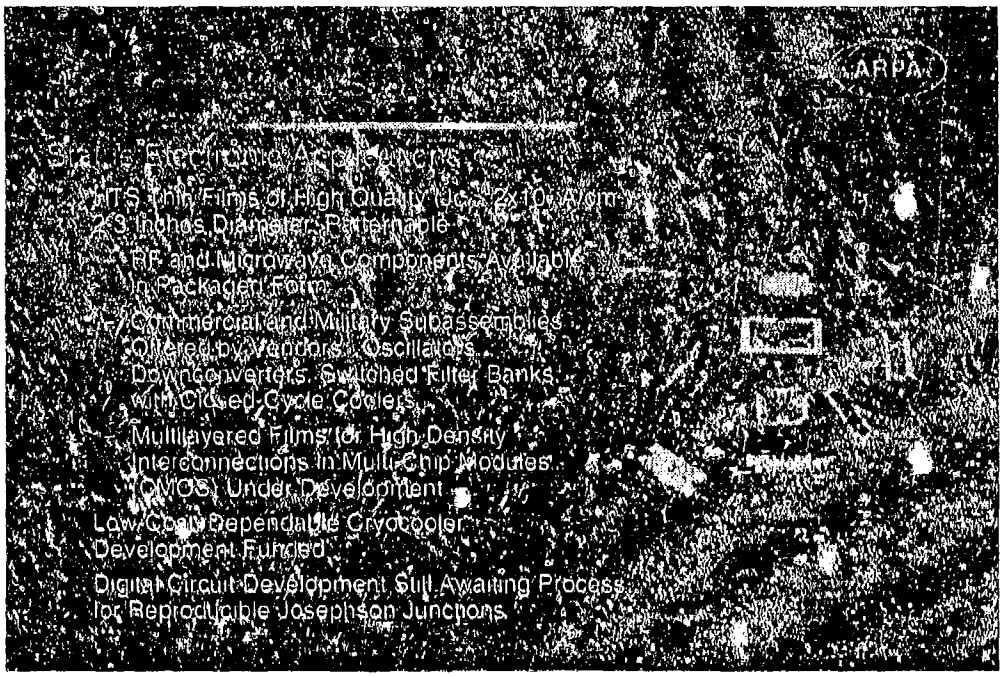


So in summary even though DOD's usage has been significantly reduced. Composites are still important to future DOD systems.

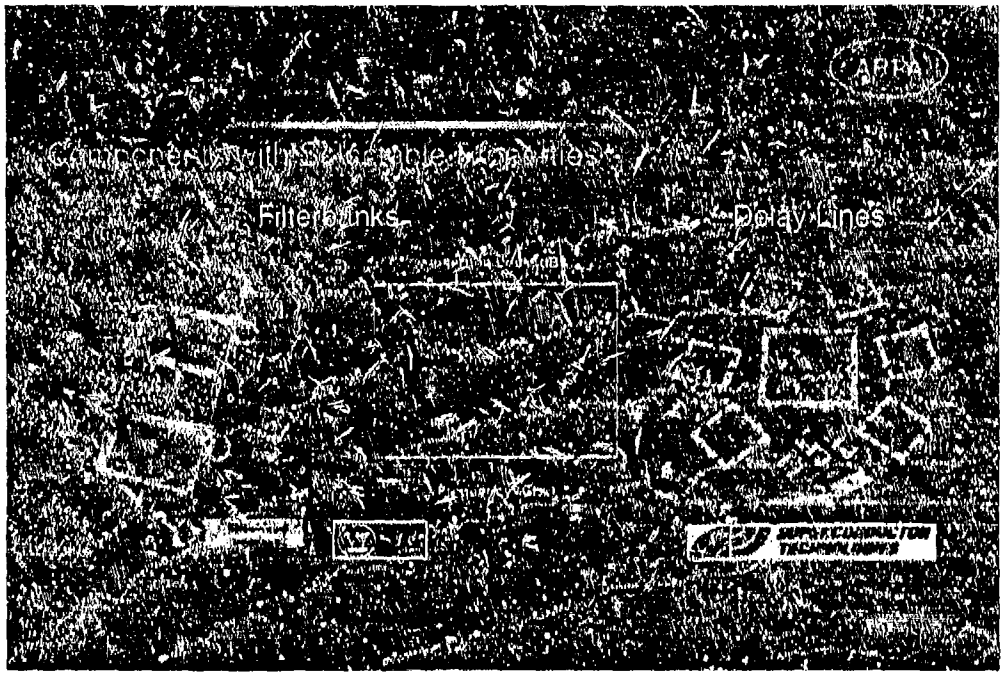
Composite materials clearly have dual use benefits.

ARPA is committed to addressing the cost issue of composites and has a solid strategy in place and significant funding committed to this effort.

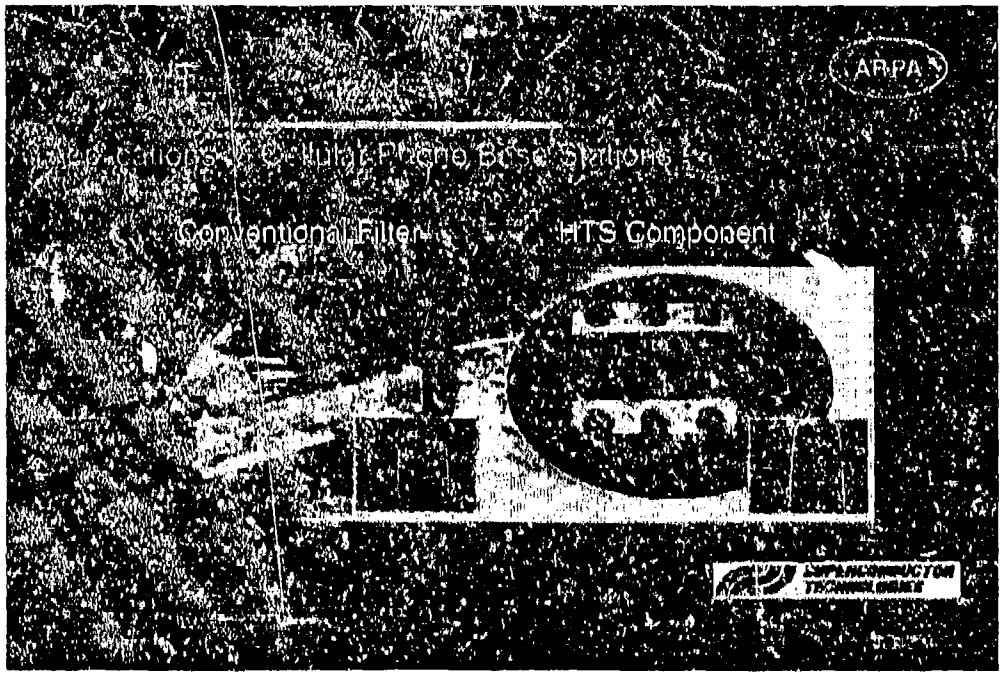

ARPA
High Temperature
Superconductivity (HTS)
Dr. Francis W. Patten



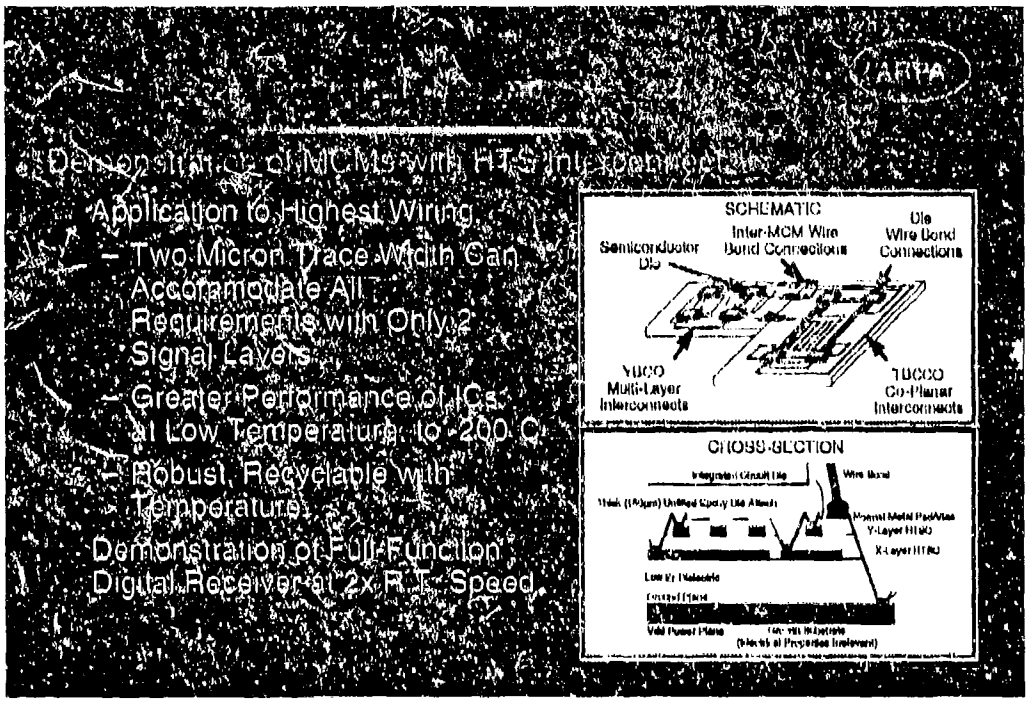
The ongoing ARPA High Temperature Superconductivity program has supported a large number of contractors, who have been able to produce high-quality films up to 3 inches in diameter for various applications. In particular, vendors of HTS components are marketing RF and microwave components in packaged form, as shown. Commercial and military subassemblies are being offered. Multilayered films also have been produced, for patterning as high-density interconnections of CMOS ICs, for cryogenic electronics. The infrastructure for these technologies is being developed, in particular the availability of low-cost, dependable cryocoolers.



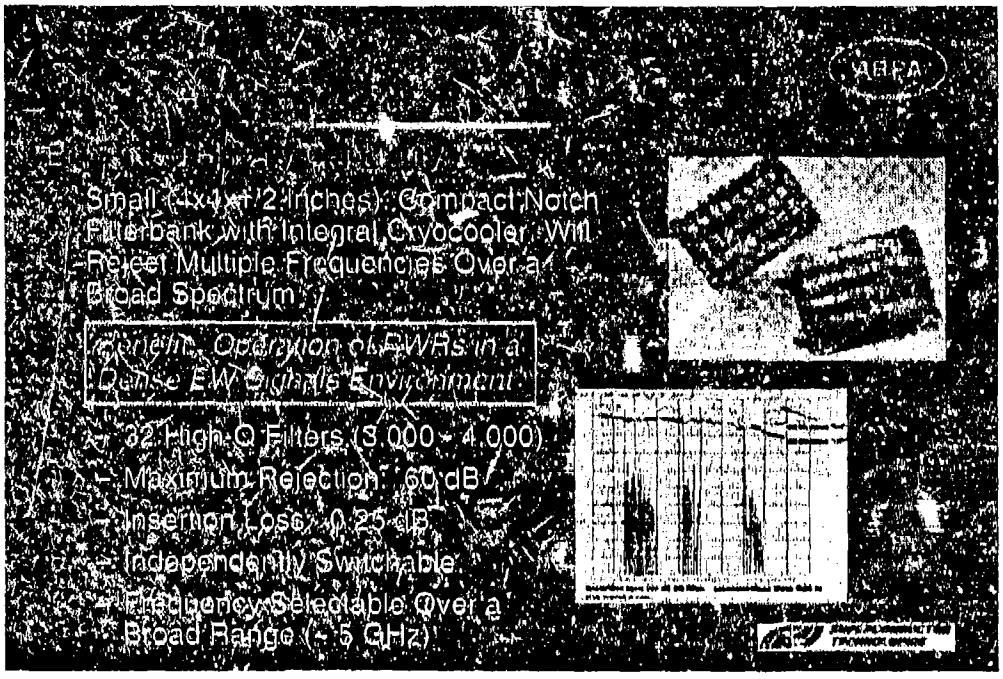
Shown are some components that are now available, with properties selectable by the customer. Filterbanks with specified properties, such as center frequency and bandwidth, can be fabricated and packaged. Delay lines with wide bandwidths, because of the almost dispertionless properties of superconductors, are shown in packaged form. Nonmilitary customers, such as the cellular telephone industry, will use HTS filters with optimal properties to replace much bulkier conventional filters in base stations.



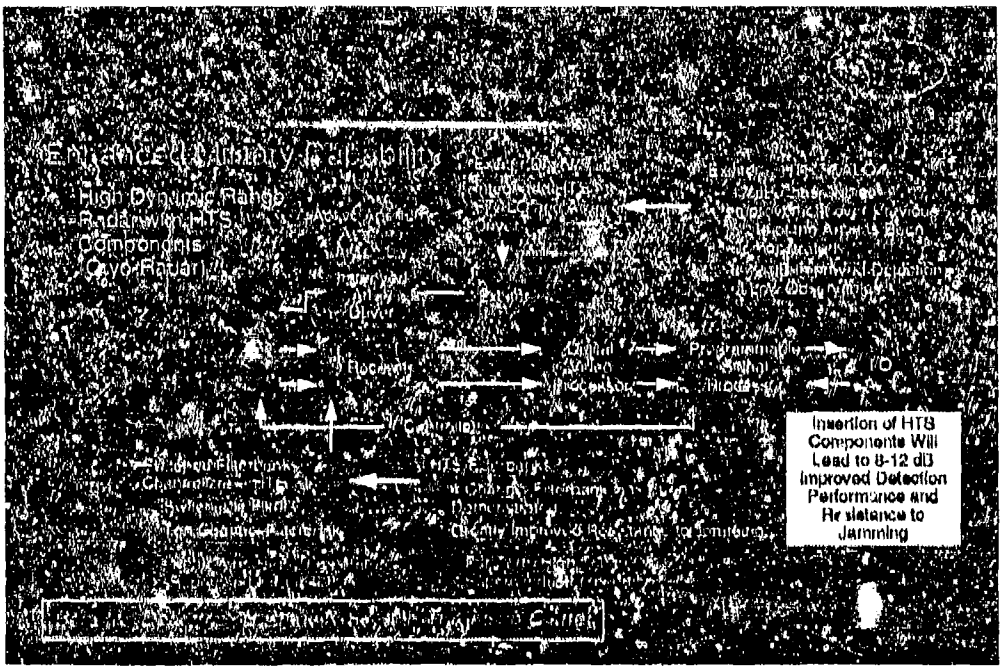
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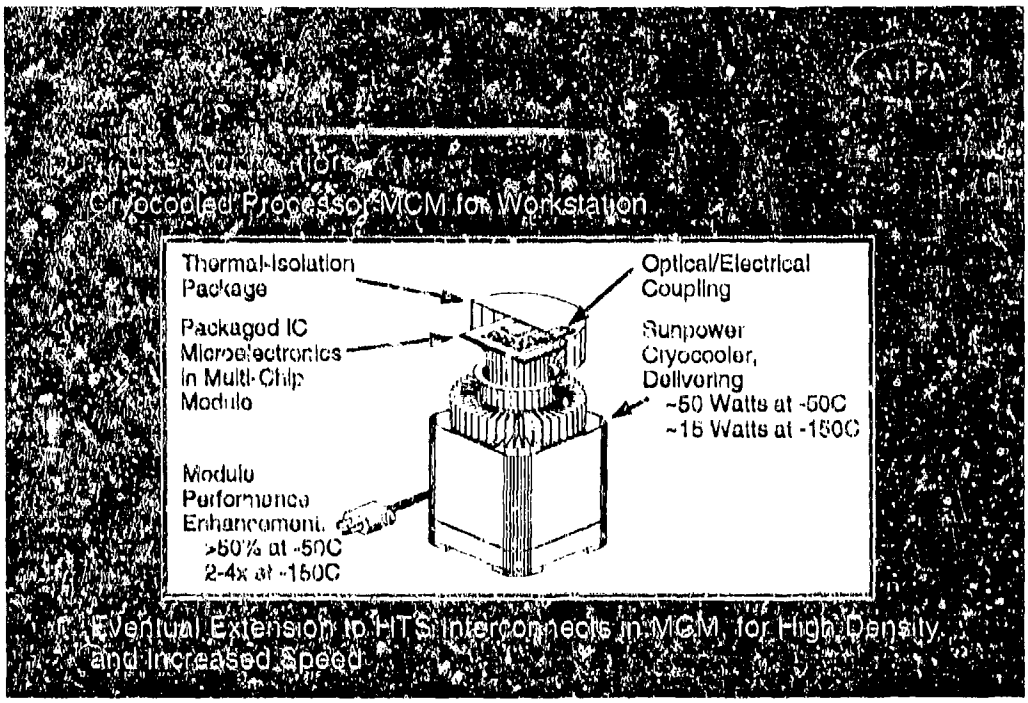
The application of HTS to conventional electronics probably will utilize interconnections for cases when the wiring density is very high, and narrow-width traces are required in order to limit the number of signal layers. HTS interconnects can sustain reasonable currents at 2 microns linewidth, more than an order-of-magnitude smaller than conventional metal. Most requirements, for up to 50-100 chips, can be satisfied with only two signal layers of HTS material. The low temperature required for HTS operation also leads to higher performance of the ICs, up to 2X the speed for CMOS, even without chip optimization. A demonstration of this technology will be a full-function digital receiver, which will operate at 2X the room-temperature speed.



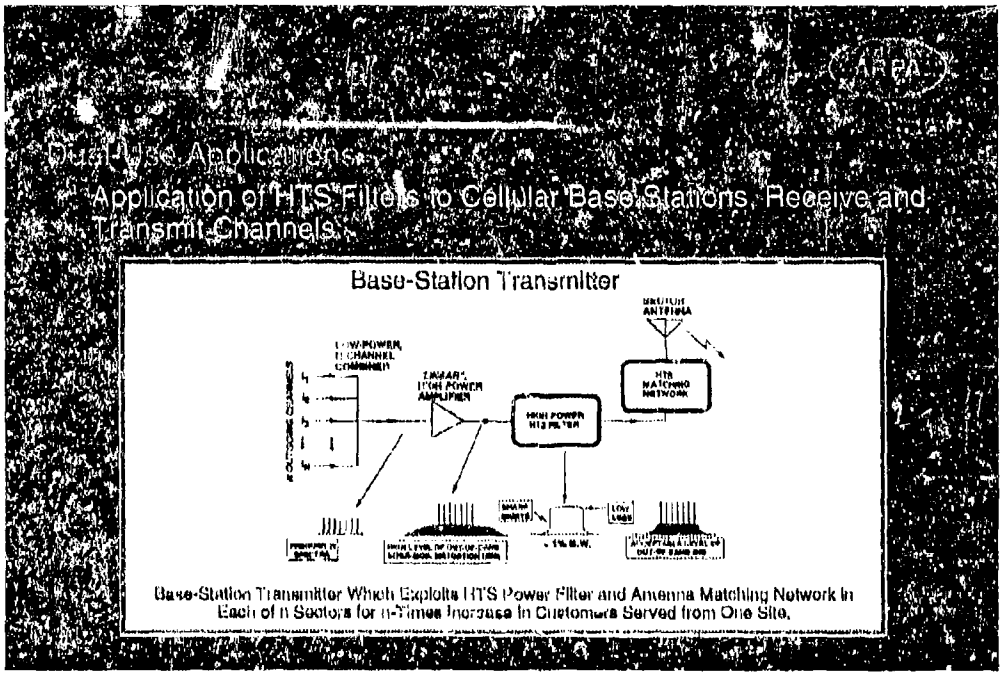
A 32-element switchable filterbank has been constructed of HTS materials, to provide for operation of radar warning receivers (RWR) in aircraft within a dense spectrum of electronic warfare signals. This compact package will be inserted in the front end of a RWR, and will allow operation in the presence of external jamming, as well as interference from the aircraft's own radars. The filterbank is fabricated to conform to all projected threats, with independently switchable notch filters providing 60 dB maximum rejection, with 0.25 dB insertion loss.



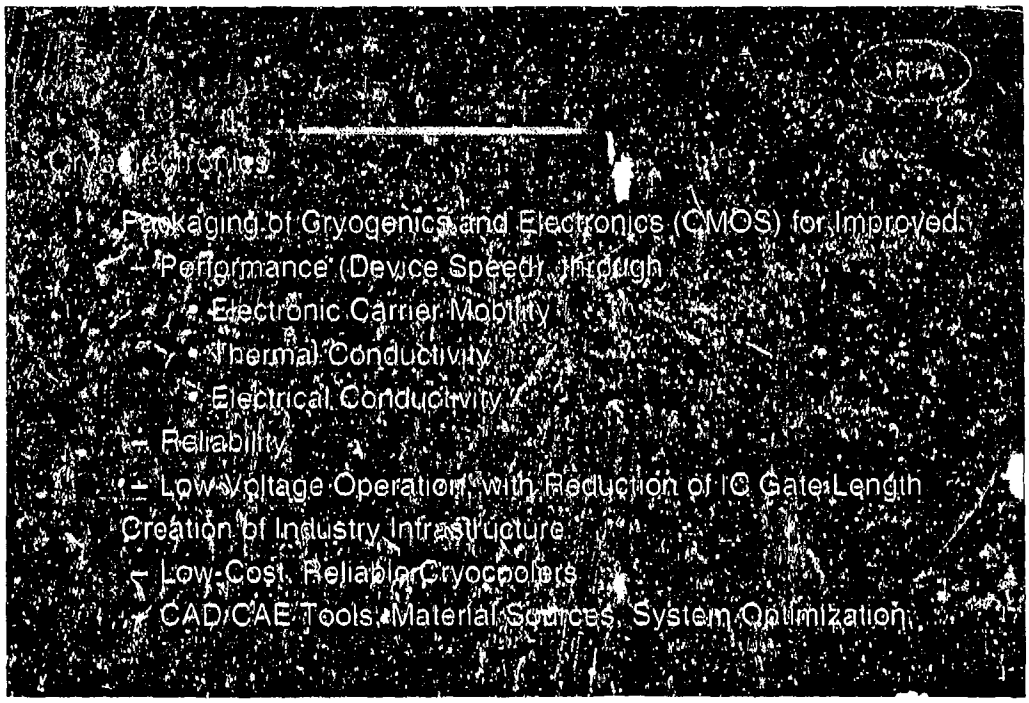
Superconducting components are being developed for insertion into a radar, whose immediate application is shipboard self-defense. An ultra-high Q cavity (3x107) will provide a reference signal with 30:1 improvement in phase noise (at 1 KHz offset), resulting in >10 dB improved detection performance. HTS switchable filterbanks in the receive channel will provide resistance to jamming. Ultimately, the digital processor will be replaced also by HTS cryoelectronic modules.



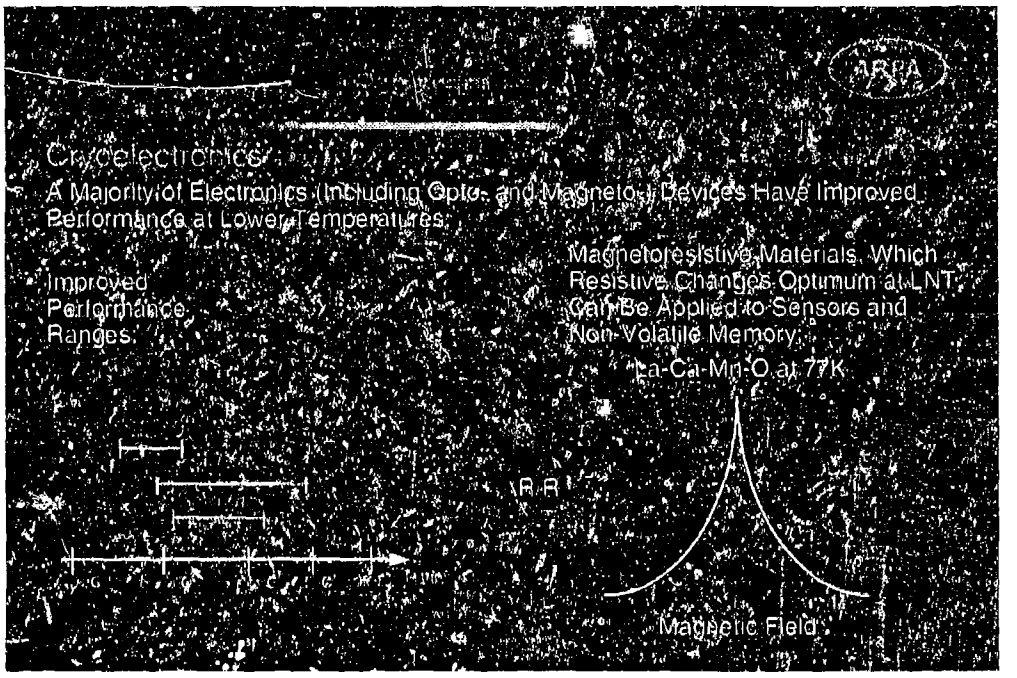
A program has been initiated with a workstation vendor to provide a cryocooled microprocessor package in a near-term model. The first phase of the program will demonstrate operation at -50C, which will allow 50% enhancement in speed. Subsequent phases will demonstrate lower temperature operation, with concomitant performance improve-ment, ultimately to full implementation with HTS interconnections.



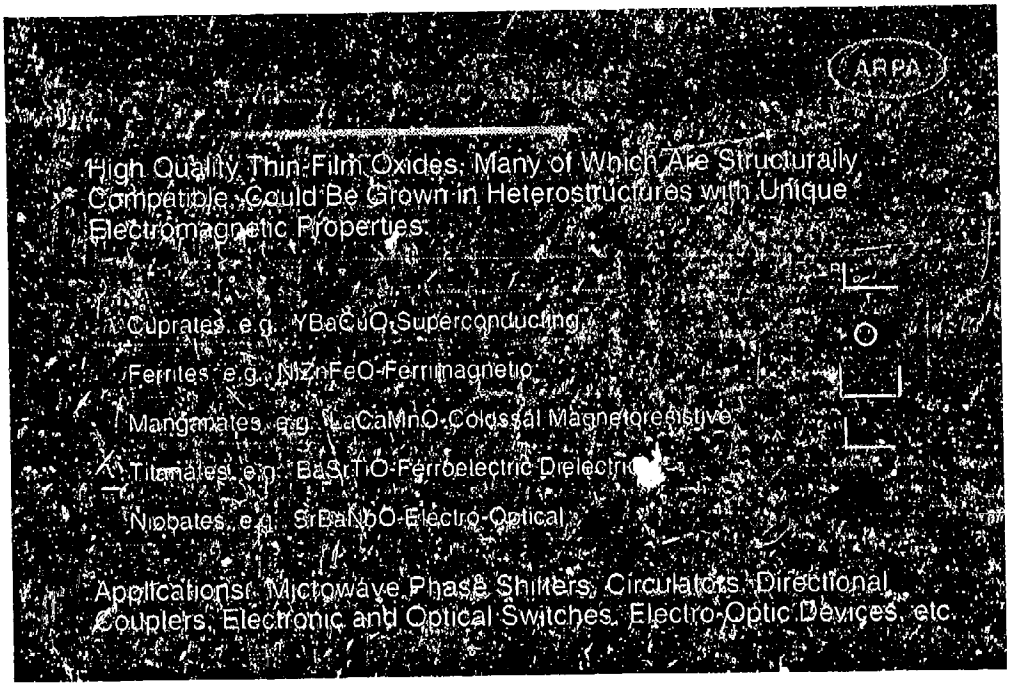
A high-volume commercial application of HTS filters will be to cellular telephone base stations, which require a number of large, high quality filters in the receive channel. High-power HTS filters also can be applied to the transmit channel, to limit the amount of intermodulation distortion due to nonlinearities in the amplifier.



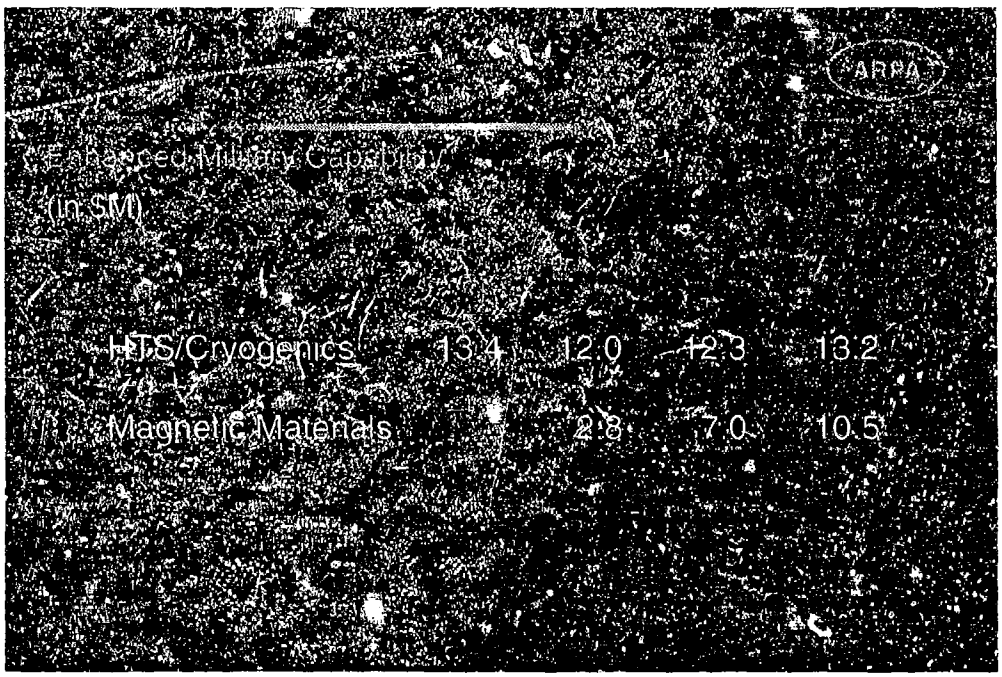
It is expected that cryoelectronics projects will be funded for applications involving cold CMOS with improved performance and reliability. As devices tend toward lower voltage operation, along with reduction of junction gate length, it is likely that low temperature operation will improve performance further. In addition, it will be necessary to fund the development of low-cost and reliable coolers, as well as other aspects of the infrastructure for supporting this technology.



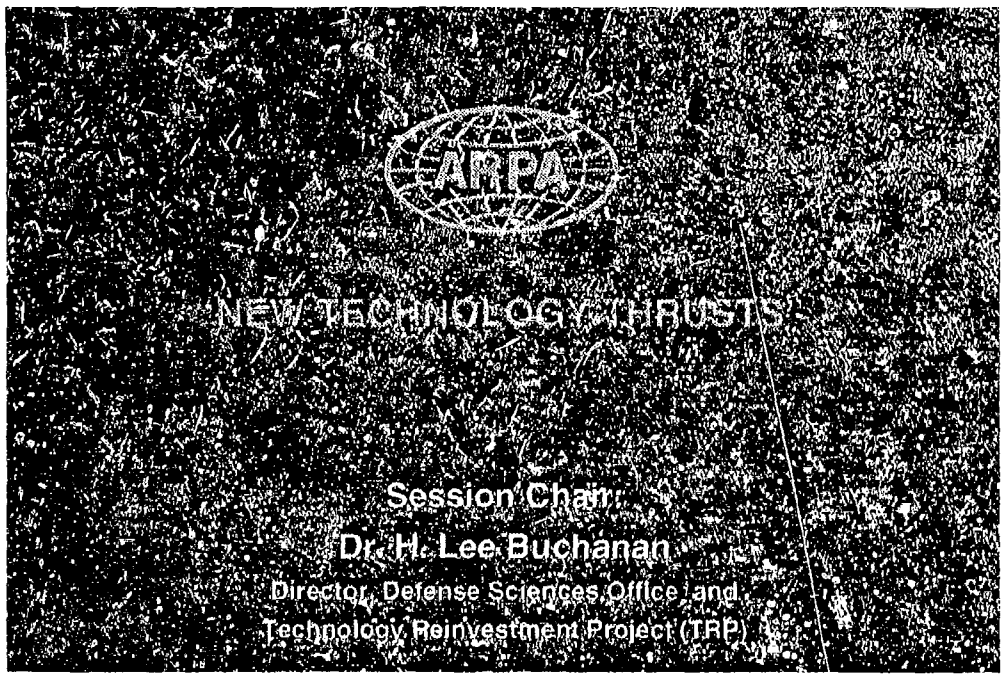
It should be noted that many electronic devices have improved performance at low temperature. Recently, a class of oxide materials has been shown to have "colossal" magnetoresistive properties which optimize at low temperature, and can be applied to sensors and non-volatile memory.



Since these and other oxide materials are structurally compatible, it would be conceptually possible to build thin-film heterostructures as shown in the figure, with unique properties adaptable to many applications.

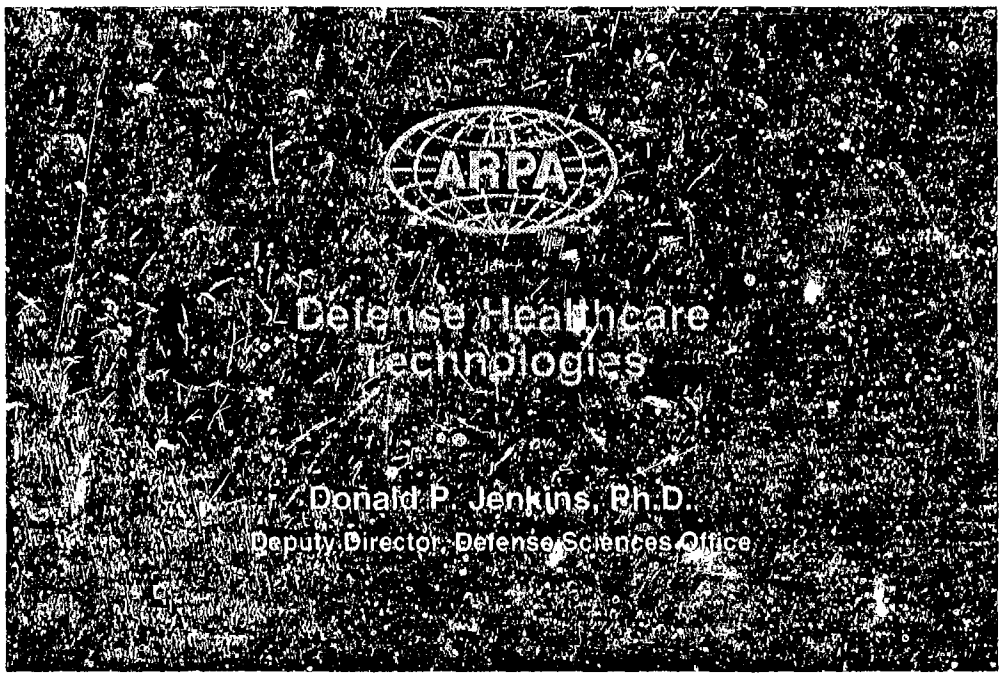


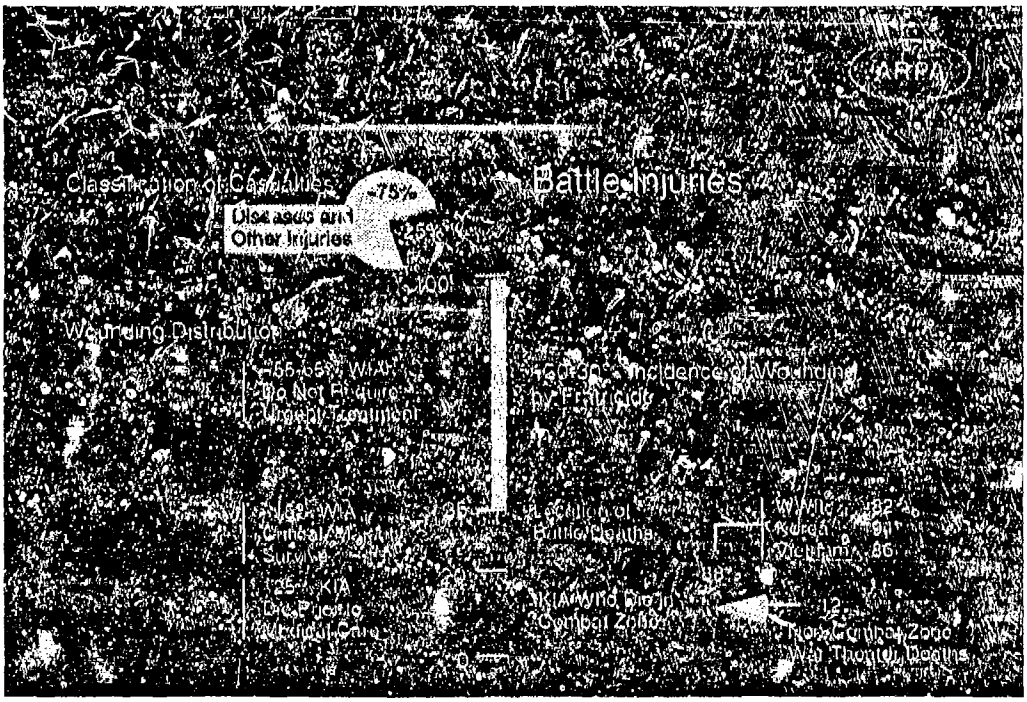
Continued ARPA funding for the HTS/Cryogenics program is shown, along with a new start in magnetic materials and devices.



Theme:

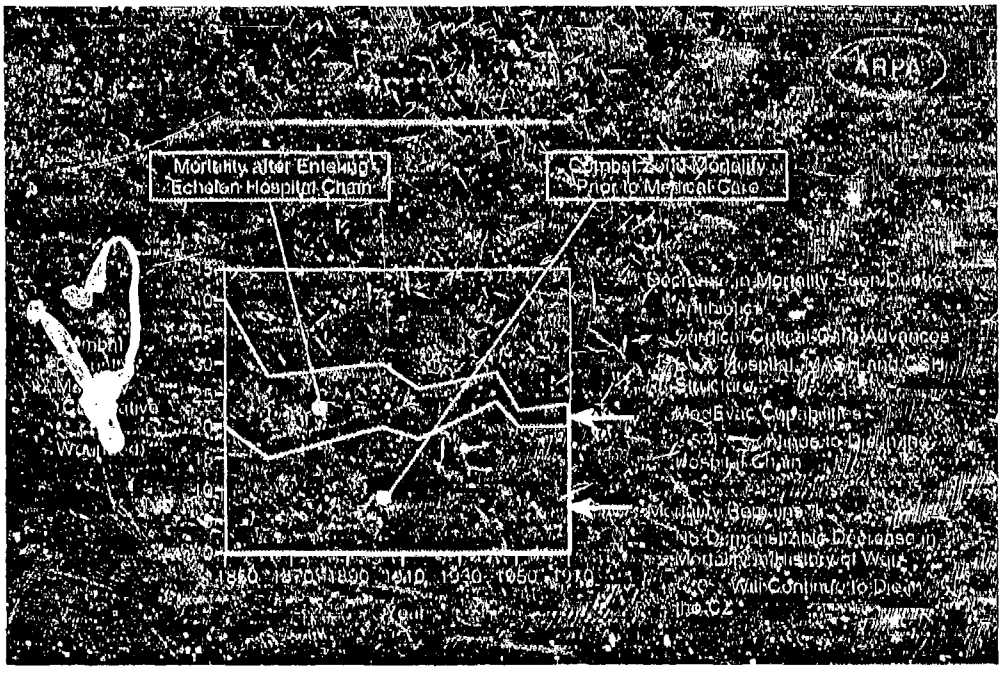
New technology programs being initiated in ARPA are under a set of guiding principles: to cause a fundamental change or to focus on critical areas that will have the greatest impact for defense and for the economic well being of the Nation.


ARPA
Defense Healthcare Technologies
Donald P. Jenkins, Ph.D.
Deputy Director, Defense Sciences Office

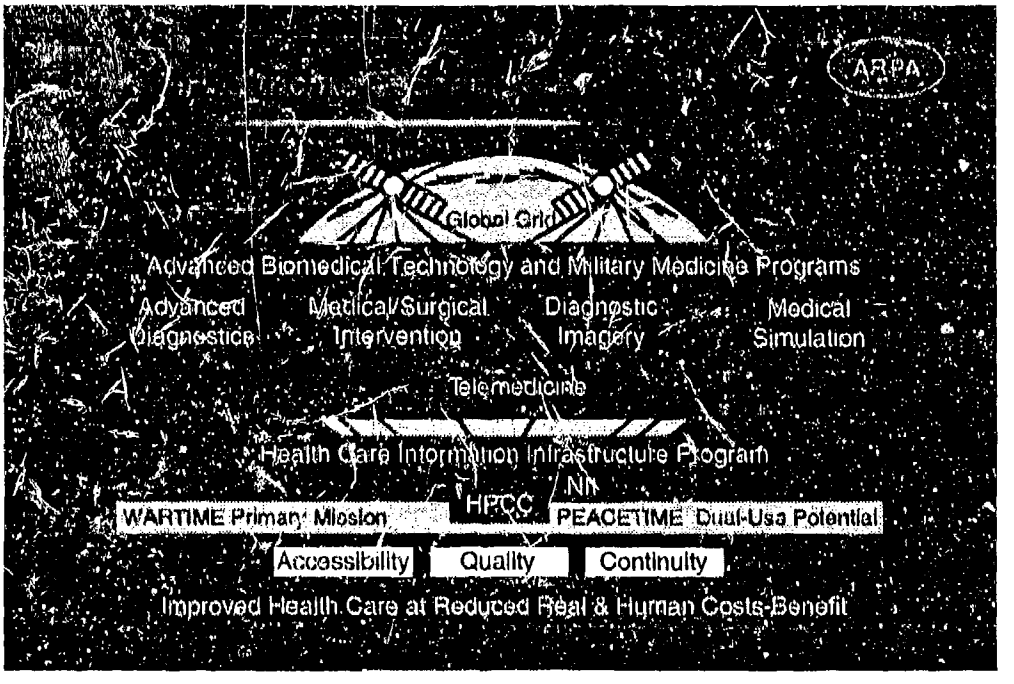


ARPA has initiated medical programs within the Defense Sciences Office (DSO) under the division entitled Defense Health care Technologies.

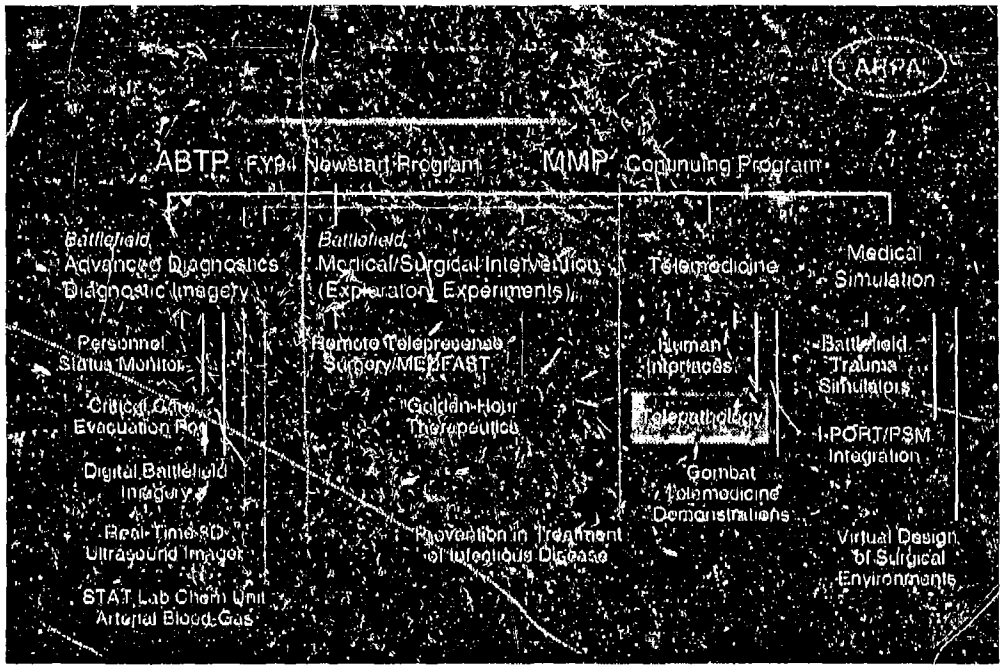
Casualties in the theater of war are classified in one of two categories: 1) as diseases and other injuries, and 2) injuries due to penetrating munitions, including blast or burn injuries, within the combat zone. About 60% of those wounded in action do not require urgent treatment and return to duty in a relatively short period of time. About another 15-20% of those wounded in action are usually critical casualties, with the majority of this category of casualties surviving. Another 20-25% are those who are killed in action and die prior to the arrival of medical care, similar to the distribution indicated in the previous figure.



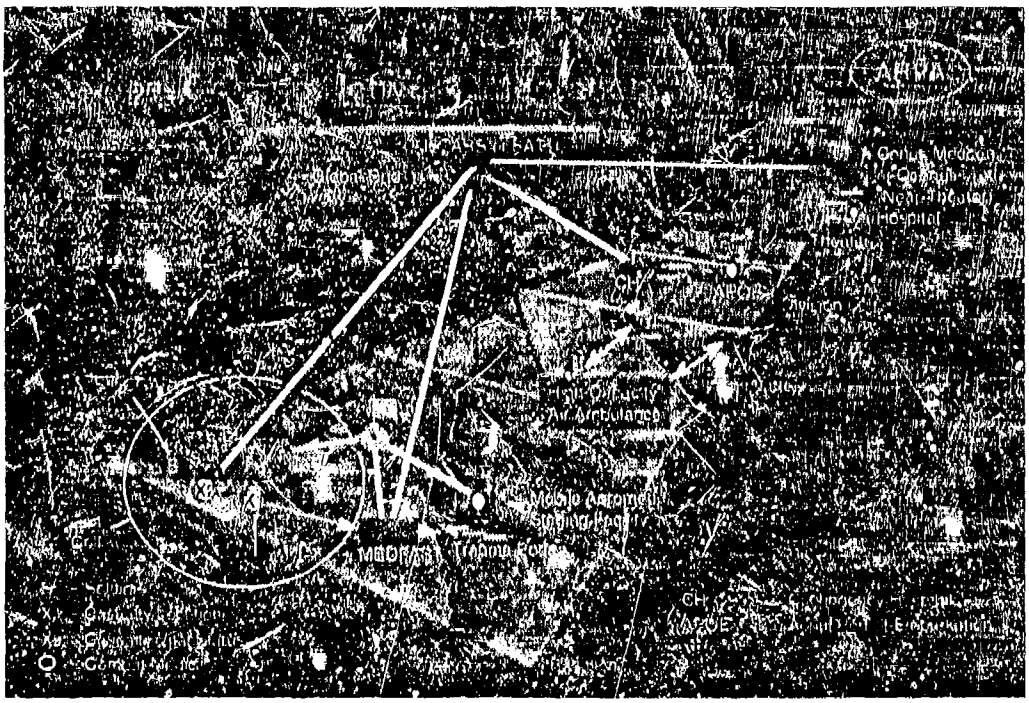
This figure describes that in the past 150 years combat mortality for casualties who have not received medical care has substantially remained unchanged. Combat mortality of those who do receive medical care in the theater of war, in contrast, due to surgical capability and the discovery of antibiotics, has decreased from about 20% in 1850 to approximately 3.5% in 1970. The concentration of the ARPA medical programs will focus on far-forward combat casualty care for those casualties who normally die within the battlefield, those killed-in-action.



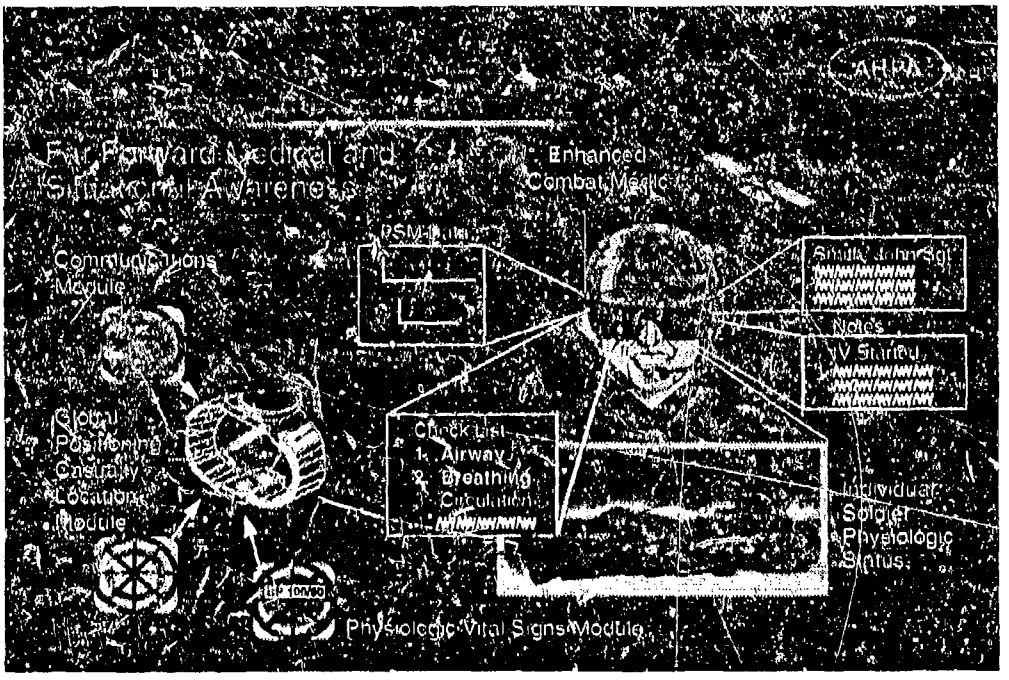
The Defense Health care Technology program effort consists of several independent programs which integrate together to form a comprehensive casualty care program for the battlefield. These programs will concentrate on the following research and development areas: advanced diagnostics, medical and surgical intervention, diagnostic imagery, medical simulation, and the incorporation of work from the Health care Information Infrastructure Program of ARPA. Coupled with other DoD- funded work in the evolution of the global grid utilizing asynchronous transfer mode, high bandwidth technologies, and coupled further with the national information infrastructure program and the high performance computing work ongoing, primary wartime mission focus with a dual-use peacetime health care system spin-off are the focal points of the programs . These programs concentrate on providing remote accessibility, quality, and continuity in the far-forward areas of the war theaters combat zone.



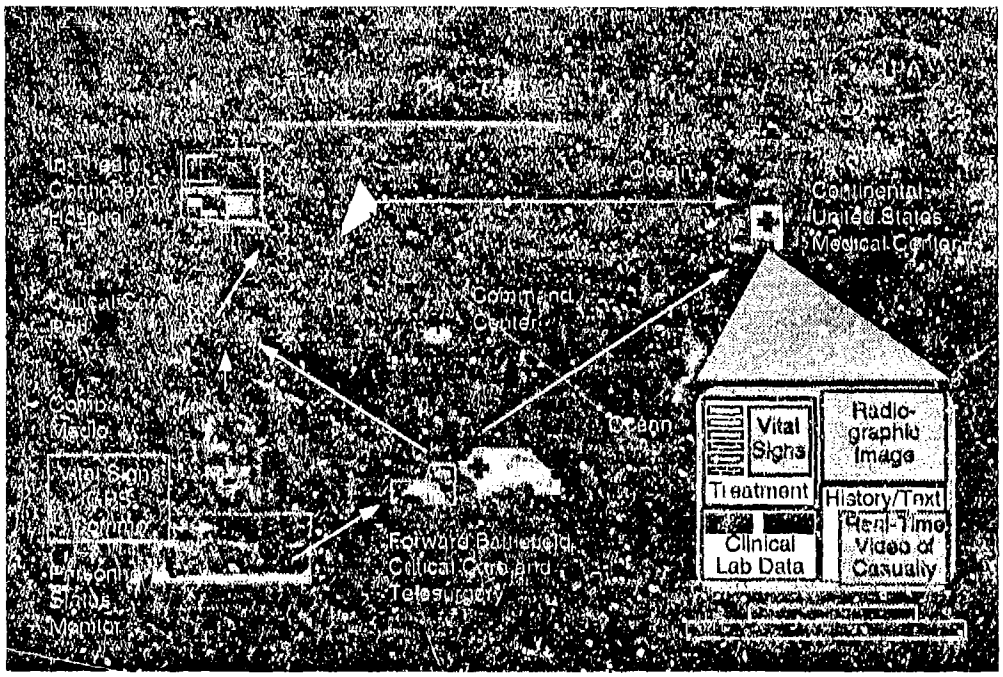
Within the research and development focus areas of the Advanced Biomedical Technology Program are several 1994 products being developed. First is the Personnel Status Monitor, a device to be worn by the individual combatant to start the train of remote biosensing from the individual soldier. A critical care evacuation pod will be the equivalent of a prenatal incubator within the combat zone destined to provide the capability of long-range medical evacuation of critical care patients formerly judged to be too critical for transport. Also to be developed are digital battlefield imageries that are portable and diagnostic for penetrating munitions and to provide real-time two- and three-dimensional digitized imagery that can be telemetered as the soldier casualty passes through the war theater medical echelon system. Also in development is a portable chemistry laboratory that is miniaturized so that certain blood chemistries and hematological determinations can be performed at the site of the casualty and in hospitals as well. In medical and surgical intervention, two areas of note are being developed. One deals with remote telepresence surgery so that within a mobile far-forward surgical unit would be the capability for a surgeon located in CONUS to perform actual surgery remotely in the battlefield. This is coupled with what is called "golden hour therapeutics" which is an exploratory research and development focus to determine if certain pharmacological combinations can actually produce a suspended animation state for a wounded casualty, despite the insult of tissue hypoixia, acute systemic shock, and exsanguination. Medical simulation is also a developmental area for the production of virtual reality simulators that can be used by trauma surgeons, combat medics, and nurses in the education and training for combat casualty care.



An intent of our program involving device technology and advanced health care information infrastructure is to enable more sophisticated medical communication networks. By the use of GPS and JSTARS or other means of centralized communication capability within the theater of war, the representative elements of the medical care system will be integrated together. This networking which will involve high-bandwidth broadband code division multiple access technologies, will allow the individual health care providers of the battlefield for the first time in the history of war actions, a communication architecture that provides an integrated communication network. Casualties that are being evacuated to medical centers or tertiary care medical centers either within the United States or in other countries, will in this system be electronically linked in order to provide the best medical care possible by advanced planning.



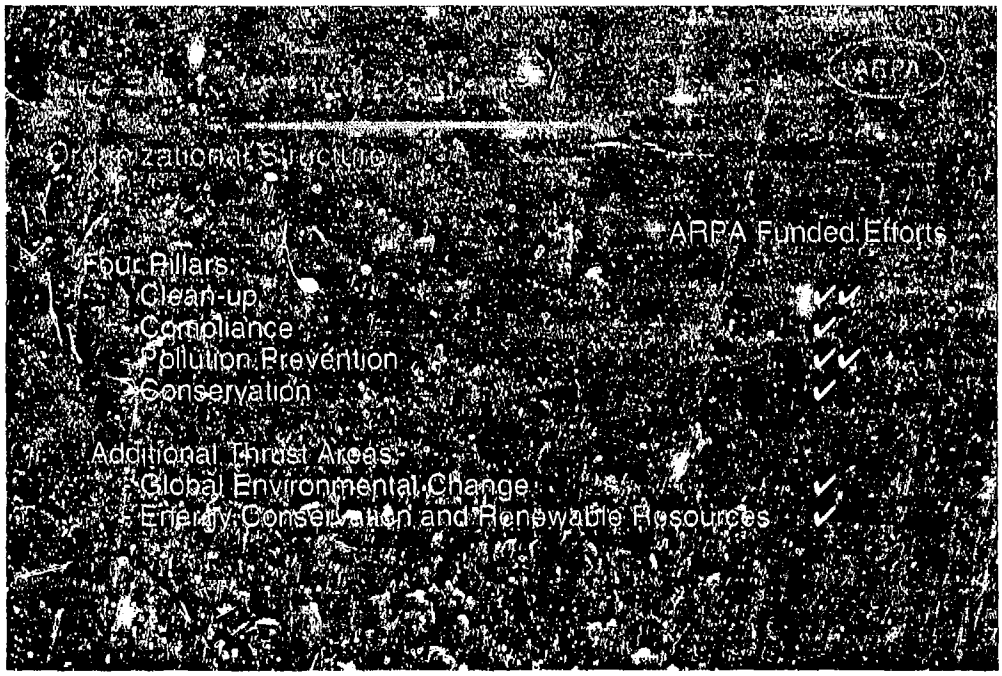
The Personnel Status Monitor will consist of a wristwatch-type unit which is built of modules that allow communication of data, a situational awareness from global position satellite data, which will also allow the location of battle casualties, and certain selected physiologic vital signs that allow remote triage as- a combat medic is en route to the location of a battle casualty. Furthermore, the combat medic's capabilities will also be enhanced by providing real-time video and simultaneous two-way audio communication to medical personnel located at a combat zone's command post. It is estimated that the combination of the personnel status monitor and the enhanced technology capability of the combat medic may reduce combat mortality to as great an extent as 40-50%.



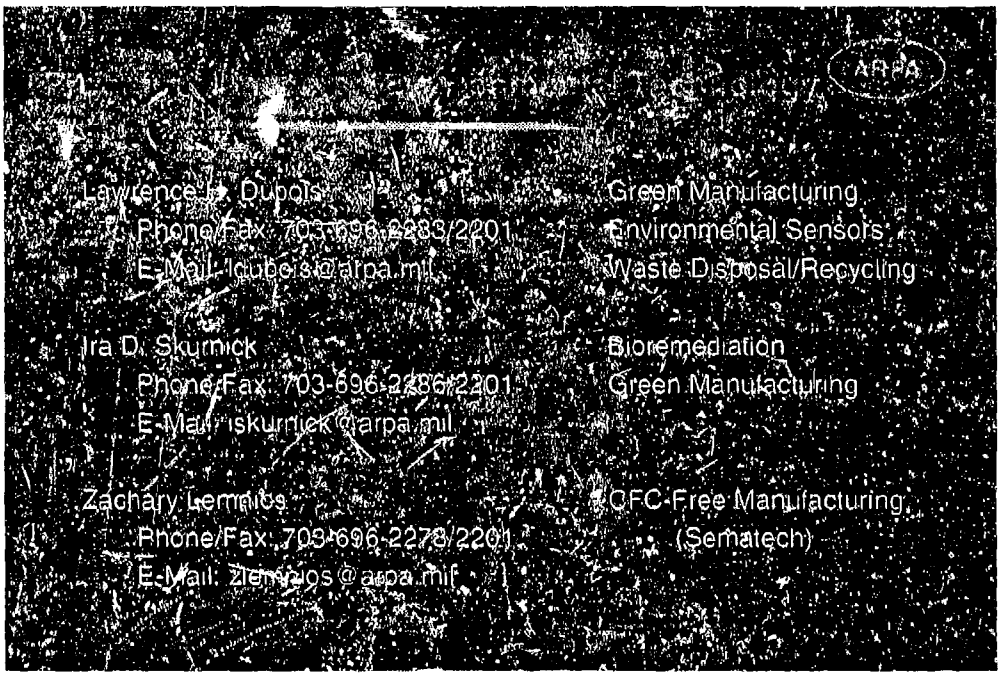
The overall integrated emphasis of the Defense Health care Technologies Program at ARPA is in direct partnership with the Army Medical Department and the Medical departments of the Navy and Air Force. While the ARPA programs build devices and technical capability, there is a system integration effort to allow a paradigm shift in the way that medical care is currently done within the battlefield. The prototypes and eventually fielded devices will form an advanced technology train of capabilities which will greatly enhance the ability of the tri-service medical departments to save lives in the modern battlefield. Fundamental to this is the ability to move data quickly and for the medical personnel to be mobile and remain in close proximity to the mobile fighting force. We anticipate also that the described technologies will have a profound dual-use technology application into peacetime military and civilian healthier systems. In particular, the application of remote telemedicine will greatly apply to civilian trauma, disaster, geriatric, and post- surgical medicine.



The Environmental Technology program at ARPA has been in place for less than three years, yet it has had a number of important successes. Today I will provide some background on the current program; try and give you the philosophy of where I think that the ARPA funded efforts fit into the bigger picture of environmental research and development, and finally provide some details into our thoughts on future research directions. In addition to being one of the principals in the Environmental Technology program, I manage efforts in Advanced Batteries and Fuel Cells; programs which are complementary to the ones I will discuss today.

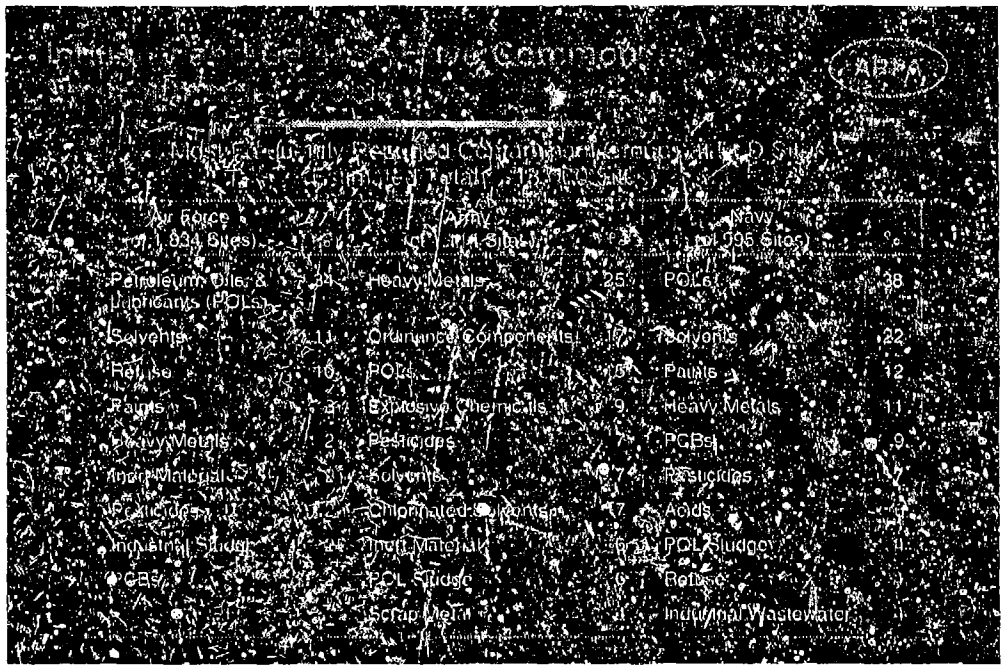


The environmental mission of the Department of Defense is to provide policy, leadership, technology, and resources to address national and international environmental problems that affect the security of the United States. These programs can be broken down into four main areas (or pillars): clean-up of existing hazardous waste sites, compliance with all Federal, state and local regulations, pollution prevention in the manufacturing and maintenance of DoD platforms, and conservation of natural and cultural resources. In addition to these four pillars, Congress has directed the DoD, in collaboration with other Federal agencies, to address two, more universal environmental issues: global environmental change and energy conservation and renewable resources. ARPA is currently funding programs in all six of these critical areas, with the largest efforts in pollution prevention and clean-up. Examples of these programs will be discussed shortly.



ARPA's role in the environment grew out of a Congressional mandate. Although a substantial fraction of our budget still comes directly from Congress, this presentation will concentrate on work derived from our core budget.

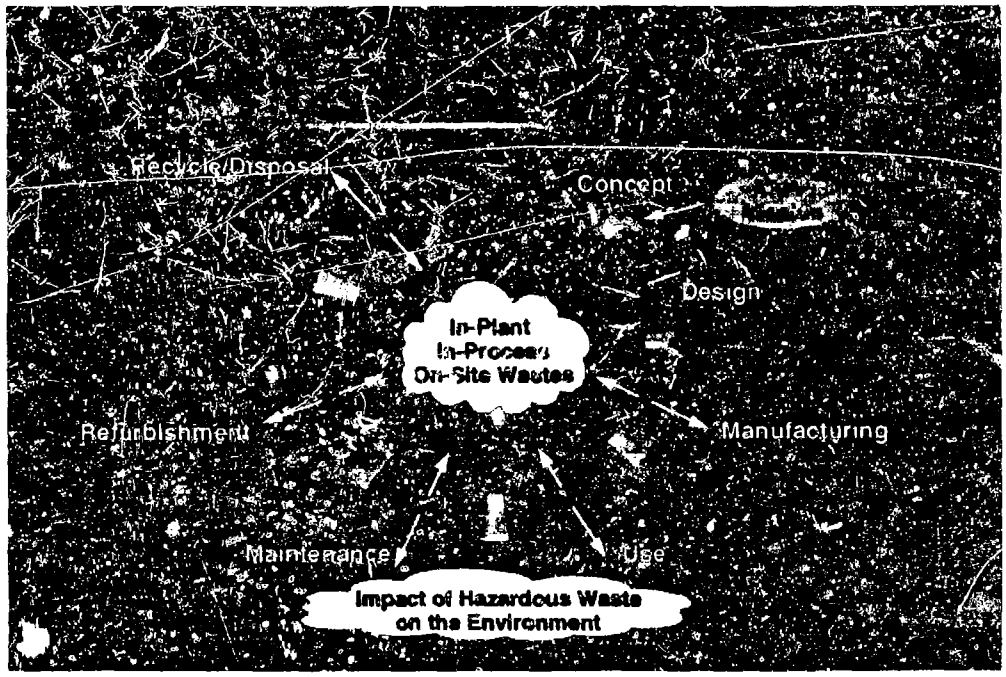
Managerial responsibility for the bulk of the new programs beginning in FY95 and beyond fall to three people. We each cover a broad, and somewhat overlapping portion of ARPA's environmental mission. Ira Skurnick's main concerns are in bioremediation and green manufacturing (including coatings, plating, and some electronics). Zachary Lemnios' purview is Sematech where there is a substantial program to develop environmentally sound manufacturing practices for advanced integrated circuits. Congress has directed ARPA to spend approximately 10% of its Sematech budget on environmental problems, although recent reports out of that organization show that an even greater proportion of the funding is having a positive environmental impact. My current and future programs deal with the green manufacturing of a wide variety of components, but primarily electronic systems above the chip level (printed wiring boards, packaging, etc.), the development of chemically specific environmental sensors for site characterization and process monitoring, and the advancement of novel waste disposal and recycling technologies.



We in the Department of Defense talk a lot about dual-use technologies these days because of its obvious advantages to both the military and civilian sectors of our economy. In some cases this is quite a stretch -- not so in the area of environmental technology. The clean-up problems that face both industry and the DoD are quite similar. For example, 34% of the 1800 Air Force sites in one study were found to be contaminated with petroleum, oil, and lubricant (POL) wastes. 38% of the nearly 1000 Navy sites and 15% of over 1100 Army sites were found to be similarly contaminated. Other key wastes found at both military and industrial sites include heavy metals, chlorinated solvents, paints, and pesticides. The only item on this list that most civilian industries do not have to deal with is ordinance and ordinance processing.

It is estimated that the Department of Defense has at least 18,000 sites to remediate at a cost of over $25 billion. This price tag may triple if all potential litigation costs are included. The total cost to clean-up all hazardous waste sites in the United States has been estimated to exceed 3/4 of a trillion dollars and this process will stretch well into the next century.

Finally, I should note that the problems associated with manufacturing and maintenance issues are also common to both military and civilian industries. Thus the development of green manufacturing and more economical reuse and recycle programs will impact both sectors of our economy.



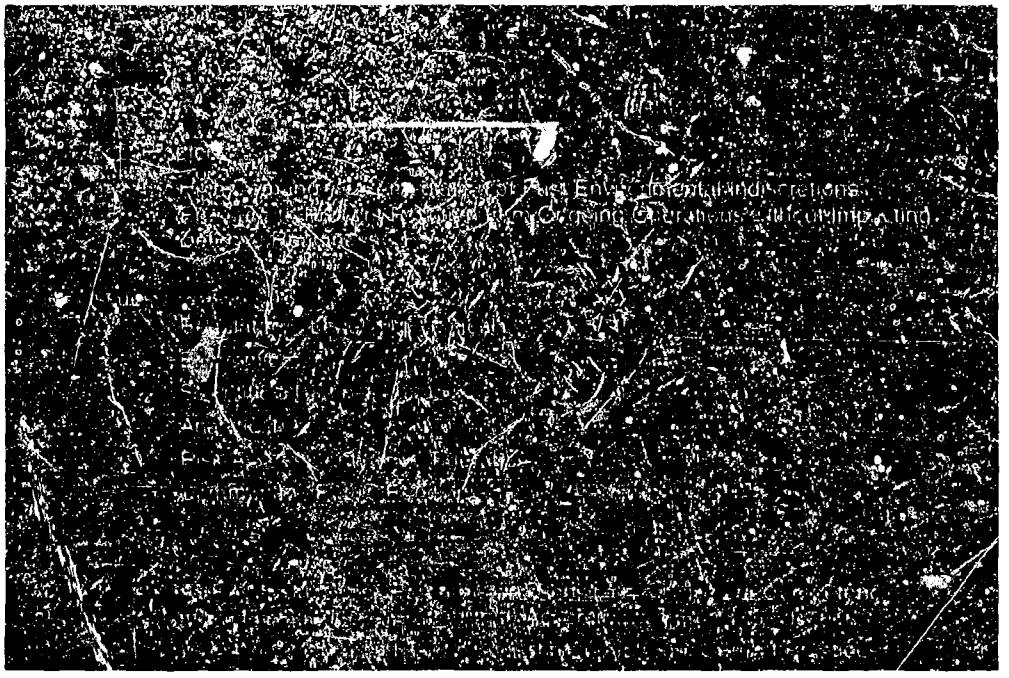
The life-cycle of a DoD system -- and this can be any component or product -- can be broken down into several stages including, initial concept and definition of customer requirements; product design and process planning; manufacturing, assembly, and packaging; use (and abuse); routine maintenance; refurbishment; and finally recycling and/or disposal (and ultimately equipment and facility disposition). ARPA's role in each of these steps is shown in yellow and in all cases it is at the very beginning of a new stage. This concept fits with the ARPA charter as the central research organization of the DoD.

Maintenance and refurbishment issues are key here and tend to separate somewhat the military and civilian markets. For a military product, initial construction may only require a few coats of paint or layers of metal plating while during the life of that product surface coatings may be stripped and reapplied dozens of times. This is not true for most of the consumer market.

You will note that at least two types of wastes are generated in each one of these steps: those initially left at the plant or on the site (scrap, waste solvents, etc.; indicated by the short arrows pointed inward) and those disposed of in the community at large via stack emissions or sewers (larger, outward pointing arrows). Any change of product or process should try to minimize both of these effluent streams.

Most efforts to date have concentrated either on worker safety and yield enhancement (thus minimizing in-plant and in-process wastes) or through air scrubbing and water treatment. The greatest environmental gains, however, will come from changing materials or processes so that these wastes will not be generated in the first place. Additional, substantive gains may also be derived from decreasing the energy requirements for each of these steps.

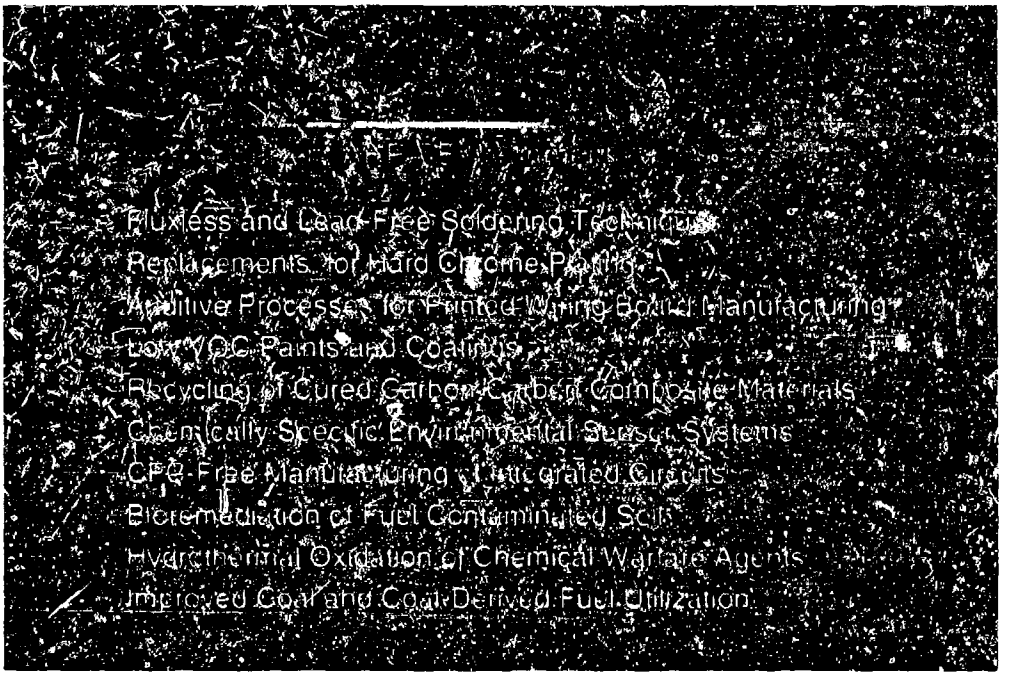
As one moves along this path, the amount of time, effort, and money spent increases dramatically, as shown by the increasing width and length of the red arrow. Thus, in a manner akin to quality initiatives, one can leverage an investment by "getting it right from the start" (i.e., design-for-the-environment). This minimizes future problems and future costs. Developing effective technologies for extending the service life of a DoD or civilian system will have many of these same, positive environmental effects.



ARPA's choice of environmental problems to tackle is predicated on two important considerations. (1) There is a significant amount of clean-up required at existing military installations. This problem is further exacerbated as the military shrinks its resources and turns bases over to civilian use. (2) The DoD is committed to reducing the amount of environmental contaminants and pollution that it generates while still pursuing the goals of defense readiness. If these two goals are to be achieved with the desired level of completion, and within existing budgets, new and novel ways must be developed to cost effectively address past and future contamination.

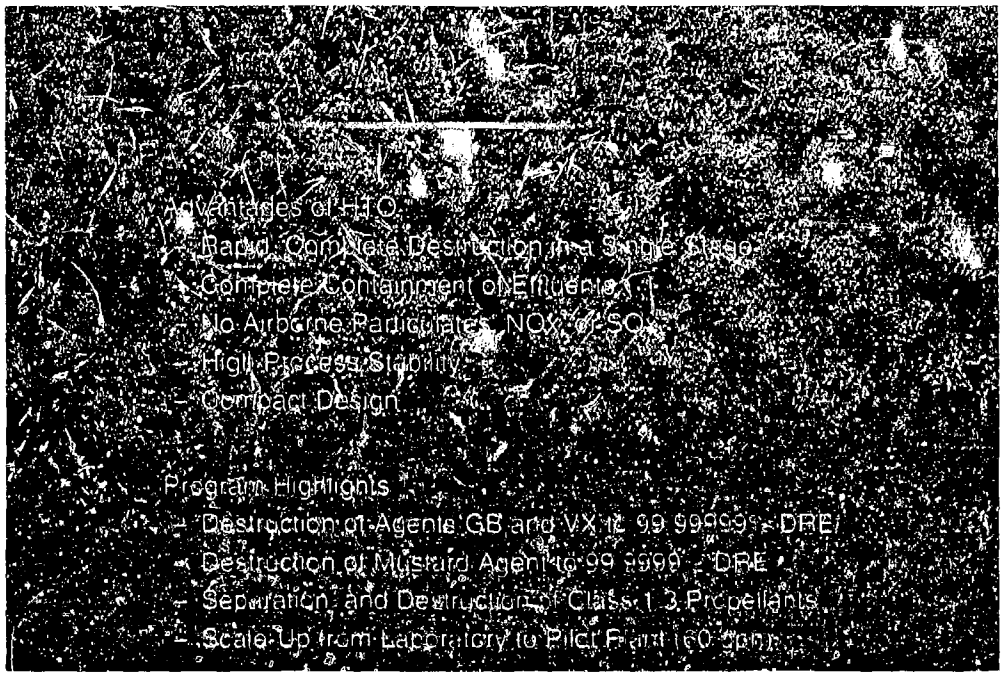
The issues are quite complex and are far from being just technical: Regulatory and legal requirements are probably the biggest drivers. The principle short-term concern, however, is the economic cost of coming into compliance. Although pollution prevention can improve the efficiency of an operation (much as quality initiatives have), the principle beneficiaries of remediation are often those who are neighbors. Environmental technologies have been slow to emerge and have often been unglamorous. The question always is: "What is the least expensive technology that will accomplish the task?"; not "What is the best?" Furthermore, estimating the cost of environmental pollution, or the benefit of environmental remediation, is a complicated economic calculation in which many values are matters of opinion (for example, the value of avoiding regulatory conflict or the value of a rain forest) and in which unambiguous economic calculations are impossible to carry out. Understanding the risks associated with most contaminants is educated speculation at best. Prioritizing these problems, communicating the risks, and understanding a communities' tolerance for risk are crucial issues facing the DoD. Finally, future DoD activities whether it be testing and training or access to foreign ports may come to depend on environmental concerns.

The conclusion that we reach at ARPA is that problems must be chosen on a sensible basis -- understanding the competencies of the organization, the pervasive impact of the problem chosen to study, its DoD relevance, and its uniqueness. These choices also reflect the interests and biases of the program managers. In the end, we invest in science and technology that will hopefully "leapfrog" current practices and provide the military with truly superior, cost effective and environmentally sound solutions.



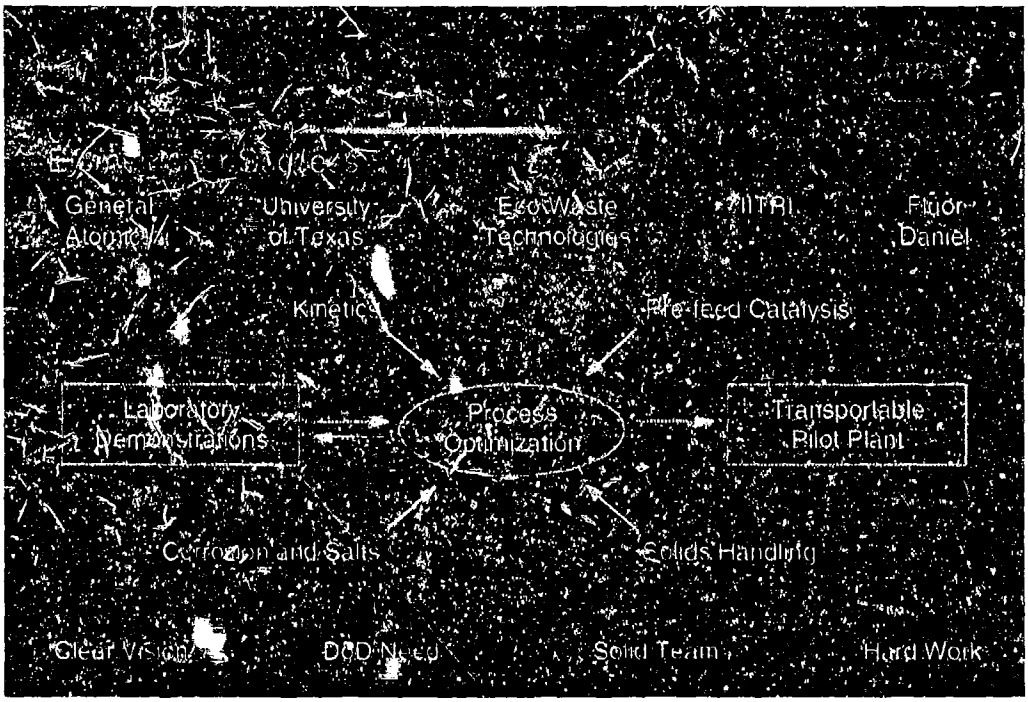
As noted earlier, ARPA plays a significant role in the environmental arena with programs in all four pillars as well as the two additional thrust areas. As this list indicates, our programs include a mix of near term and more long-range efforts. Projects are funded anywhere from two to approximately four years and involve work in industry as well as at universities, small businesses, and Government laboratories. Cost sharing is also expected on a number of these programs.

Some of these technologies are fast becoming industry standards while others are being transitioned to the services. The effective transfer of these technologies out to the field is a significant part of the ARPA environmental mission. And, as with most ARPA programs, we tend to push the envelope technologically.



Let me provide an example of one of my current efforts to give you a feel for the types of programs that we at ARPA are interested in. More importantly I hope it will provide a flavor for how we do things in the Environmental Technology program. The example that I will discuss this afternoon is the hydrothermal oxidation of live chemical warfare agents. Hydrothermal oxidation (or HTO) is a moderate temperature (450-550 oC), moderate pressure (3500 psi) process where live agent is mixed with oxygen and water above its critical point to form a homogeneous single phase solution. Due to the low viscosity of water in the supercritical state and to the solubility of both agent and oxygen at these temperatures and pressures, the oxidation reaction is rapid (<15 sec residence time) and leads to complete destruction of a wide variety of effluents in a single stage. There is no chance for air or water pollution since all effluents are completely contained. Because there is no high temperature, open burning, airborne particulates, NOx, and SOx are not formed. Finally, since the system is relatively insensitive to most operating conditions, there is very high process stability.

The program has demonstrated the destruction of agents GB and VX to > 99.99999% destruction and removal efficiency (or DRE) and mustard agent to >99.9999% DRE. These are the detection limits for these compounds. In addition, Class 1.3 propellants have been separated and selectively destroyed. Due to the success of the laboratory scale reactor, a 60 gallon per hour pilot plant was designed and is currently being fabricated.



The success of the hydrothermal oxidation program is due to a variety of factors. First, there was a clear vision of the needs of the program: the ability to destroy live chemical warfare agents to below the limits of detectability using an alternative to incineration. Note that this need had a very strong DoD focus. Stepping back from this goal it was clear that a number of important issues had to be dealt with in order to optimize the process. First, the kinetics of the reaction had to be understood and then the effects of a pre-feed or catalyst on the overall destruction chemistry. Because of the high chlorine, phosphorous, and sulfur content of the feed, corrosion and salts became a critical issue. Finally the handling of solid products had to be dealt with. The process was optimized using a series of laboratory scale reactors with the final tests conducted on a 1.5 gal/hour feed of live agent.

In order to accomplish these tasks, a solid, interdisciplinary team was assembled since no single entity had all of the necessary skills. This is a trait common to many of the environmental projects and is driven by the interdisciplinary nature of the problem. The HTO team includes General Atomics, the prime contractor; the University of Texas, providing some basic science and engineering; Eco Waste Technologies, a small business with a strong background in hydrothermal oxidation and waste water treatment; IITRI, a surety facility with the ability to handle live chemical warfare agents; and Fluor Daniel, a large engineering firm to help with the scale-up and design of the pilot plant. Of course it also took a lot of hard work and quite a bit of luck to pull-off the program.

ARPA was willing to take a significant risk in this case because the pay-off is so high. Thus, problem selection becomes a critical factor in all of our efforts.

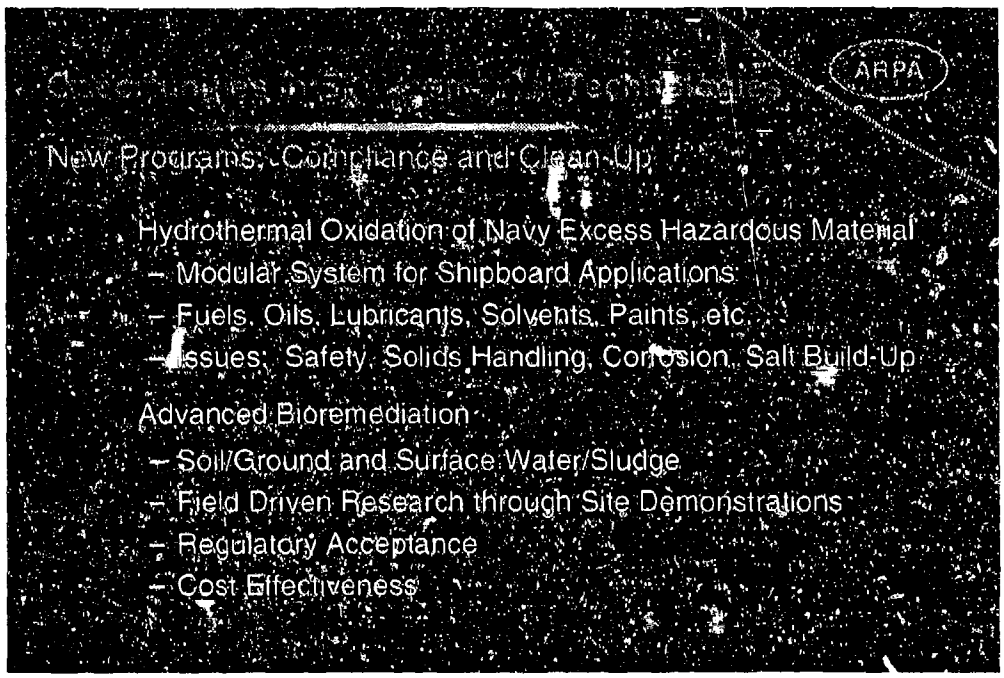


Probably of greatest interest to this audience is not so much past success as the future prospects. Beginning in FY95 and 96, ARPA will initiate at least four new programs in environmental technology; two in pollution prevention and one each in compliance and clean-up.

Electronics manufacturing is a typical ARPA strength and it should come as no surprise that we will be funding more efforts to "green" this industry. Work at the chip level will be coordinated through Sematech. I will be working at the board, package, and system level to develop these new processes. The focus of our efforts will be based on an industry developed roadmap which ARPA is currently funding. Copies of this roadmap may be obtained from the Microelectronics and Computer Technology Corporation of Austin, TX. These new efforts will last approximately two years and will concentrate on recycling and reclamation of existing electronics as well as a design-for-the-environment modelling/manufacturing program to try and minimize both the in-plant and environmental wastes noted in an earlier slide.

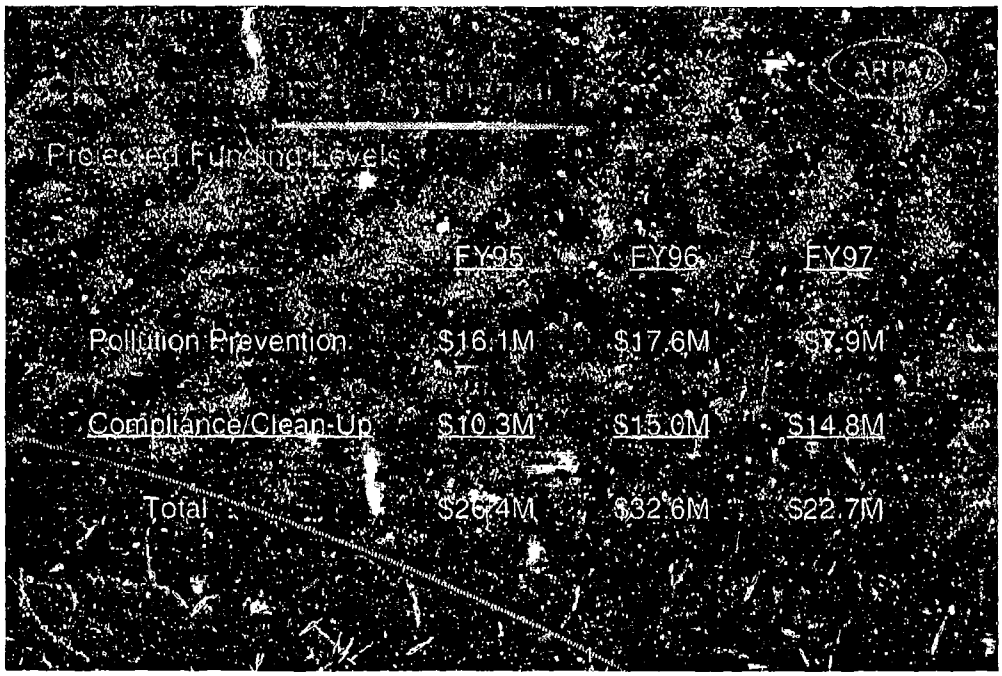
Since the major components of any electronic assembly are glass, metal, and plastic, this program can serve as a model for the reuse, recycling, and/or reclamation of a wide variety of other DoD and consumer-relevant systems. In addition, short product life cycles mean that many new ideas can be tried in rapid succession. Funded programs in this area will be approximately two years in length.

The second new program in the pollution prevention arena is something we call Environmental "Green". This will be a new design-for-environment and/or manufacturing effort not for electronics. The detailed choice of topics has not been established yet, but there will be a specific DoD relevance and a pervasive impact on the environment. Expect an announcement sometime in early calendar year 95. Although the ARPA budget is substantial, it is not infinite and we want to prioritize and tackle the most important problems first. Issues to be considered include new designs for enhanced performance, optimized processes for reduced costs, new materials and manufacturing/maintenance processes to minimize waste as well as ultimate recycling and disposal in an environmentally sound manner. As noted earlier, unlike most consumer products, maintenance activities for DoD systems may create far more environmental problems than the initial manufacturing of the system. The total effort will be approximately four years and projects must culminate in significant technology demonstrations.



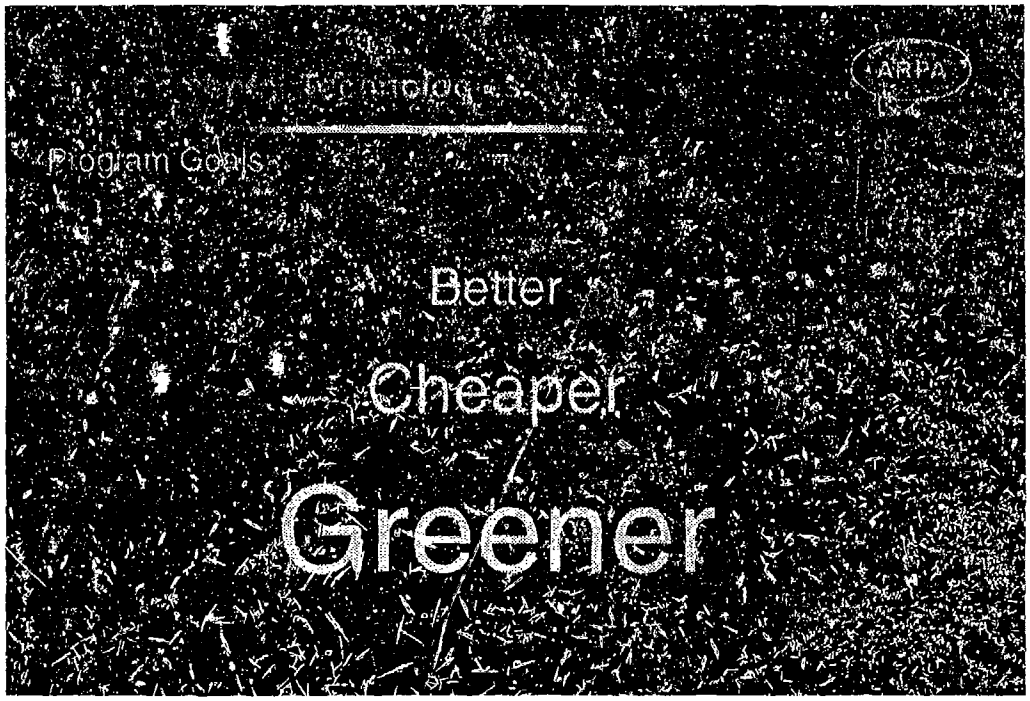
New efforts in the areas of compliance and clean-up include a major new thrust in hydrothermal oxidation. In this case it is for the development of a modular system for the destruction of Navy shipboard excess hazardous material. Typical materials that need to be destroyed include contaminated fuels, oils, lubricants, solvents, and paints. Quantities can be as large as 1000 lbs/day on an aircraft carrier. A number of issues need to be considered including safety, solids handling, corrosion, salt build-up, and simple operation. This will be a three year program coordinated with the Office of Naval Research. If successful, the Navy will fund a follow-on effort to place one or more of these units on a ship. Such a modular system may also find application in many civilian and shoreside facilities.

Finally, ARPA will start an advanced bioremediation program in FY96. This will look at the in situ remediation of soil, ground and surface water, and sludge. The key here will be field driven research where tests will be conducted on "real" soils. The program will culminate in one or more site demonstrations. Important points to keep in mind for this program include thoroughness, regulatory acceptance, and cost effectiveness. Ira Skurnick will be the ARPA point of contact for this approximately four year effort.



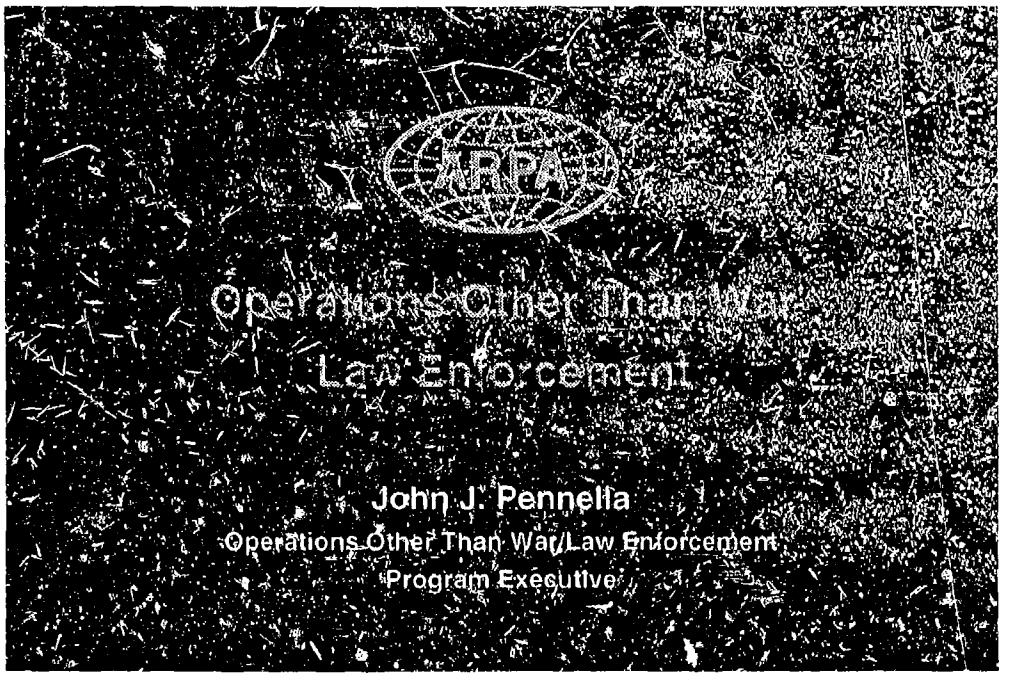
As this chart indicates, ARPA's investment in the environment through its core budget is substantial. The "real" funding is actually somewhat larger, however, since the numbers listed here do not reflect programs that might impact the environment (e.g. solar photovoltaics or fuel cells), but are not strictly "green". Additions to the budget due to Congressional actions may also increase these values substantially (i.e. ~$20M in FY95).

While one cannot predict the future, because of the importance of the environment, it is anticipated that significant funds will be available beyond FY95. Our funds are also being leveraged through cost sharing and by coordinating our efforts with the Services, the Department of Energy, and the Environmental Protection Agency. Note that the significant drop in FY97 funds is due to the end of Government funding at Sematech.



Let me close with a little more of the ARPA philosophy on environmental technology. Any program that we work on in this effort must have the following goals: It must lead to the development of a better product or process; one that is of importance to the Department of Defense. This includes the development of new components as well as methods for cleaning up past spills -- no one will tolerate poorer performance, least of all the DoD. The cost of this new system or process must also be less than that of the original. As budgets grow ever tighter, we must try to get more for less. Finally, this new product or process must be a "dark green".

We are looking for efforts that will truly make a difference in the way we do business and that will have a significant impact on the world around us. Companies have shown that it is possible to achieve all three of these goals simultaneously. The challenge now is to expand this list from a few isolated examples to a substantial body of work.



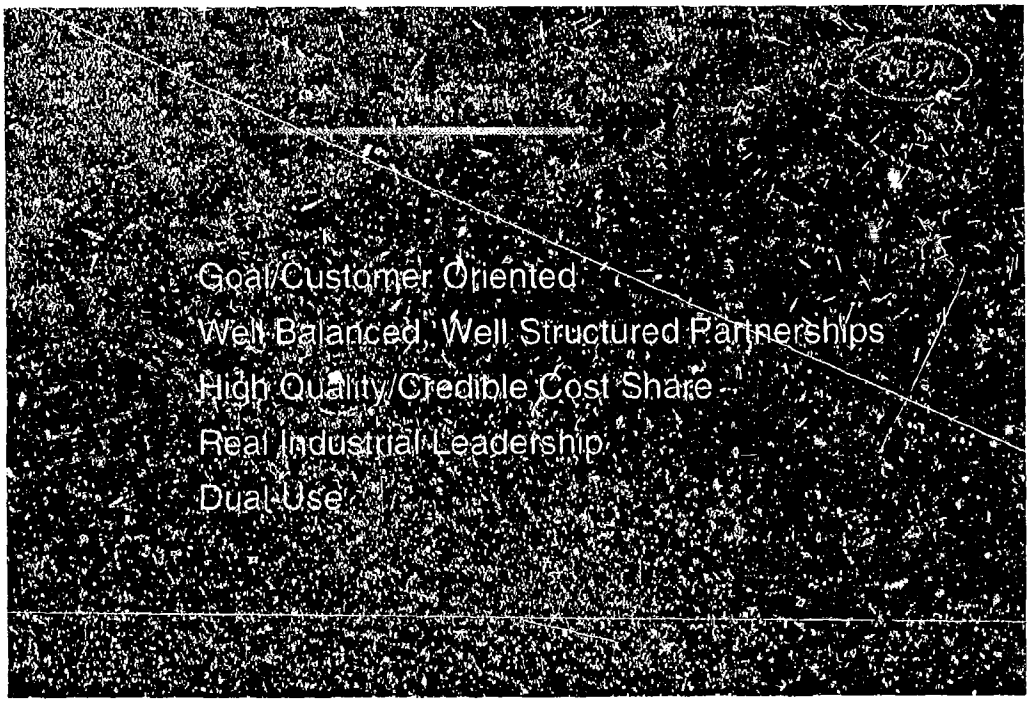
Good afternoon, my name is John Pennella. I am the Program Executive for Operations Other Than War (OOTW) and Law Enforcement at arpa. My objective, this afternoon is to provide you with an understanding of the vision and direction of the arpa operations other than war/law enforcement program. I will also provide a summary of planned, near term opportunities for industry participation in arpa's OOTW/LE program.



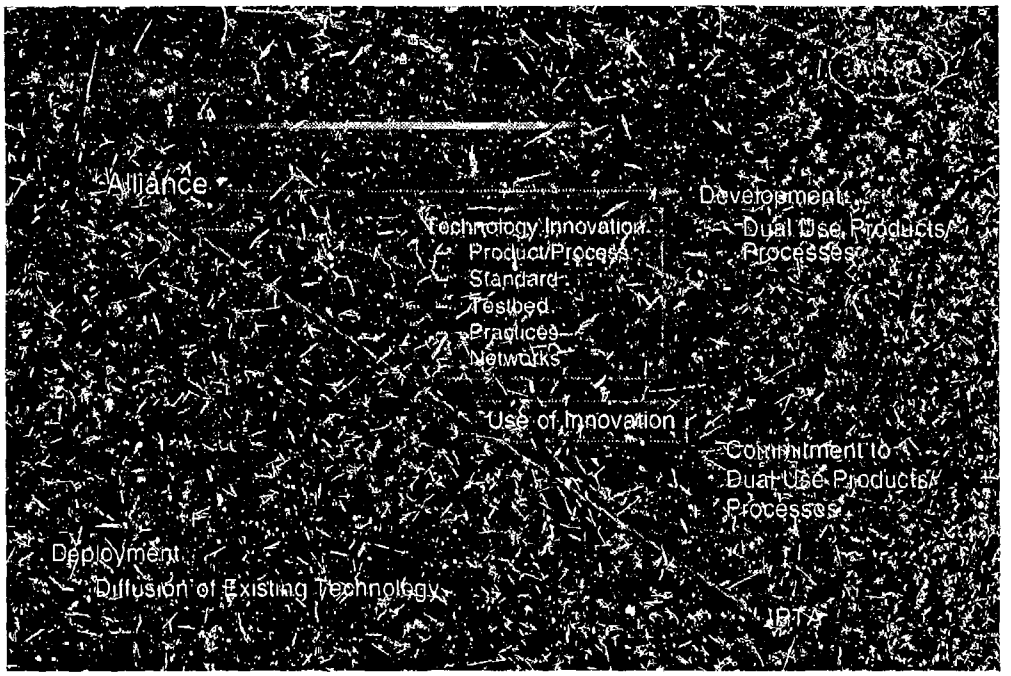
Finally, while new technology is at the center of the TRP, it is a toll and not an end in itself. This is the primary difference in the TRP and the est of the ARPA investment portfolio. What we're really after is a new way of doing business that makes defense affordable.



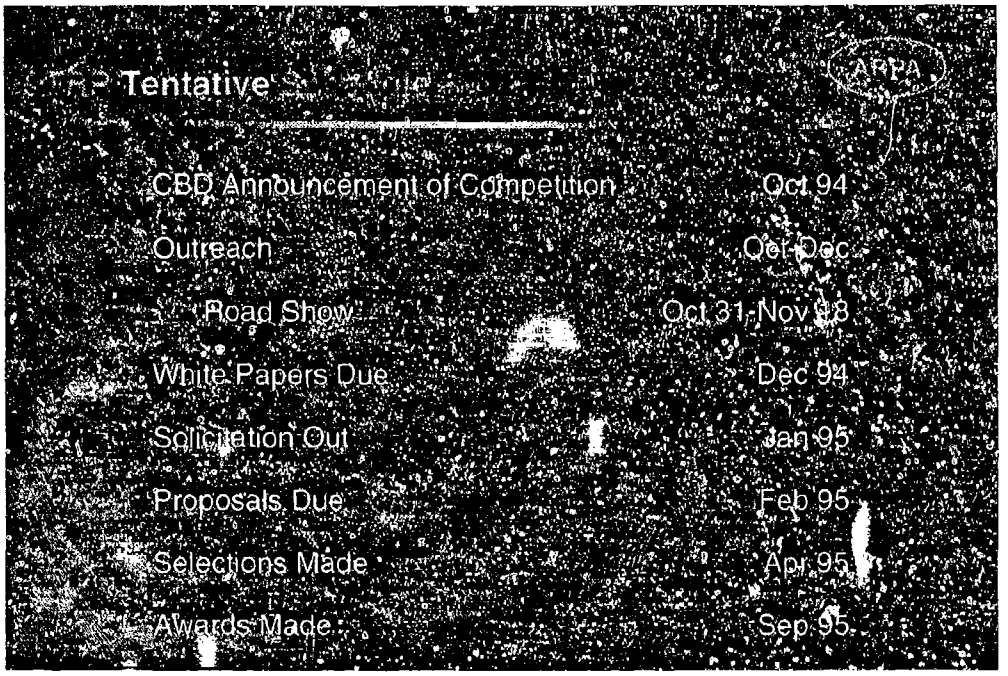
In addition, there will be a much more explicit discussion of the Regional Technology Alliances part of the solicitation. RTAs are expected to take on a flavor that is intermediate between the Technology Development and Alternative Deployment Modes categories of the first solicitation.



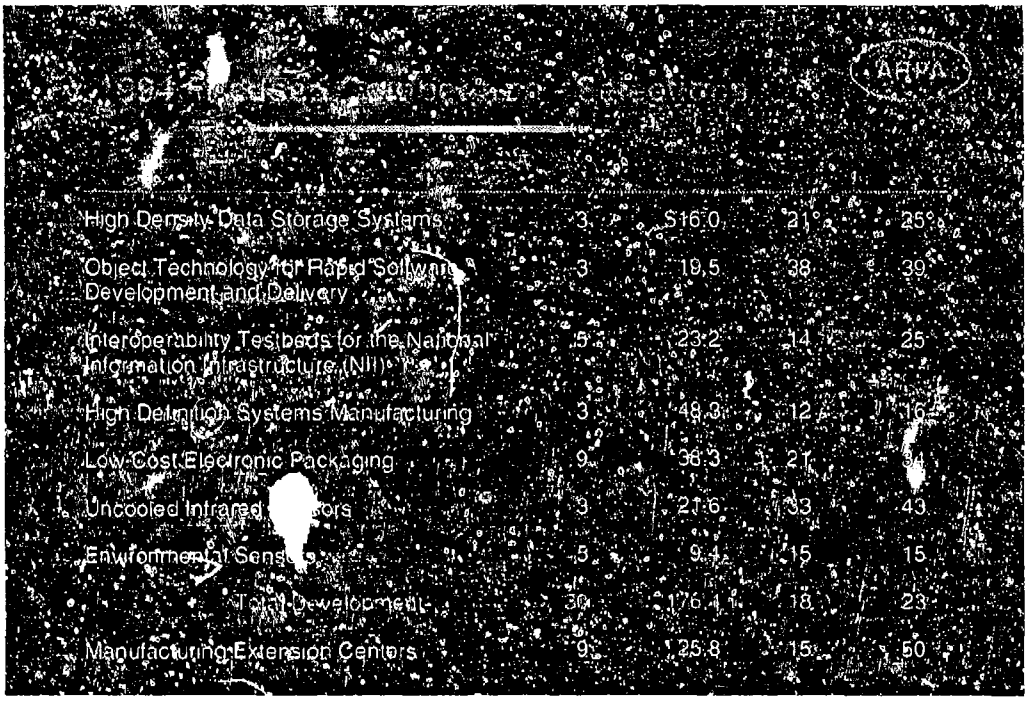
In all of the TRP competitions a few characteristics distinguish winning proposals from others. While many may regard this list as obvious, every proposal put aside has been flawed in one or more of these areas.



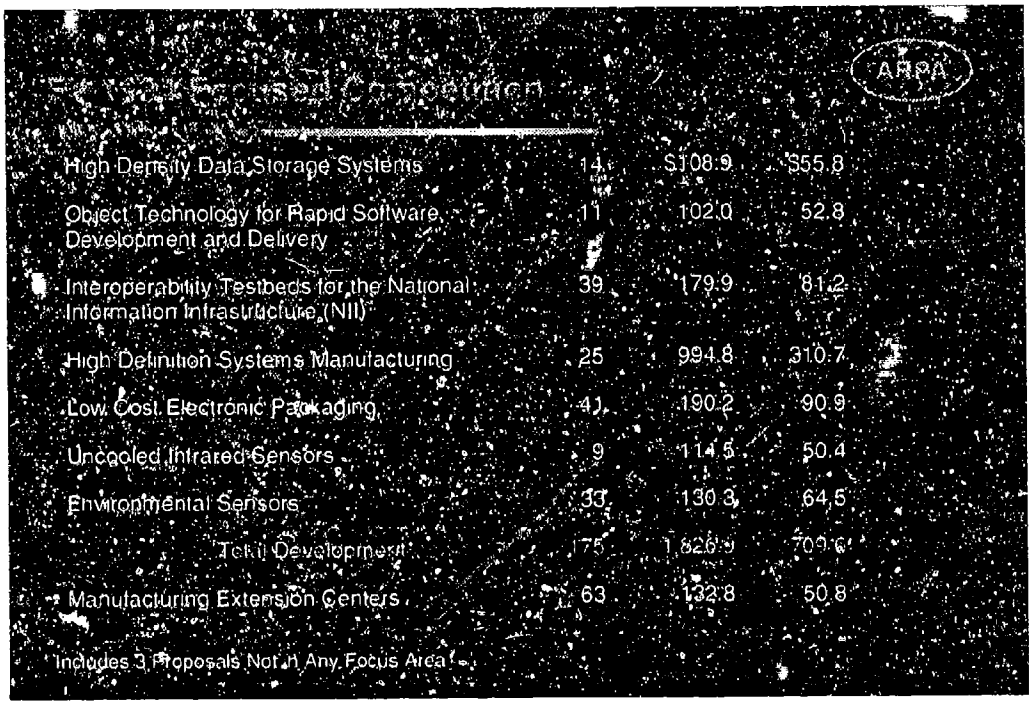
In the first solicitation, Development and Deployment are viewed as distinct and somewhat separate; one dedicated to the creation of new technology, the other dedicated to the moving of technology into the hands of users. We believe that in some cases these two activities can both be enhanced by unique regional attributes that are strengthened. That is the focus of the RTA program, to recognize and enhance existing, regional relationships of firms to benefit both themselves and the potential access of defense technologies and products.



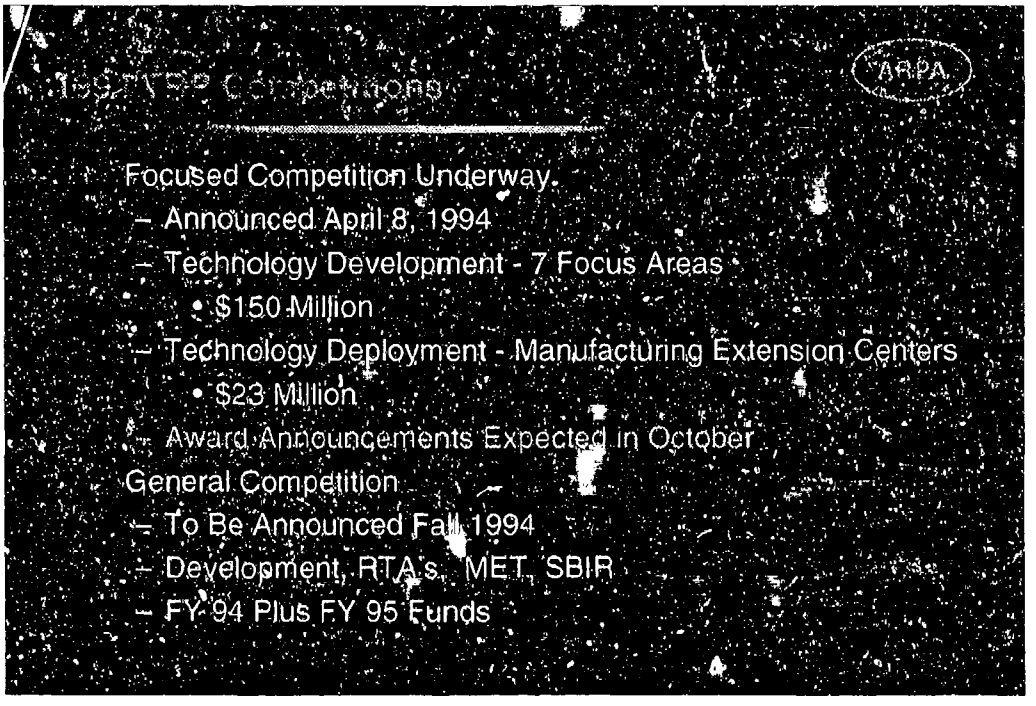
This is a rough schedule for the third competition. Notice that the actual solicitation will not be published until January. This is to allow plenty of time for unrestricted interaction between potential proposers and government program managers.



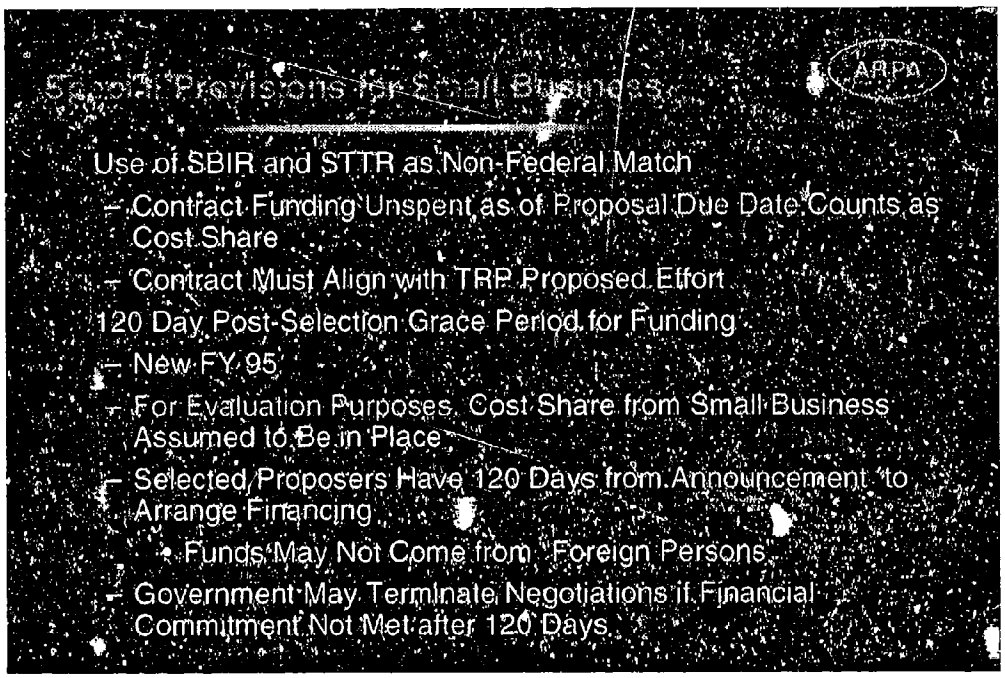
The second TRP competition was conducted this spring. Proposals were submitted along much more focused technology areas, partly for the purpose of giving prospective proposers a firm basis for making a bid-no bid decision. This competition attracted only 175 proposals total with a selection percentage of nearly 20% compared with about 3% for the first competition.



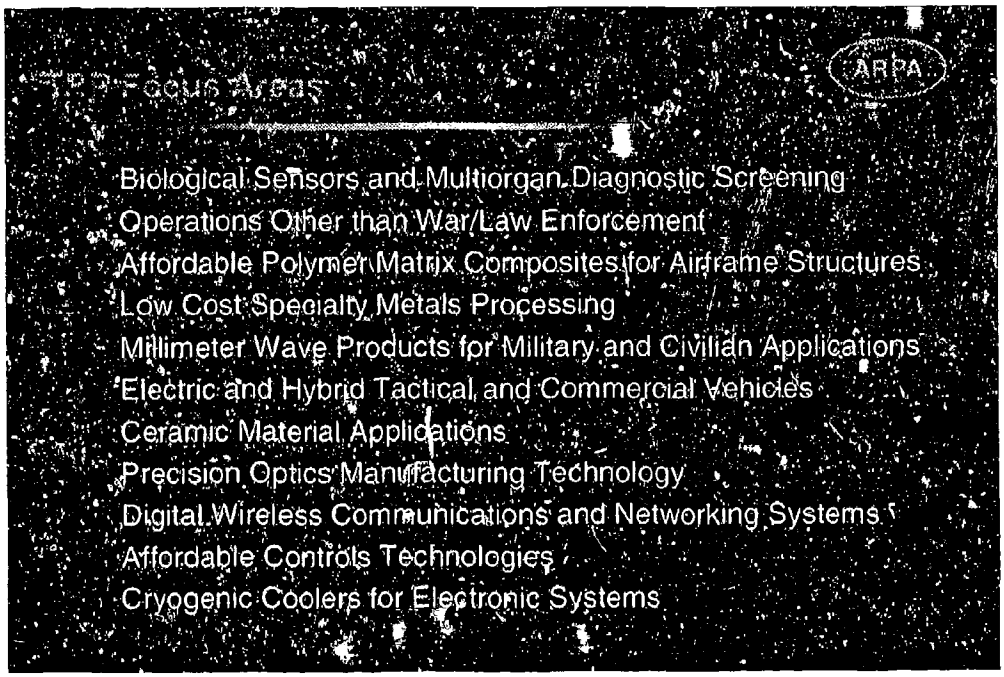
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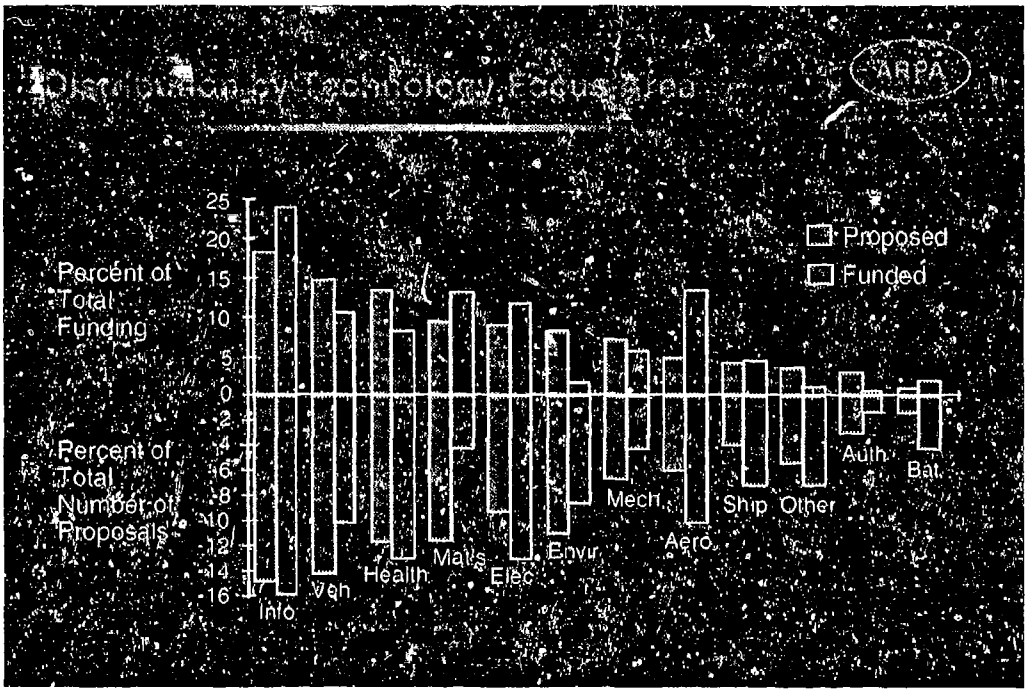
The second TRP competition , smaller and more focused than the first, closed on April 8. Proposals were solicited in seven focus areas and in manufacturing extension. Selection results are expected about now. The next large competition will also be announced this month. We expect this solicitation to include about 10-12 new technology focus areas and a solicitation for Manufacturing Education and Training.



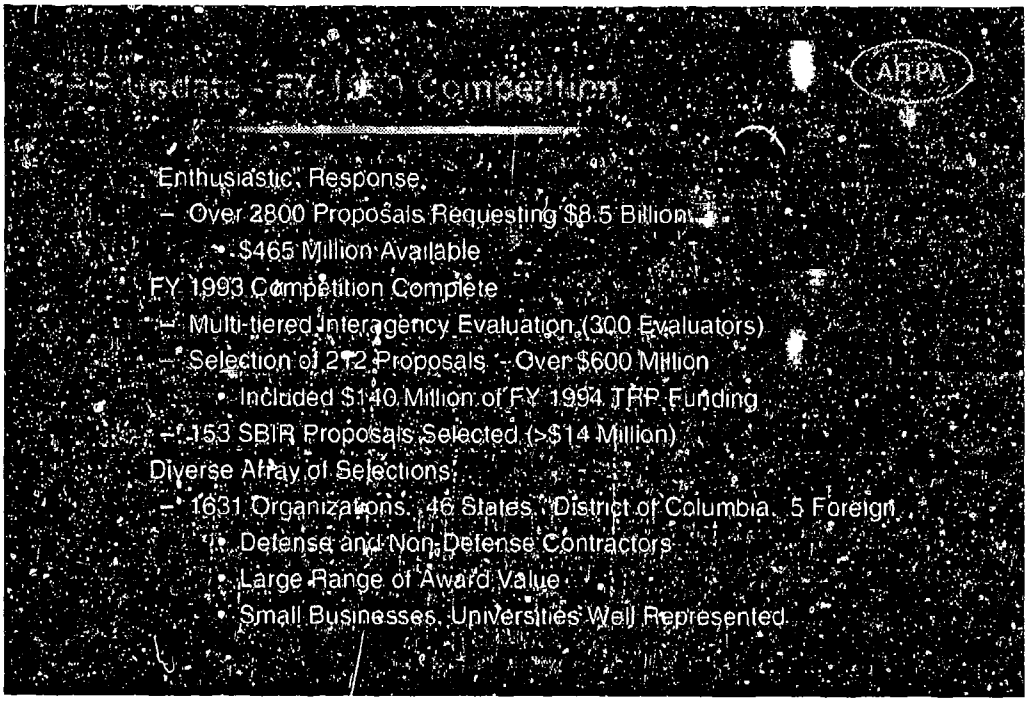
There are two new provisions this year designed to enhance the value of the program to small business.



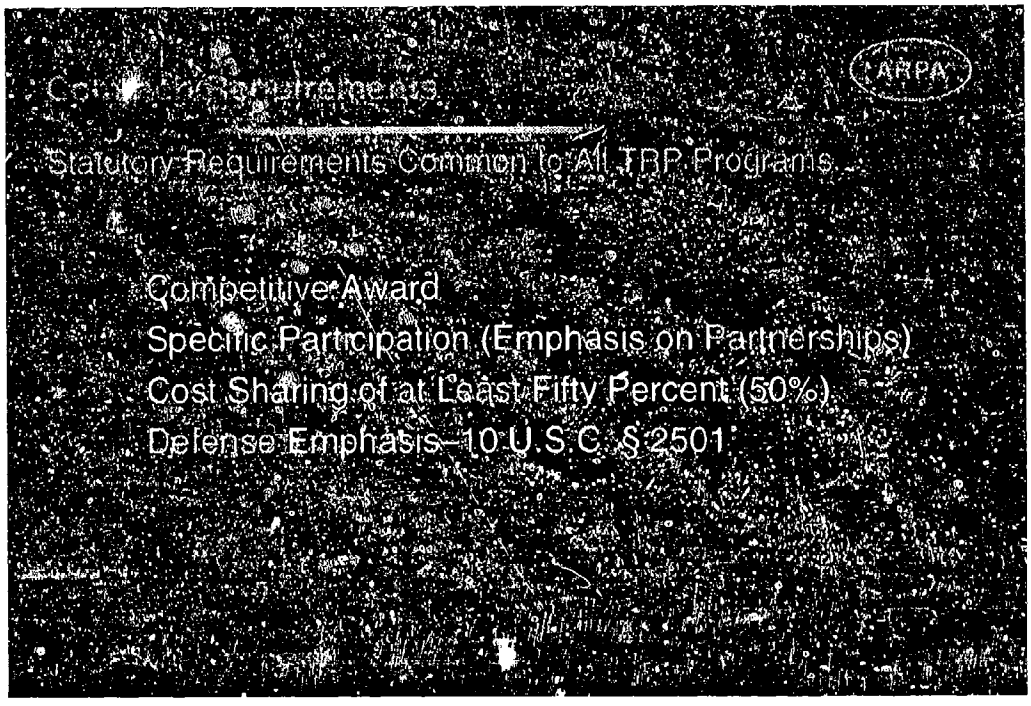
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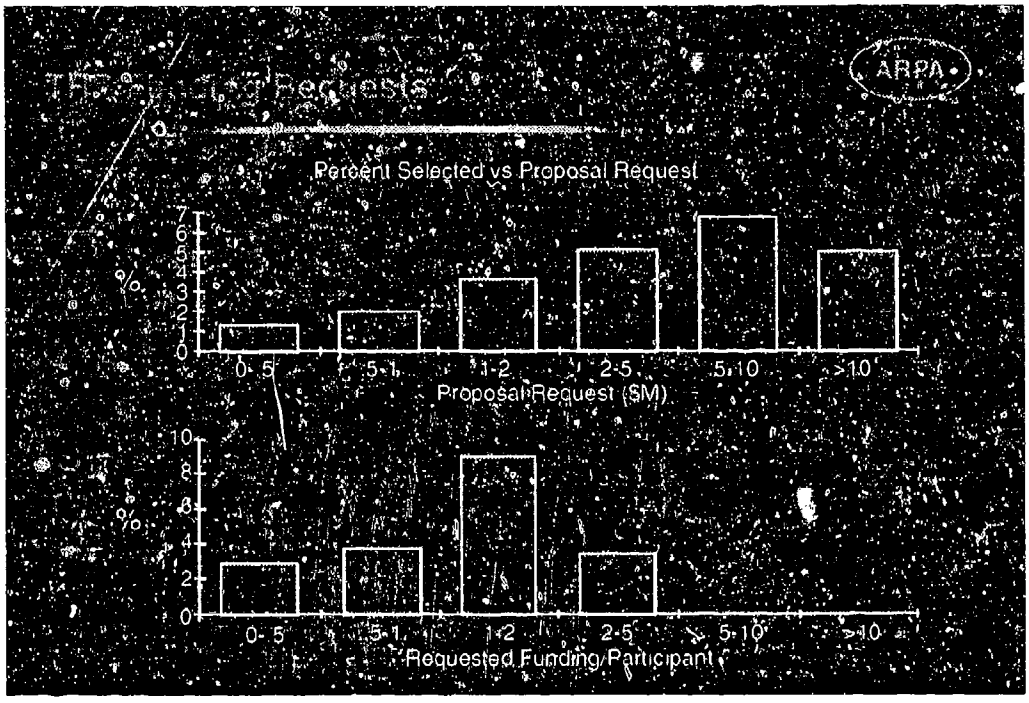
This bar graph shows the distribution of selected proposals by technology focus area. It important to note that there were no fixed amounts assigned to any of the focus areas, proposals were selected based only on their individual quality and merit. Therefore, some areas did much better than others in both number of selections and total dollar value. This will continue to be our policy in future competitions.



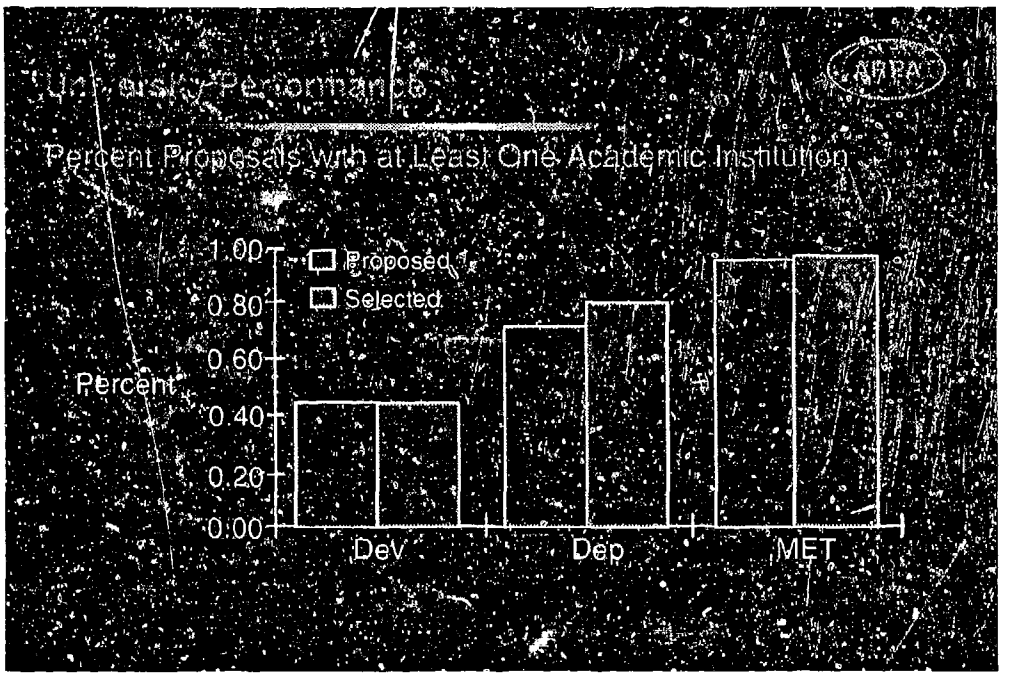
The first TRP competition was announced by President Clinton on March 15, 1993 in a speech at Westinghouse. By the due date of July 23 nearly 3000 proposals had been received requesting nearly $9 billion of TRP funding. On October 22, the President announced the first of 212 selected proposals in the three TRP areas, development, deployment, and manufacturing education, which would eventually receive over $600 million. Today, almost all of these projects are up and running although many are somewhat different than originally proposed. As detailed negotiations progress, partners were dropped and added, work plans were more fully defined, and collaborate agreements were refined. In every case, these agreements have been outside "business as usual" and have been a learning experience for government and industry alike.



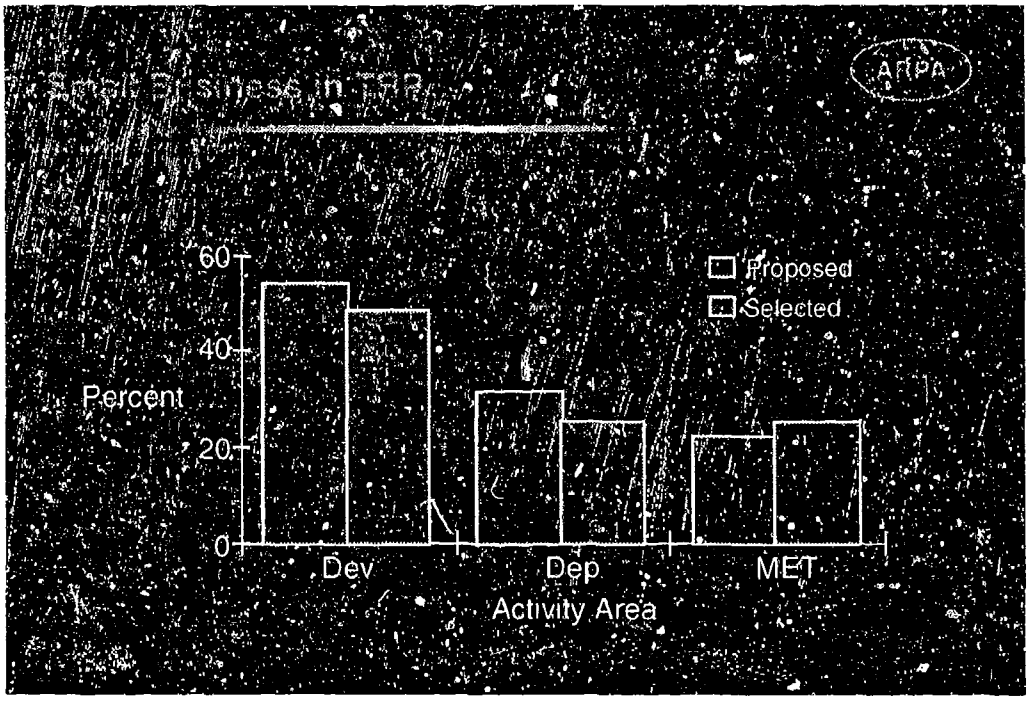
As in the first competition, there are four underlying principles that guide all TRP awards. Some of the eight statutory programs that comprise the TRP have additional restrictions beyond what is shown here and are discussed in the Program Information Package published prior to each solicitation. In addition, there are some new provisions for small business that will be more fully described later.



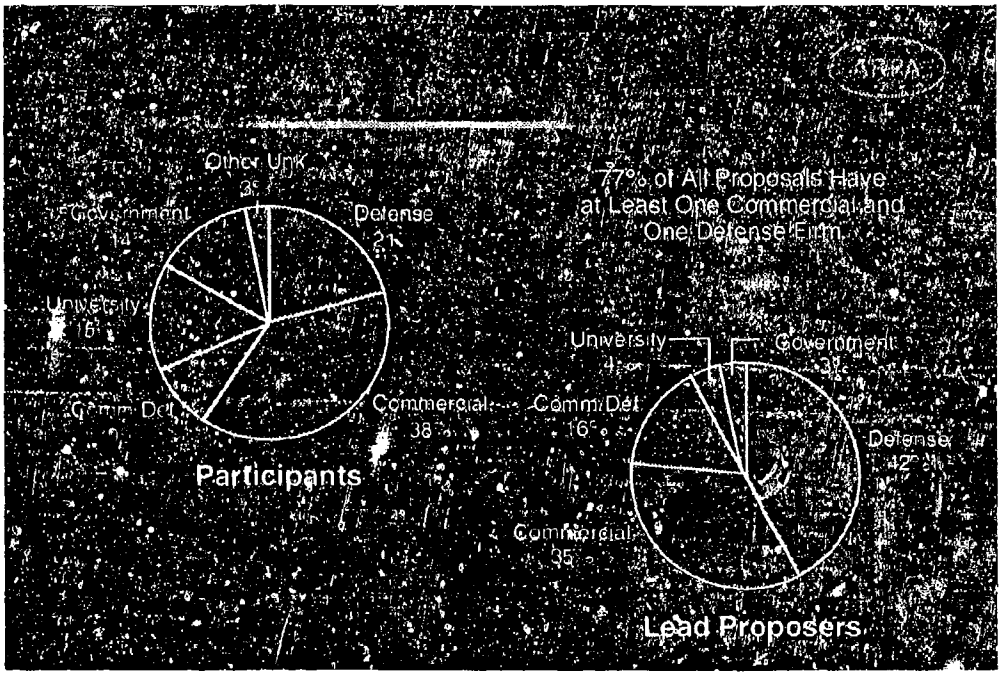
There was also great variation in the proposed size of proposals that were both submitted and selected. The top graph shows that there was only a very broad peak in the $5-10 million range of proposals submitted and selected. The smallest selection was less than $80 thousand and the largest was over $30 million. When the total dollar value of selected proposals was divided by the number of participants on a team, however, a sharper pattern emerges. Most selected proposals were in the range of $1-2 million per participant. We see this as appropriate since a much smaller fraction would would probably signify sub-critical participation and much great would indicate too great a concentration in since team members.



Contrary to early fears and predictions, university participation was also very high. It is, perhaps, not surprising that in MET nearly all of the selections had at least one university. But even in development, where university proposers were least prevalent , nearly half of all selected proposals had at least one university partner.



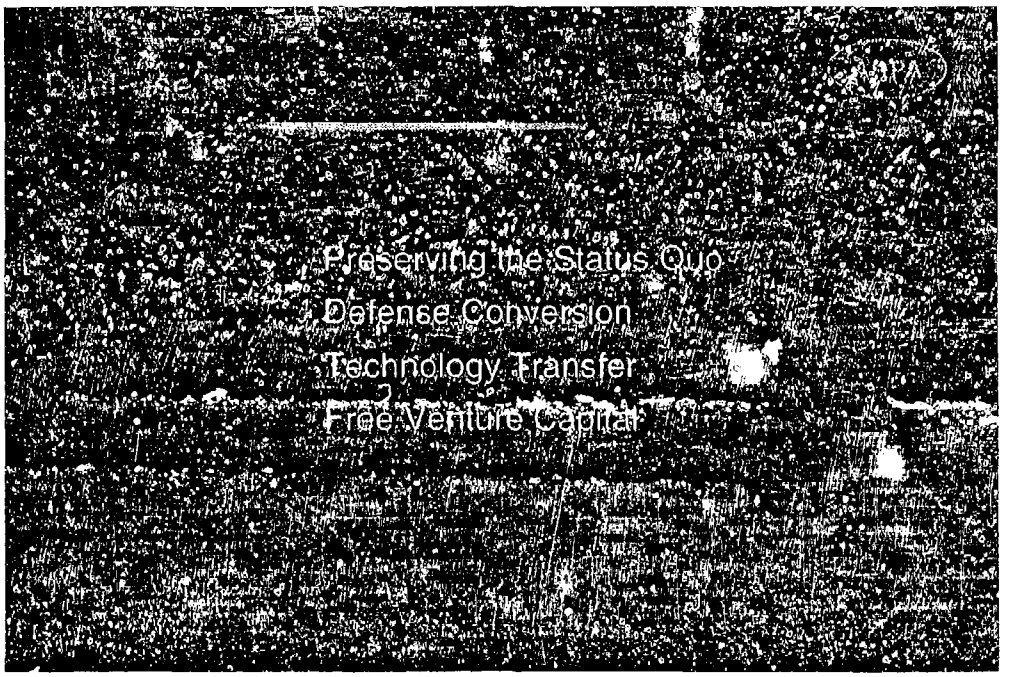
Early expectations were that small business would not be strongly represented as a result of the requirement for cost sharing. That turned out to be not the case. In fact, in the development area, where small business would be expected to have most relevance , more that half of all selected proposals included as least one smell business. While small business was typically not in the lead, they often played the critical role of a supplier of the piece of new technology that made the proposal attractive. The most successful proposals also incorporated a partner capable and committed to productization as well.



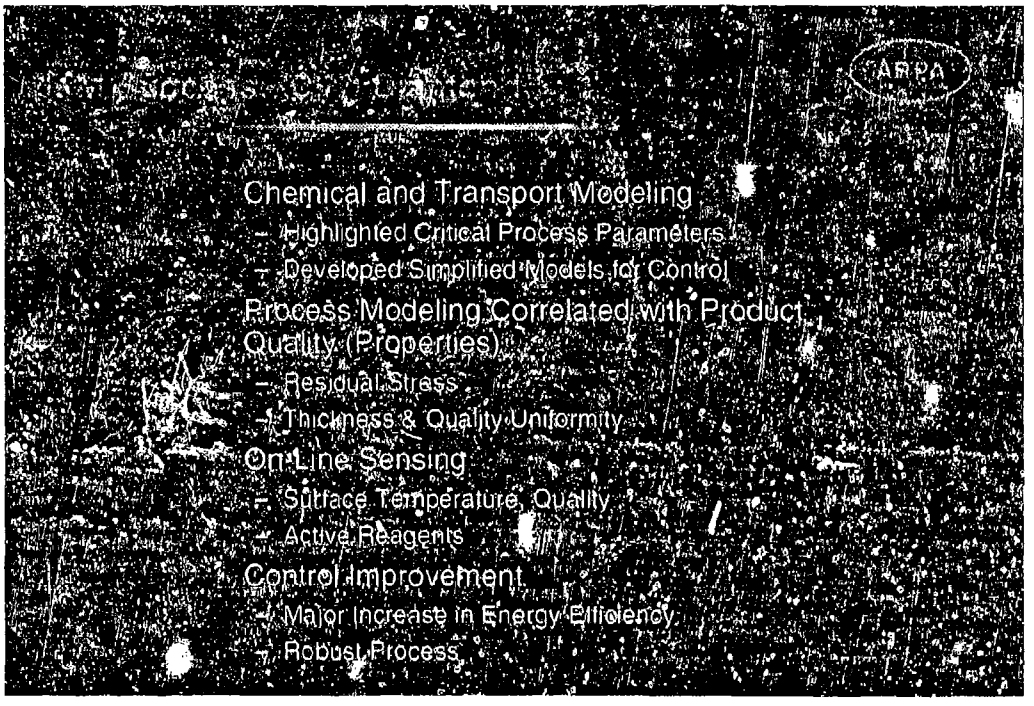
The first competition attracted a diverse array of participants. As the data at the top shows, the overwhelming fraction of participants on selected proposals were from outside of the defense community with only 21% being traditional defense suppliers. However, the published selection criteria emphasized a compelling defense benefit. As a result, it is not surprising that DoD industry had a very strong showing as the lead participant on the proposing team. Even more significant is that almost 80% of selected proposals had at least one defense firm and one non-defense firm on the proposed team. This is very good evidence for the beginning of true commercial-military integration, a primary objective of the TRP.



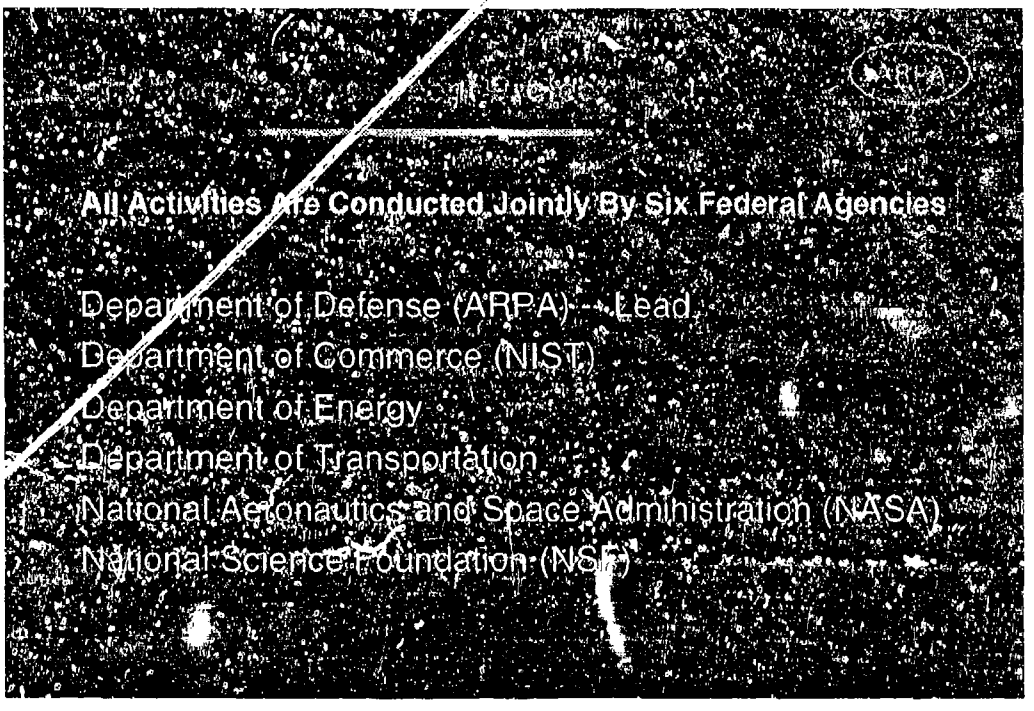
What this means is that for-profit, commercial business is at the center of attention. Which is not to say the universities, national and federal labs, FFRDCs are without a place, each of them has a unique role, just not at the center. And while economic competitiveness is not a direct aim, success in dual-use will surely contribute. The point is that the DoD is after a way to provide a more affordable defense by building off more efficient, commercial industry. DoD wants to join with these firms as partners sharing in both the risk and benefits.



Dual use is a poor strategy for justifying the practices and the organizations of the past. Those that have tried to cosmetically recolor themselves have been unsuccessful in general. Dual-use is not a remedy for the ills of defense contraction in the past. It is not a way to get money to defense firms suddenly without defense customers. The point of dual-use is not even to plunder and strip mine past investments in technologies that might be useful commercially. Its value is in the future and its benefit is mainly to the DoD and those firms that understand the benefits of functioning in an alliance with the government.



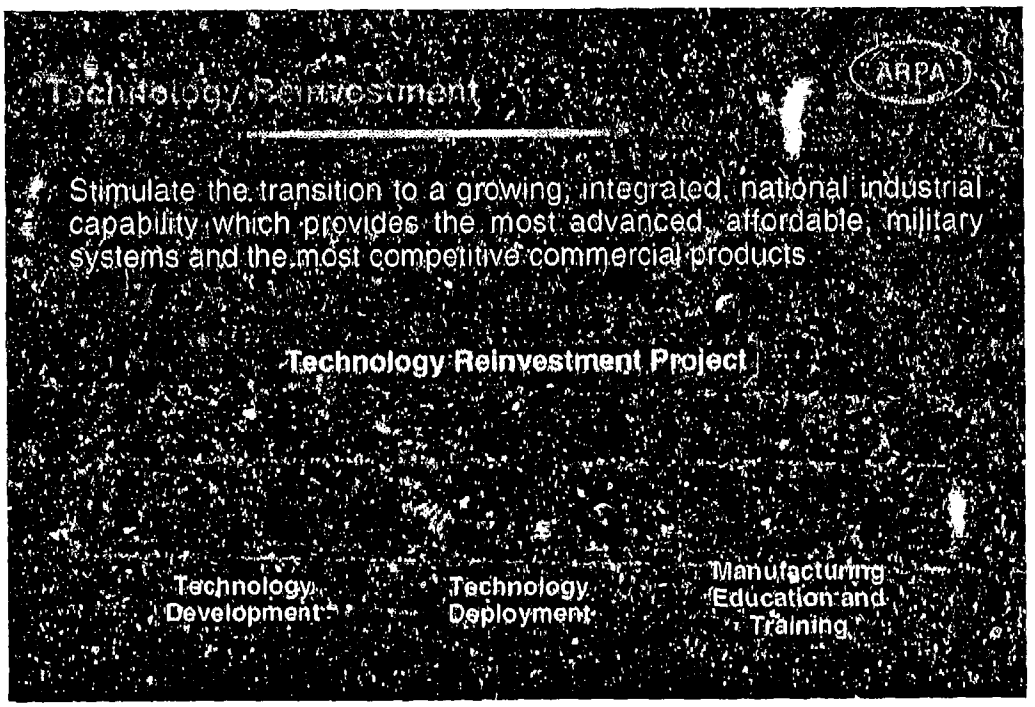
The IPM process applied to chemical vapor deposited diamond growth identified critical process parameters such as atomic hydrogen generation, methyl radical generation, substrate temperature profile, gas enthalpy, gas stream temperature spikes, etc., and related these variable to product qualities such as cracking, residual stress, thermal conductivity, thickness uniformity, texture, etc. Control strategies were modified to either eliminate detrimental process phenomena or on-line sensing developed to directly measure and control the variable through a closed loop process. Substantial improvements were realized in energy efficiency; yield (due to significantly reduced cracking); product uniformity; and cost effective thermal conductivity.



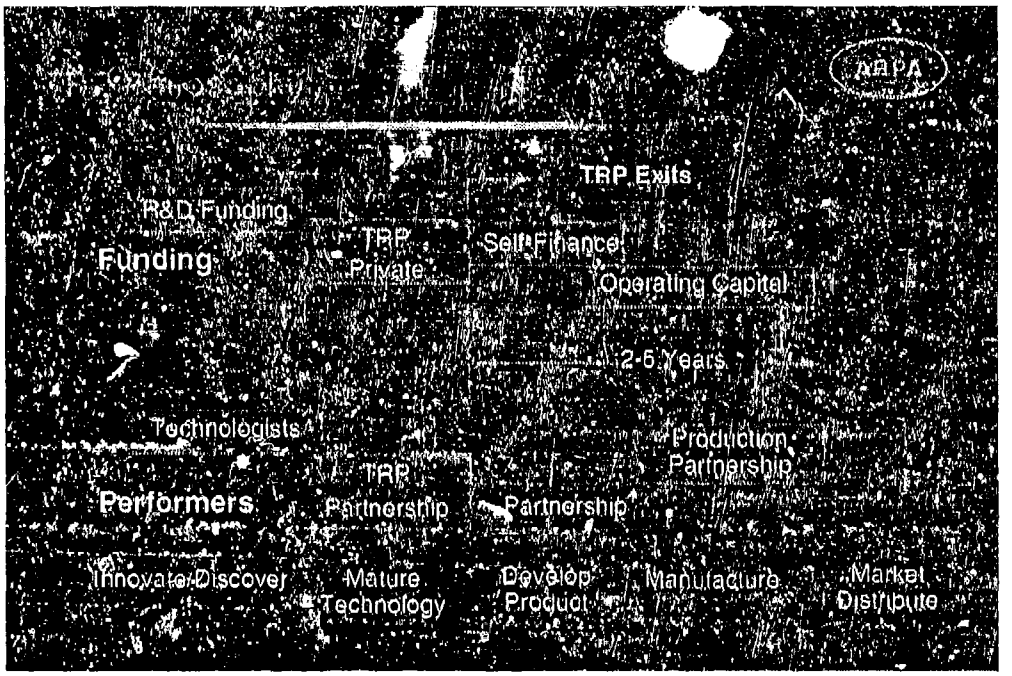
The TRP is itself a partnership among six separate agencies of the federal executive branch who jointly choose the areas for focus, publish the solicitation, select the projects for funding, and represent the government on project teams as partners. In the upcoming solicitation, each of the Military Departments will be separately represented on the Defense Technology Conversion Council, the "Board of Directors" of the TRP.



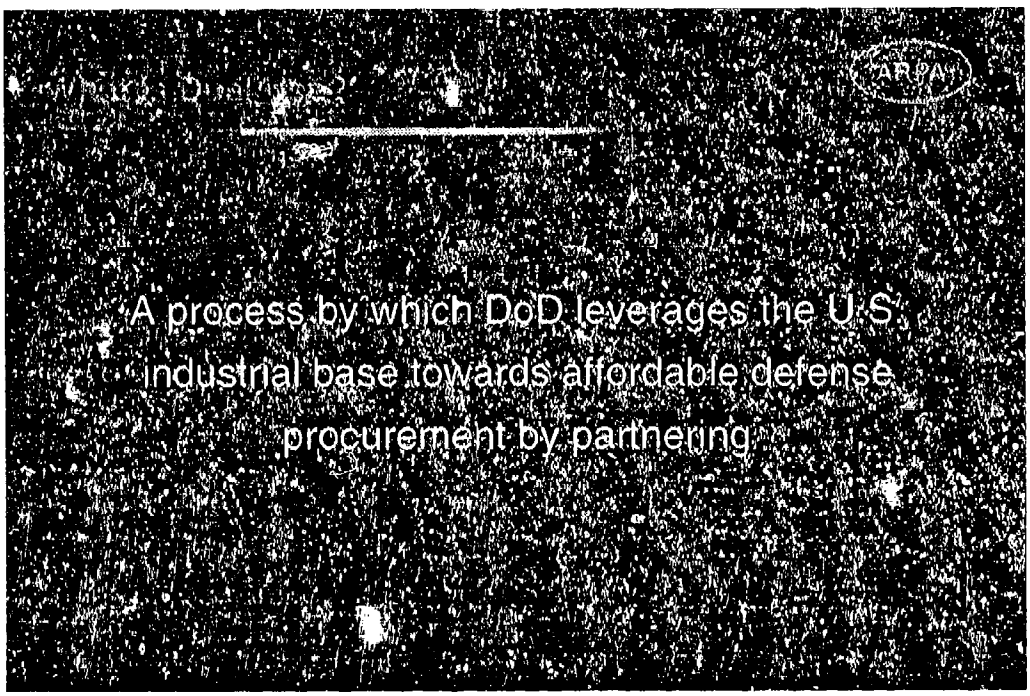
What benefits might these be? Commercial firms are looking to make money, the DoD is looking to save money. We are looking to buy the critical technologies that we need at a price consistent with the commercial market, not the synthetic market set up during the Cold War. Sometimes these technologies won't be naturally developed in a direction of DoD need or won't be developed at all because of a commercial risk that is too high, this is where dual-use becomes important. Sometimes no new development is required, an existing technology or industry needs preserving. In that case, dual-use means finding new uses and new markets for these technologies. And where none of this is appropriate, then dual-use means developing new manufacturing techniques that flatten the price-volume curve so that even small lots or high variety can be produced affordability.



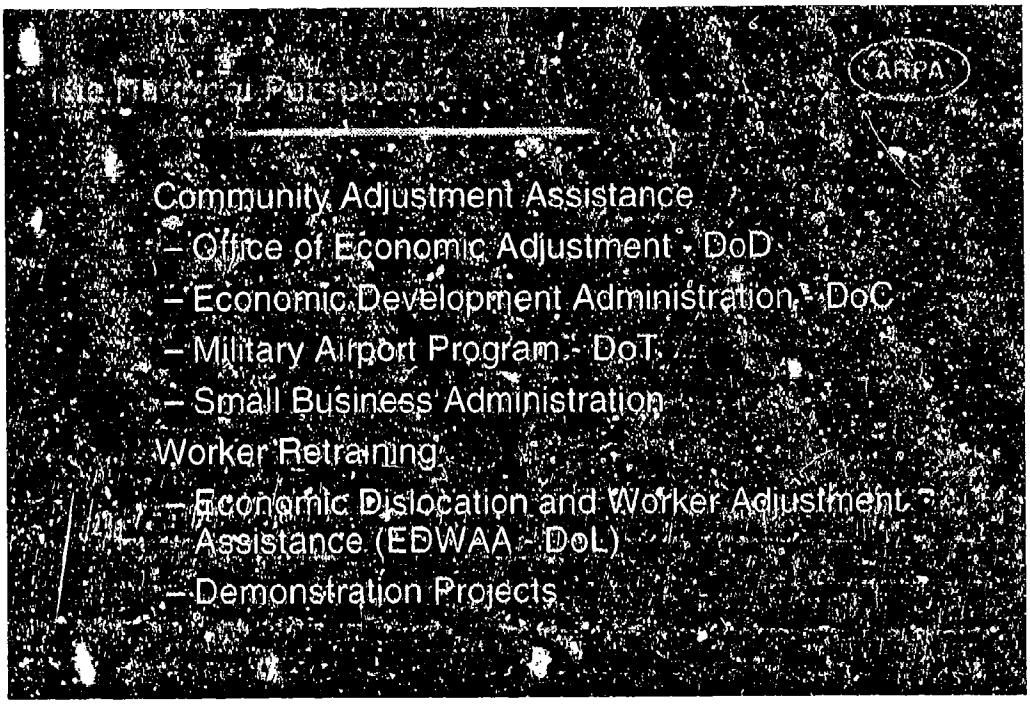
Now, let's talk about the TRP, a program based around the bigger notion of dual-use that we have just discussed. This is the chart that I always use first just to demonstrate that the mission statement of the TRP, unchanged since the beginning of the program, does not anywhere contain the words "defense conversion." Rather it talks about commercial-military integration and dual-use. There are three parts of the program: (1) the technology development part which works to create new technologies, (2) the deployment part which are principally third-party activities to provide technology to small and medium sized manufacturers, and (3) the education part which is concerned with trying to raise the art and craft of manufacturing into a science on a par with other scientific disciplines.



This chart is a graphical depiction of the role that we envision for the TRP. The top line show how the various stages of development are funded in a TRP-like endeavor. After early R&D funding is provided in a conventional way, the TRP enters the process as a development partner, investing as much as half the total cost of the effort. As shown in the bottom line, the proposing team, partnership, or consortia performers a technical effort selected along several criteria including a promise of both commercial viability as well as compelling benefit to the DoD. When commercial viability as been established, TRP financial participation in the venture ends and the partnership moves ahead towards a dual-use product.



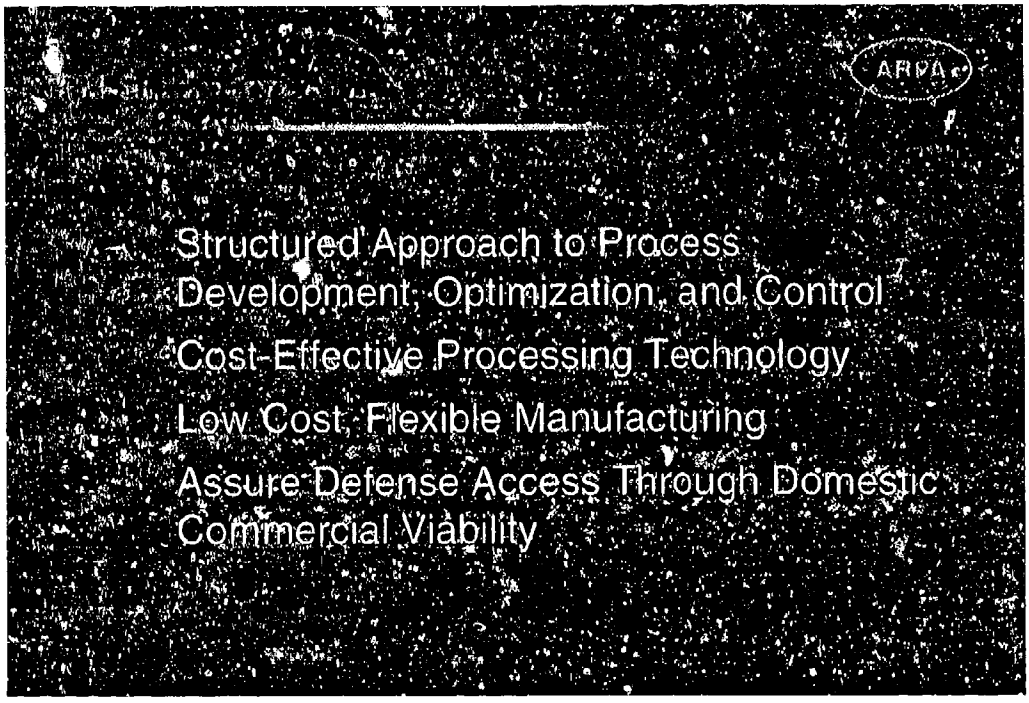
There is much misunderstanding about the dual-use model. Unfortunately, too many have tried to warp the definition to serve specific special interests. It is not a program for defense conversion but rather a model for a new way of doing business for the DoD. It is itself an experiment in Commercial-Military Integration in which the government is no longer simply a customer but rather a partner in a large activity that has a chiefly commercial objective.



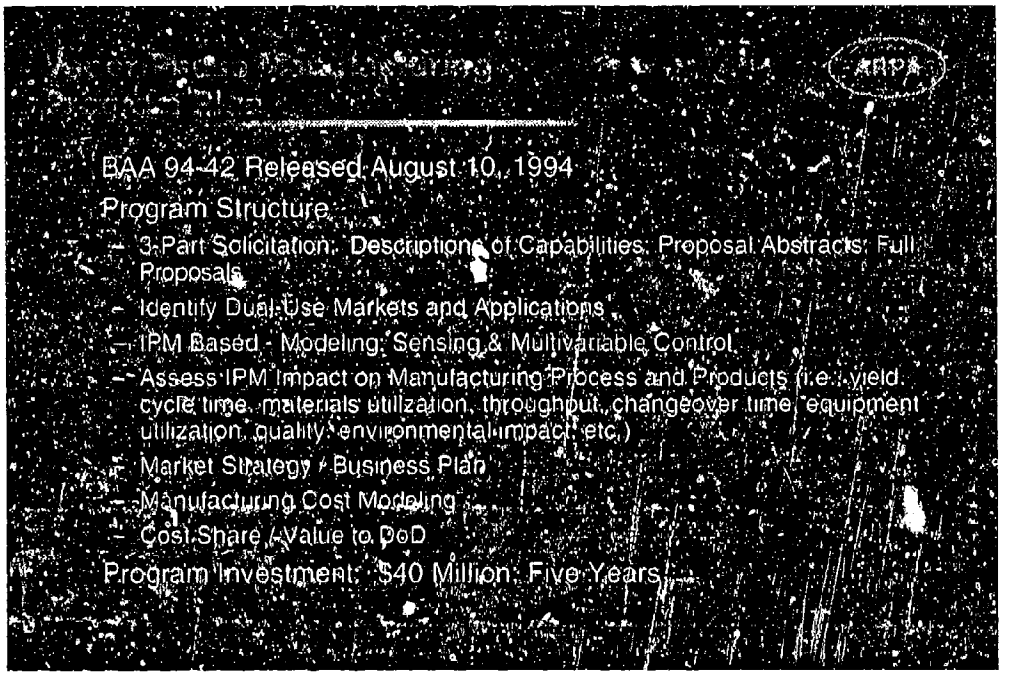
The first is the area of Community Adjustment Assistance and is one of the categories that is most most concerned with defense conversion and transition. These are activities directly aimed at helping individuals and communities hard-hit economically by defense down-sizing. The OEA was created in 1961 to help communities cope with military base closures and organizes planning groups, provides planning grants and help develop reuse plans. The EDA has broader authority with an annual budget approaching $100 million. In the DoL EDWAA, in partnership with state and local agencies, has a FY 94 budget of over $1 billion to provide expanded training programs for displaced defense workers including counseling , retraining , and job search.



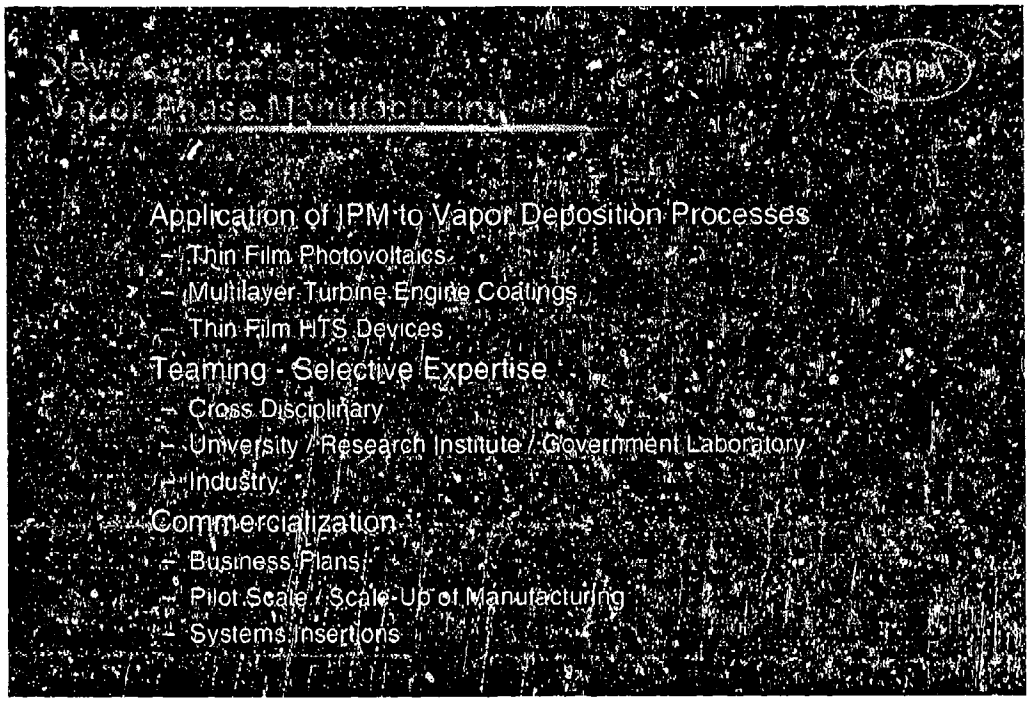
The third pillar of the program is devoted to the integration of the commercial and defense industrial bases. Three of the most important strategies are shown here. At the highest level are certain legal impediments, the DoD must be given certain authorities for streamlining small purchases and trying out new ways of doing business. The DoD must revamp its own web of regulation and specification that hobbles most commercial companies in trying to do business with the government. Finally, and its relative position here is probably correct, is the strategy of dual-use.



The IPM strategy is a proven method for developing and transition new materials and manufacturing technologies into both defense and commercial markets. It allows industry to continuously assess the economic viability of the manufacturing technology under development and has the capability of developing flexible manufacturing systems such that small lot size defense production requirements can be accomplished on high volume commercial manufacturing lines.



A three part solicitation was developed to assist team formation and to hopefully reduce non-competitive proposal writing. The first stage called for submission of descriptions of capabilities to aid team formation; the second stage evaluated proposal abstracts and the third stage will be final competitive proposal evaluation. Materials processing and manufacturing technology development is pursued with clear business strategies and the impact of process equipment development is assessed with manufacturing cost modeling. ARPA will invest about $40 million over five years.



- Product Focus

  Photovoltaics: Flexible
  Copper-Indum-Diselenide (CIS)
  Cadmium Telluride (CdTe)

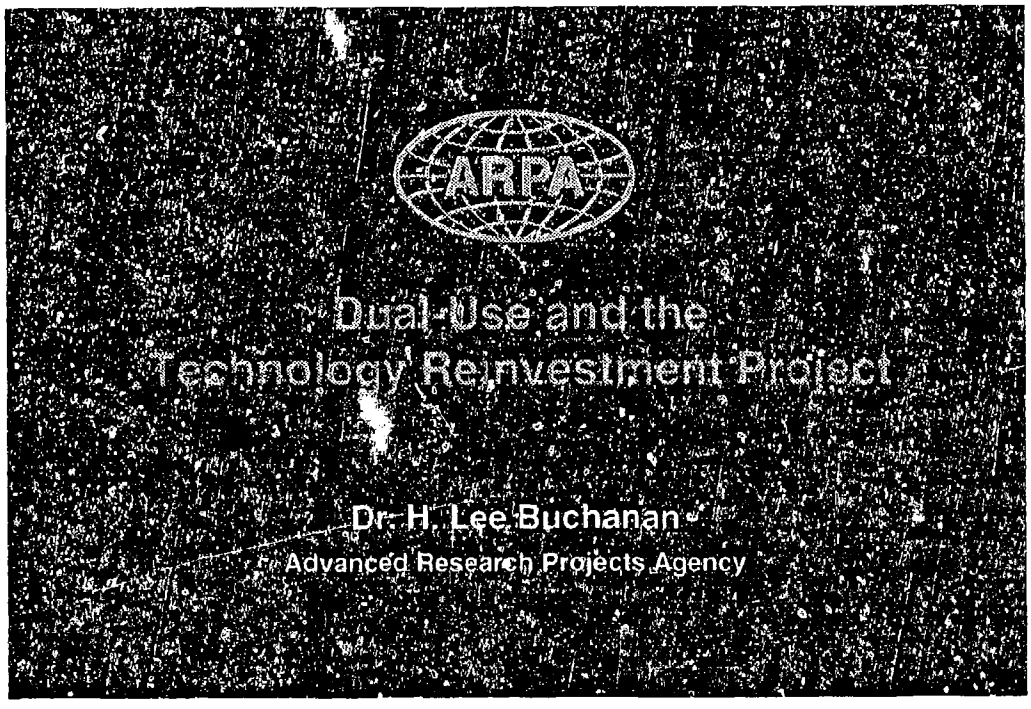
  Engine Coatings: Thermal barrier
  Erosion resistant

  Thin Film HTS: Communications
  Medical Instruments
  Imaging

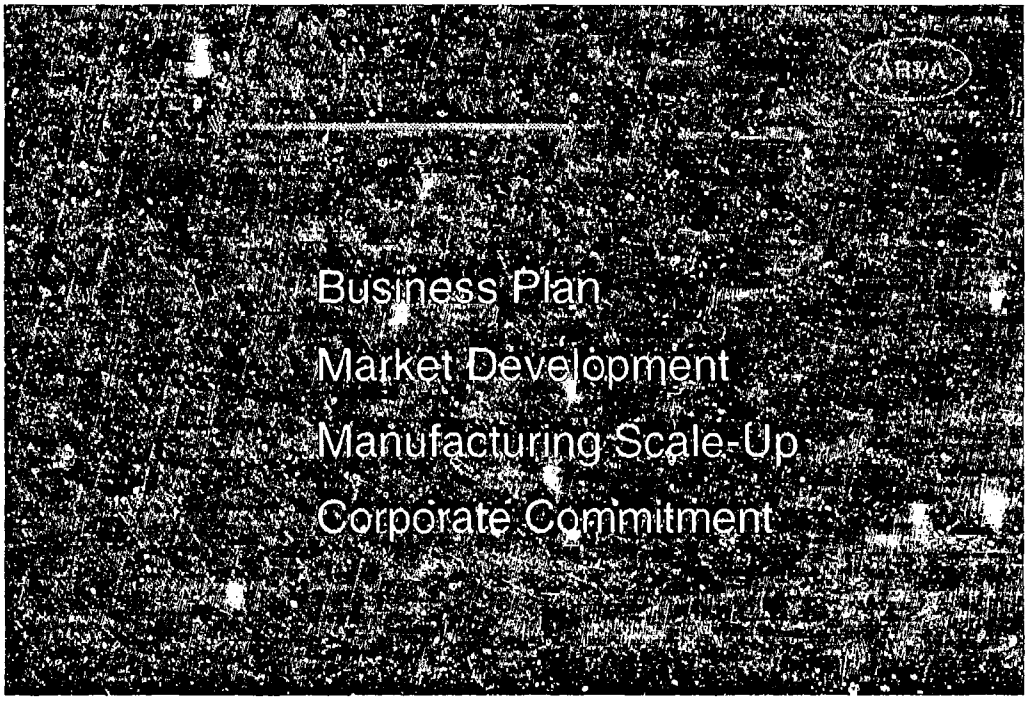
- Teaming

  Interdisciplinary approach is emphasized to achieve all aspects of program - developmental and manufacturing

- Commercialization
  - Business plans
  - Technical cost modeling
  - Pilot scale manufacturing
  - System insertions



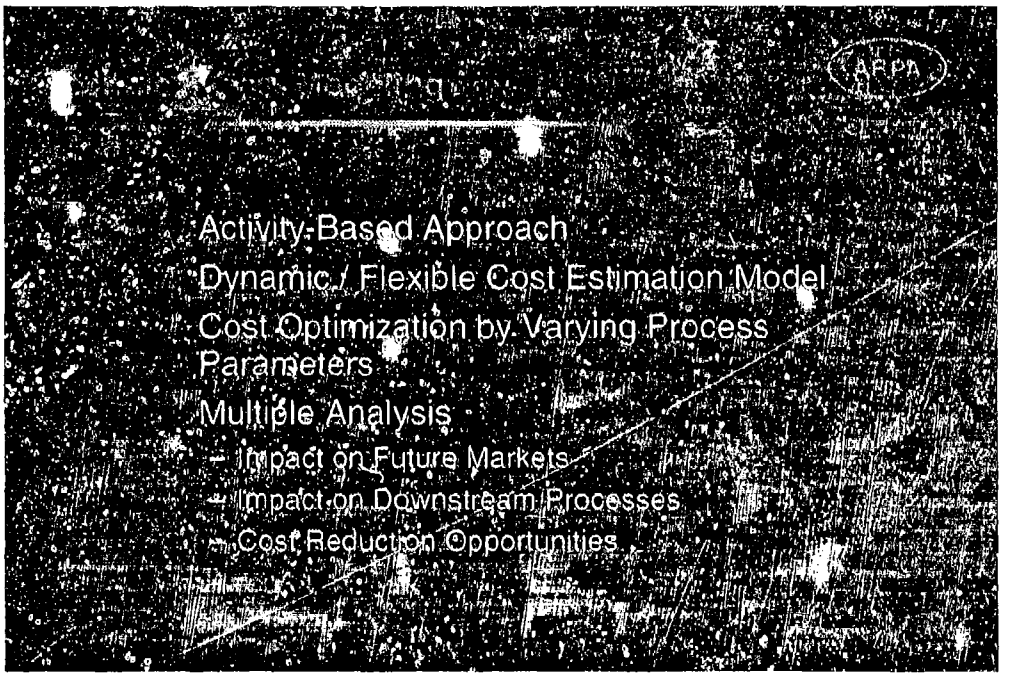
The administration's efforts in defense conversion, reinvestment, and transition span many Departments and Agencies beyond Defense. There are three thematic pillars which make up this activity. Two are described here and I will talk about them first because I won't be touching on them much afterwards.



Process and cost optimization are also linked to the business plan.

The price a commodity can bear will influence the extent or type or process optimization that can be justified.

The plans layout the roadmap the technology and business must follow to ensure commercial success.



Activity-based approach simulates fabrication and assembly costs.

Competing materials, processes, and technologies can be assessed.

The justification of a new process and equipment hinges on a strong economic story.

In complex processes, this justification is not a simple analysis. A total manufacturing cost approach is more applicable than traditional accounting analyses.

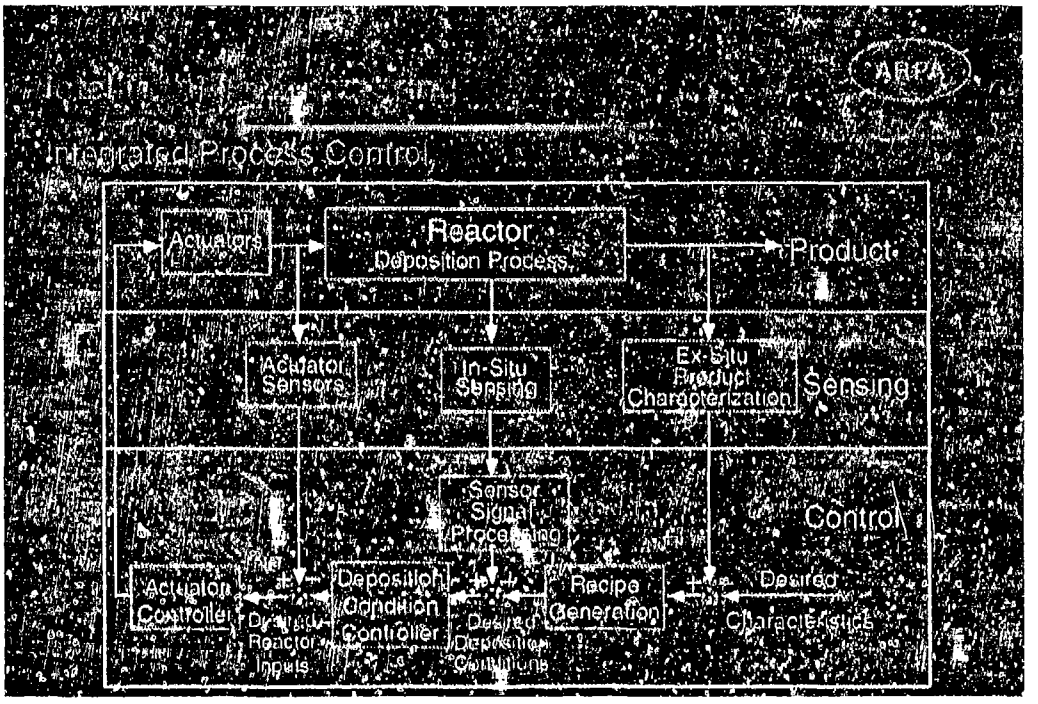
For example business sensitivity to changes in product designs, process conditions, and market projection can be assessed.

How good is good enough?

Use the market current and future requirements to dictate how "good" the process must be

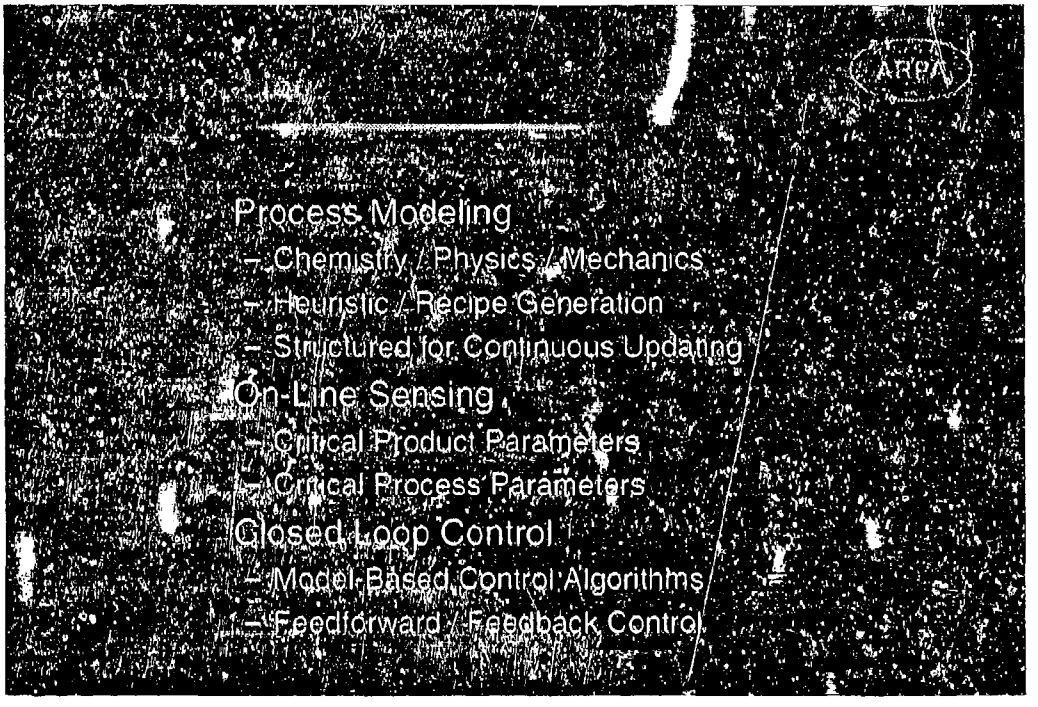
- Market Analysis

- Business Objectives

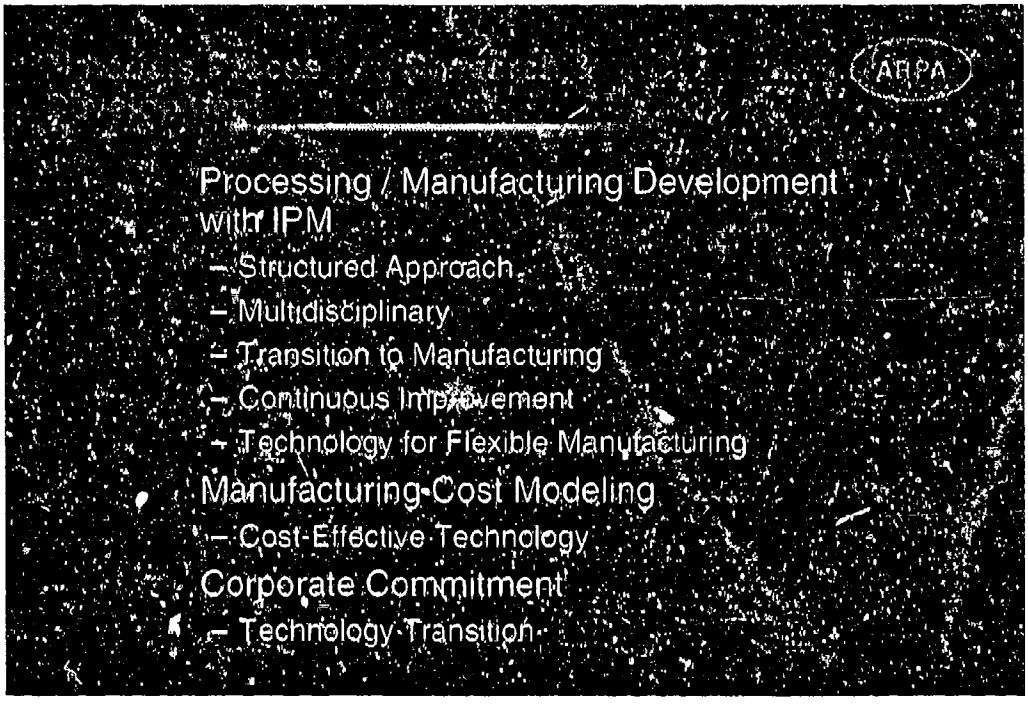


Three levels of Integrated Process Control

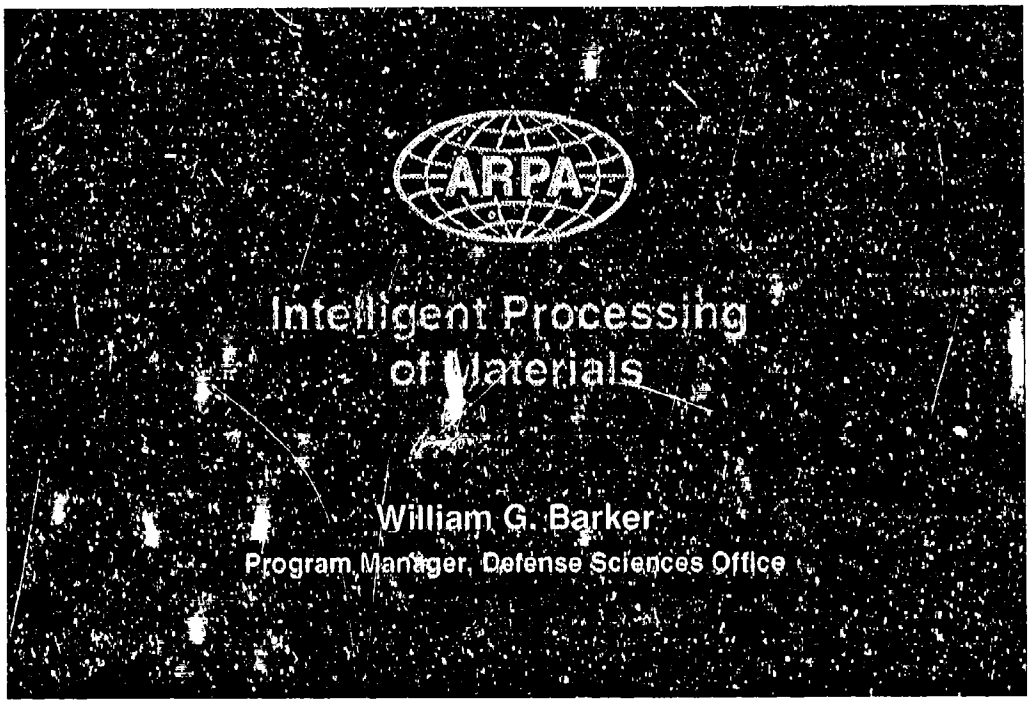
1. The Manufacturing Process
2. On-line Sensing
3. Model-based control



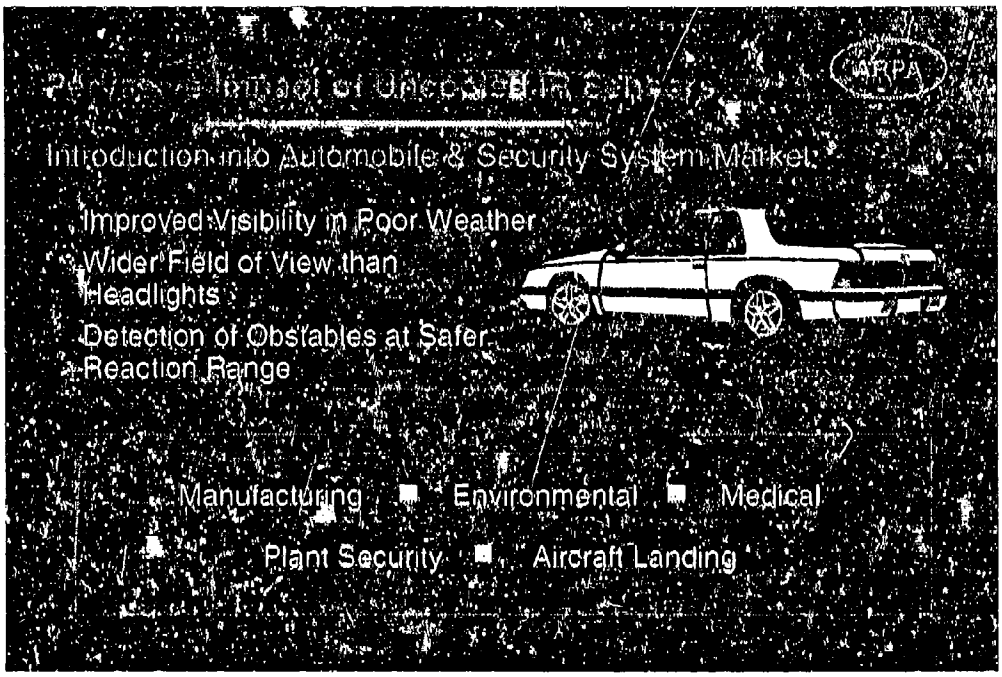
The IPM strategy is to develop a materials manufacturing system that achieves cost-effective product production through development and application of appropriate modeling, on-line sensing and multivariable process control. The process model captures the most current scientific or heuristic knowledge of the process in a computational format for process scale-up and control purposes. As additional process knowledge develops this computational model can be updated and process know-how maintained. A process sensitivity analysis run on the model provides insight into the critical process parameters for on-line sensor development. On-line sensing is also desirable for critical product parameters which provide on-line quality control. These on-line sensors require advanced algorithms in order to relate the multiple sensed signals to the multiple process control variables in closed loop controller.



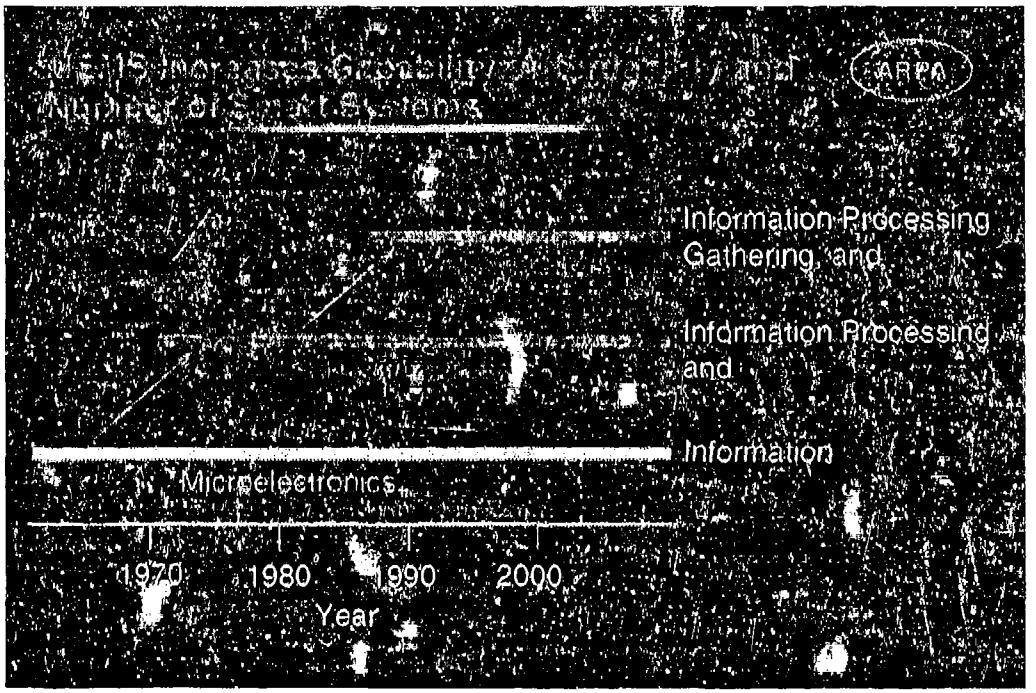
The Department of Defense has literally spent billions of dollars on research and development of new materials. Most of these efforts resulted in intellectually interesting research publications but relatively few have transitioned into either defense or commercial products. Why? Because the metric used in judging the success of a program or attractiveness concept has been materials performance, with little serious consideration of manufacturing cost. In the past, the goals of stronger, lighter, stiffer, more corrosion resistant, higher strength at elevated temperatures were pursued with the assumption that if the material offered a signification performance advantage, the military would pay for it. These days, in times of limited resources, shrinking budgets and highly volatile defense markets, the notion of cost effective performance and defense production on commercial manufacturing lines has captured significant interest. The application of intelligent processing of materials (IPM) methods, coupled with manufacturing cost modeling and corporate commitment establishes the structure to do just that.



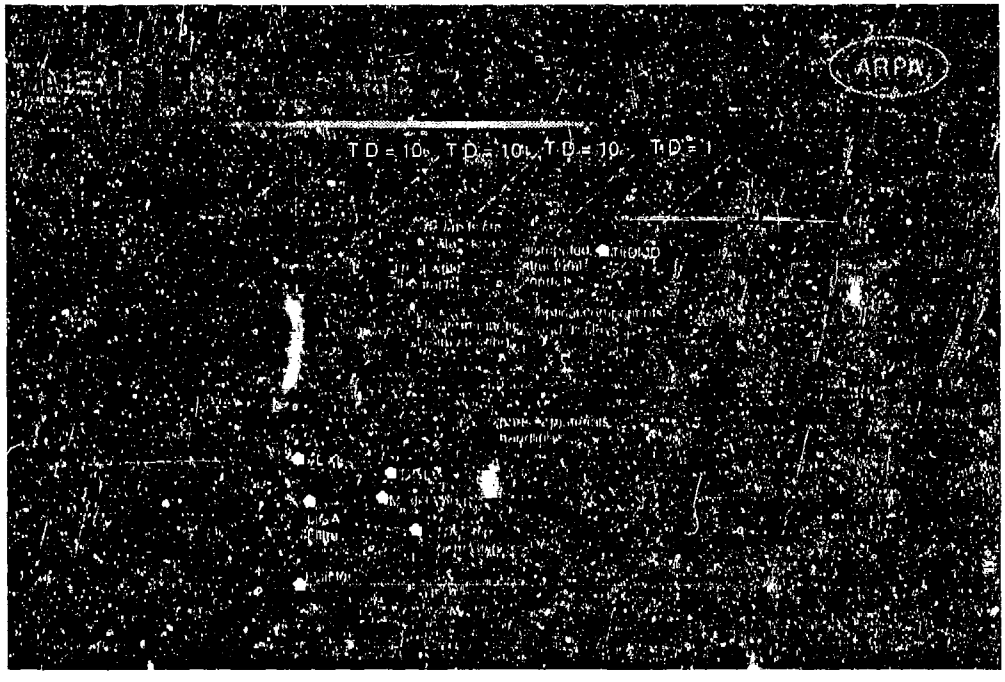
Good afternoon, I am Bill Barker from the Defense Sciences Office of ARPA. I run a variety of Programs in DSO including metal matrix and carbon/carbon composites; CVD Diamond; large format multichip module manufacturing; and vapor processing of materials. The unifying theme of all these programs is the development of cost-effective, materiels processing and manufacturing technology via intelligent processing of materials methodology.



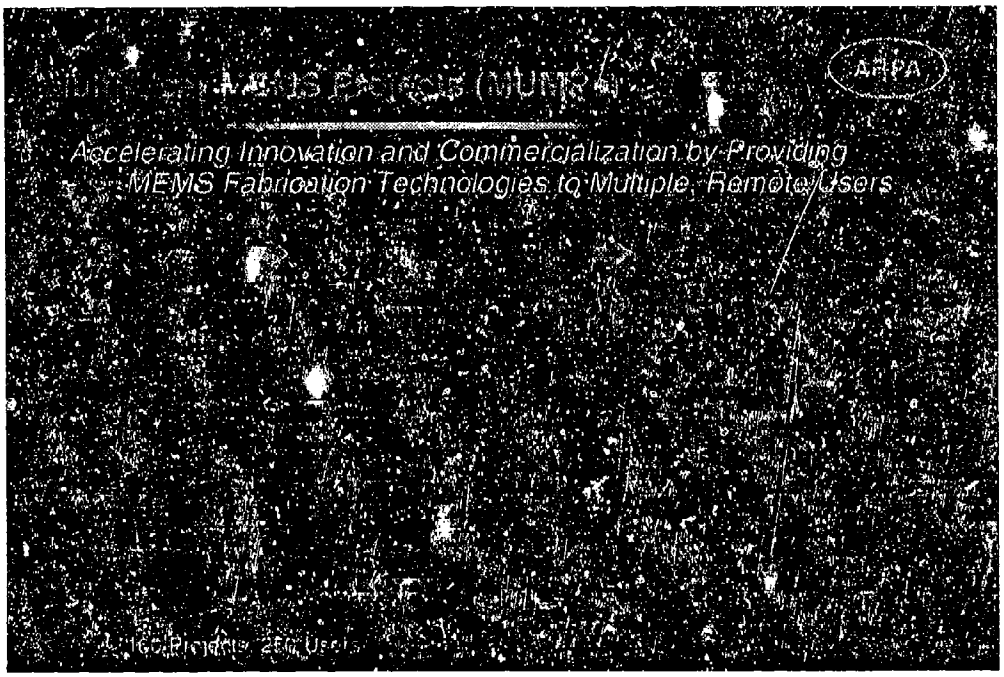
The infrared sensors have application in multiple application areas, with uncooled infrared sensors having the broadest applicability due to their lower cost and logistics simplicity. The major areas where uncooled infrared sensors can be used is in manufacturing, environmental, medical, plant security, and as aircraft landing aids. The initial introduction of uncooled sensors will be in the mobile market, with automobiles the highest volume potential user. This market is closely related to the police and security market, where prototype uncooled sensors have shown their utility.



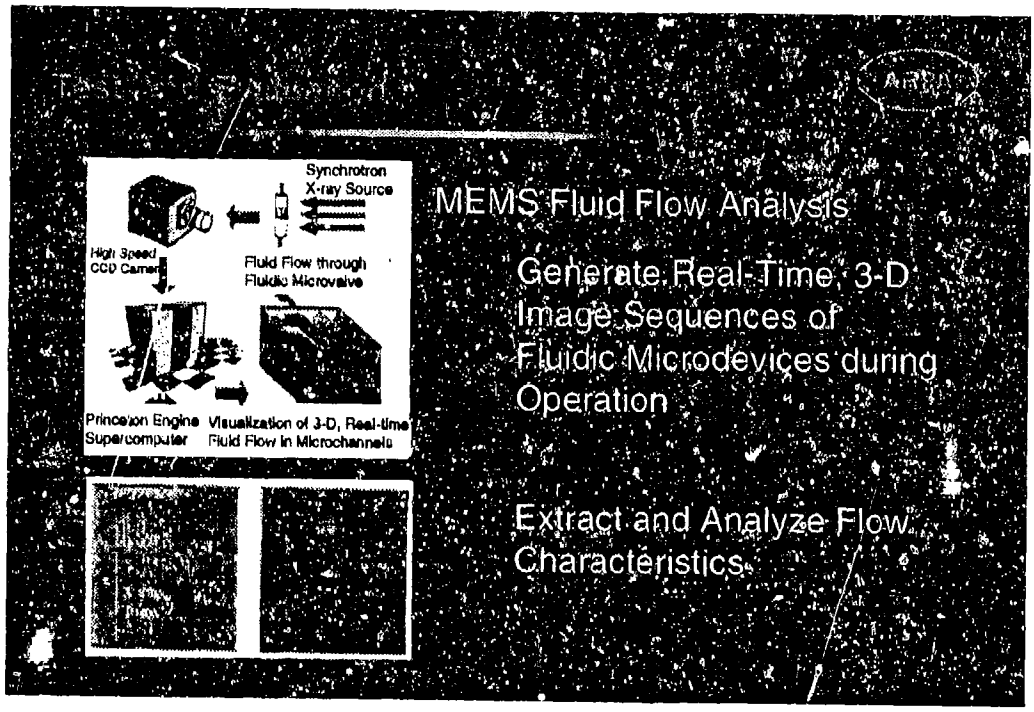
With the advent of microelectronics, the possibility of information processing was made readily available. From that point, the introduction of solid-state sensors allowed the gathering of information as well as processing power...and with microactuators, it will soon be possible to actually control the environment with fully active closed-loop systems, in addition to gathering and processing information.



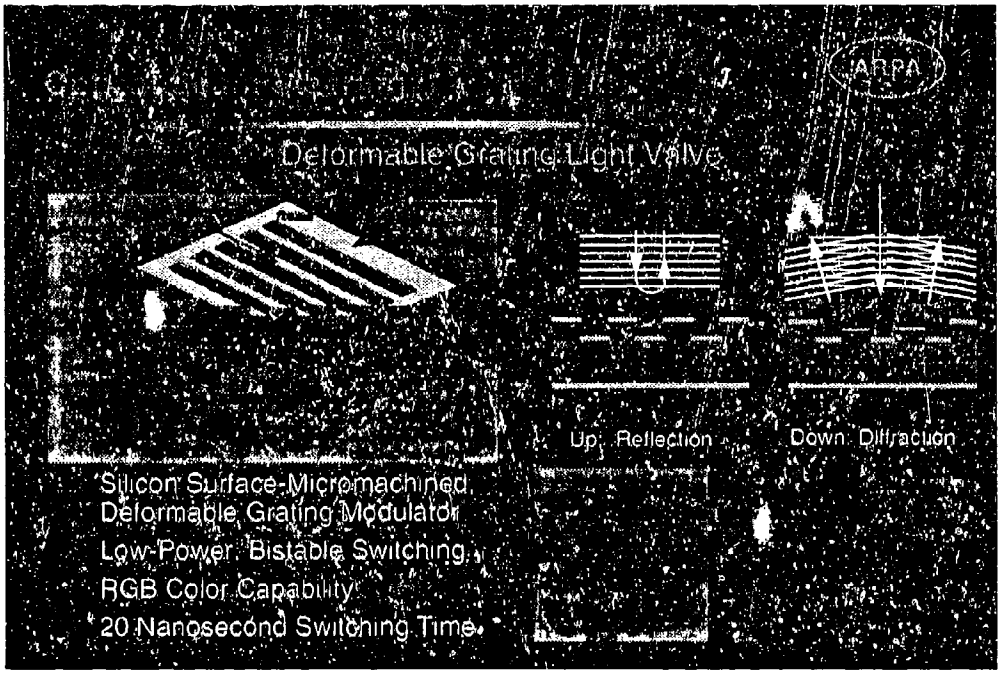
This integration map shows the development in MEMS from a different perspective. The abscissa represents the number of degrees of mechanical freedom in a MEMS technology, and the ordinate is labeled with the number of transistors on a MEMS device. The transistor-to-degrees of mechanical freedom-ratio, therefore, demonstrates the area of this technology that has been explored, and gives an idea of what remains.



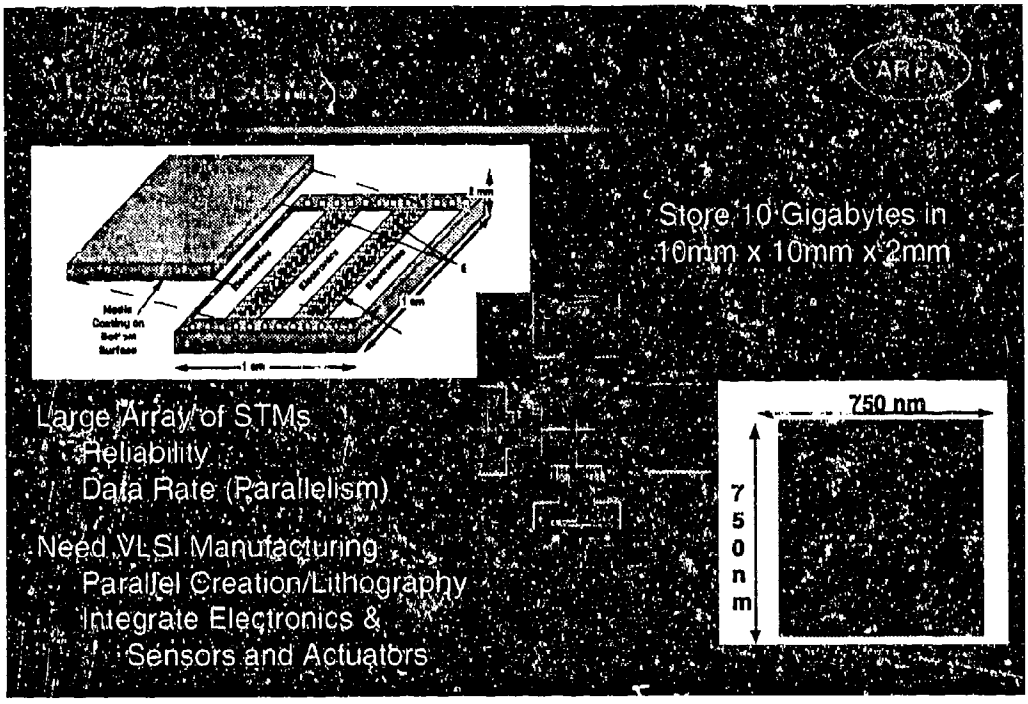
Infrastructure is another crucial aspect of the ARPA MEMS Program. Without fabrication services, it is not possible for many organizations such as universities and businesses to invest realistic amounts of time and capital in a new technology such as MEMS. Thus, ARPA has begun a program in which relatively inexpensive MEMS fabrication services are available to the general MEMS public. MCNC in Research Triangle Park, NC has been a main contributor to present for providing MEMS fab services. Here is a example of a Multi-User MEMS Process (MUMPs) run. Several organizations submit designs which are all within some design constraints, and MCNC provides the services from the initial masking to release, if desired. In conjunction with Tanner Tools, who have written a software package for layout and editing, MCNC now offers a short course for the MUMPS Process and LIGA, which was discussed earlier to some degree. MUMPS has shown marked improvement in interest from universities, industry, and federal organizations as well. For a mere $500, one can submit a design and receive it twelve weeks later, on a 1cm x 1cm chip. Additionally, 40% of the users are getting their first access to MEMS technology through MUMPS.



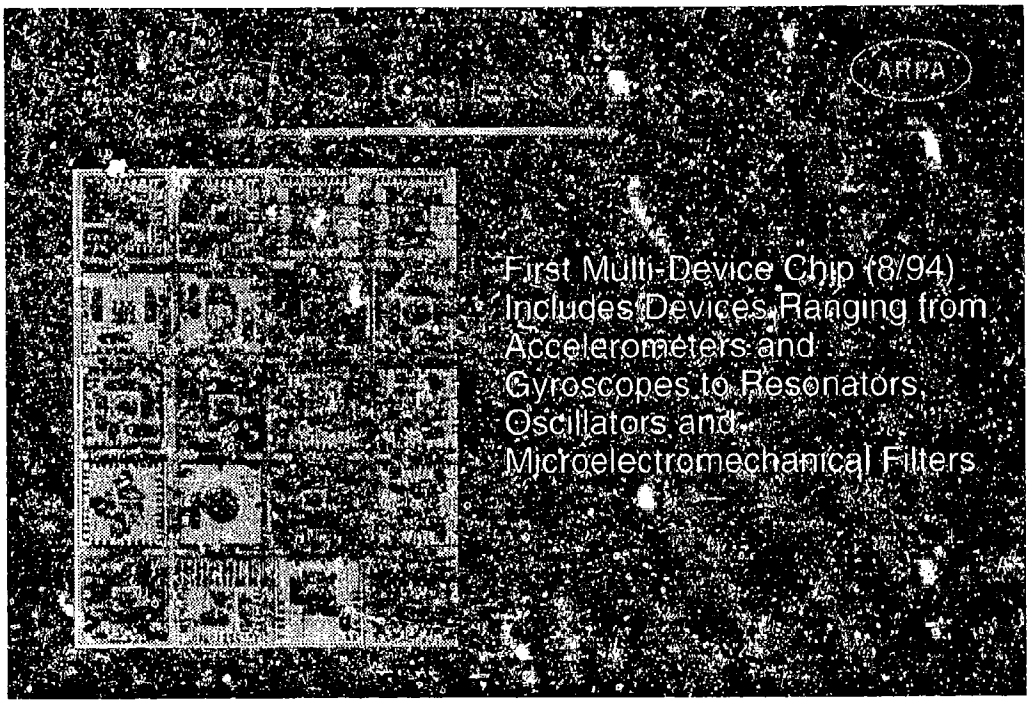
The test and evaluation stage of research and development is already underway for particular programs such as the MEMS Fluid Flow Analysis Program being conducted at the David Sarnoff Research Center. They have generated real-time, 3D image sequences of fluidic microdevices during operation, and they have also extracted and analyzed flow characteristics within the microdevices.



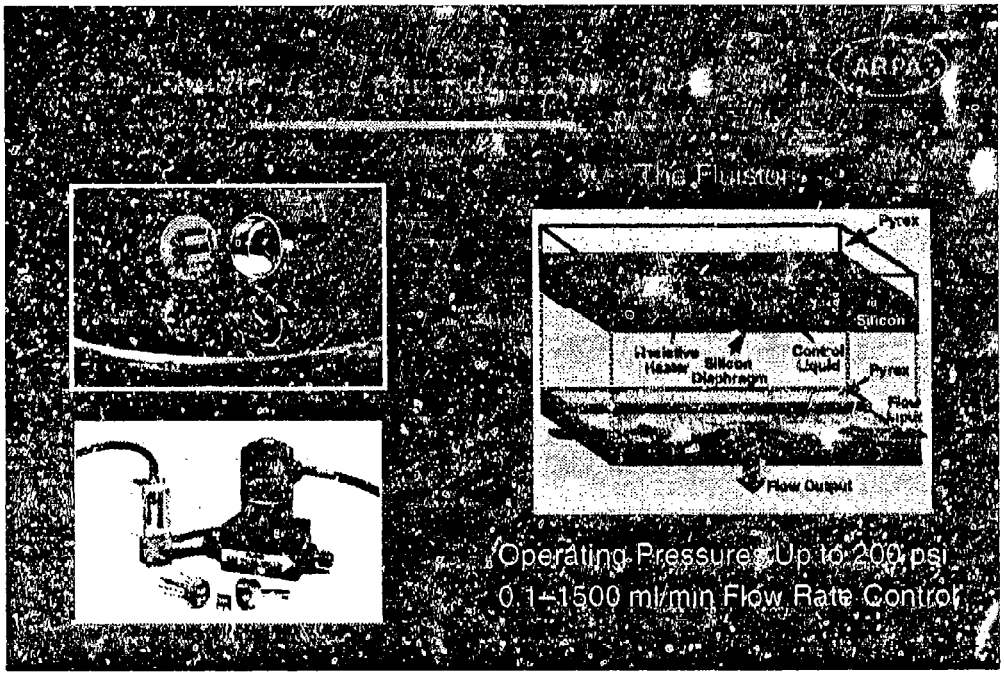
The Deformable Grating Light Valve has an aluminum top electrode and reflector which is the reflecting surface of the silicon nitride, which has parallel beams going across the frame. Directly beneath that is a silicon oxide spacer, which allows the aluminum reflector/electrode and silicon nitride beams to be suspended above the substrate surface. The beams are held up by tensile stress when there is no voltage applied, and they are pulled down electrostatically when a voltage is applied. The DGLV is an electromechanical diffraction grating; when the beams are in tensile mode, incident light normal to the surface undergoes perfect reflection, as a grating would be with a half-wavelength spacer. When the beams are undergoing electrostatic pull, then the effective spacing becomes a quarter-wavelength, which in turn is equivalent to -1-diffraction and +1-diffraction for incident light normal to the surface. In summary, the DGLV is a silicon surface-micromachined deformable grating modulator, a one-mask process; it is high-speed, and demonstrates bistability, RGB color capability, and has potential as a head-mounted and projection display, as well as a possible SLM Application.



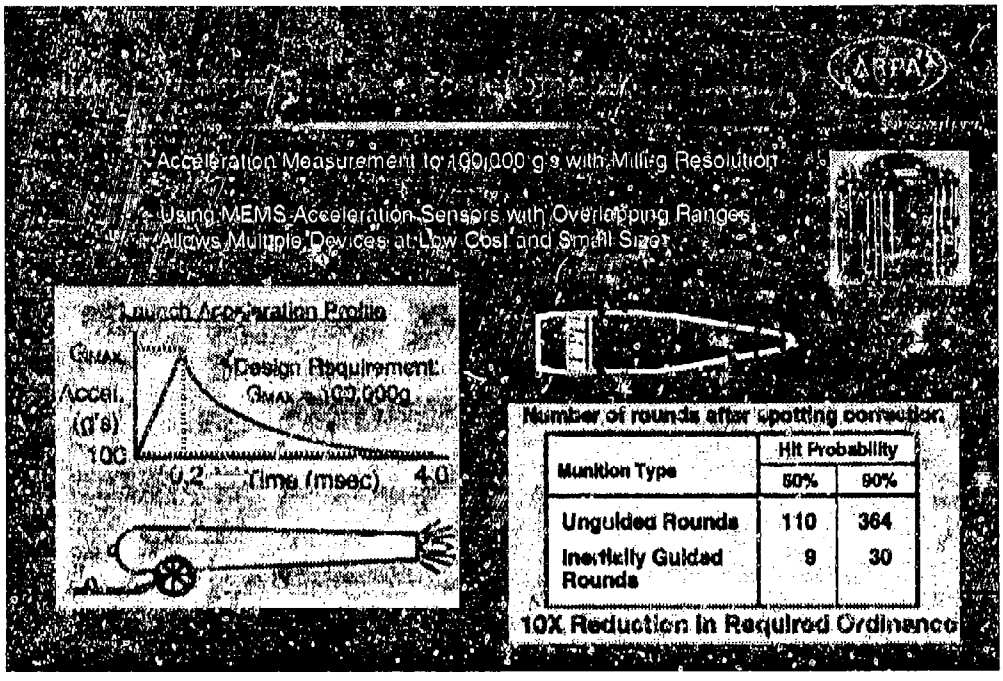
Cornell University and Carnegie Mellon are among some of the academic institutions working on developing high-density mass data storage systems, which aim for near-term goals such as a 10 Gigabyte storage element with 10mm x 10mm x 2mm volume.



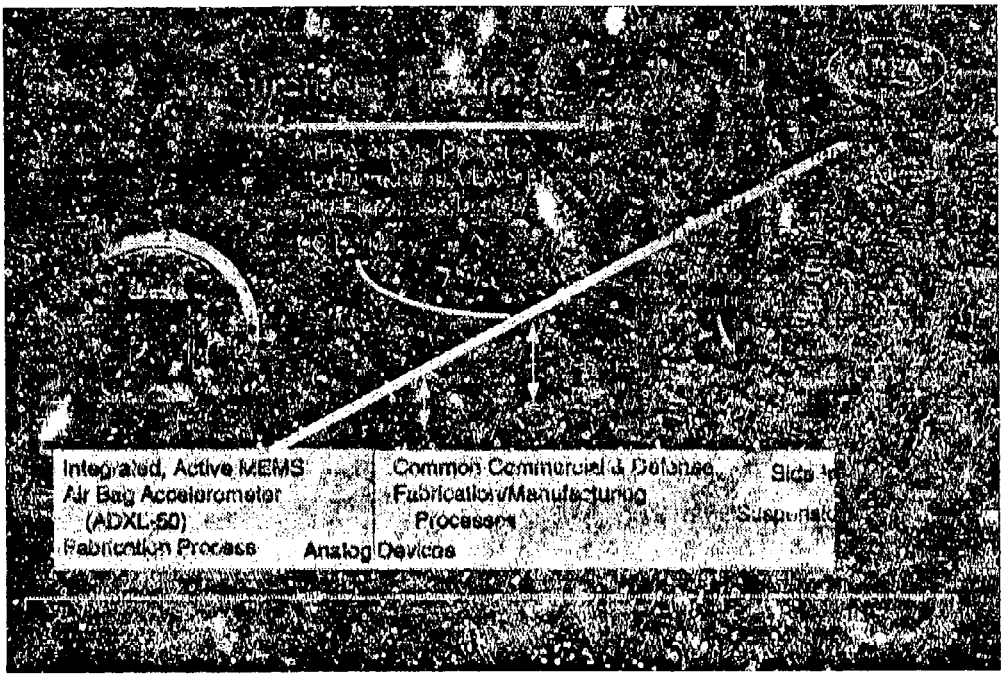
The ARPA-funded Analog Devices/U.C. Berkeley Multi-Project Chip includes devices ranging from accelerometers and gyroscopes to resonators, oscillators and microelectromechanical filters. The chip represents the wide range of devices and applications which can be fabricated in Analog Devices' BiMOS sensor process.



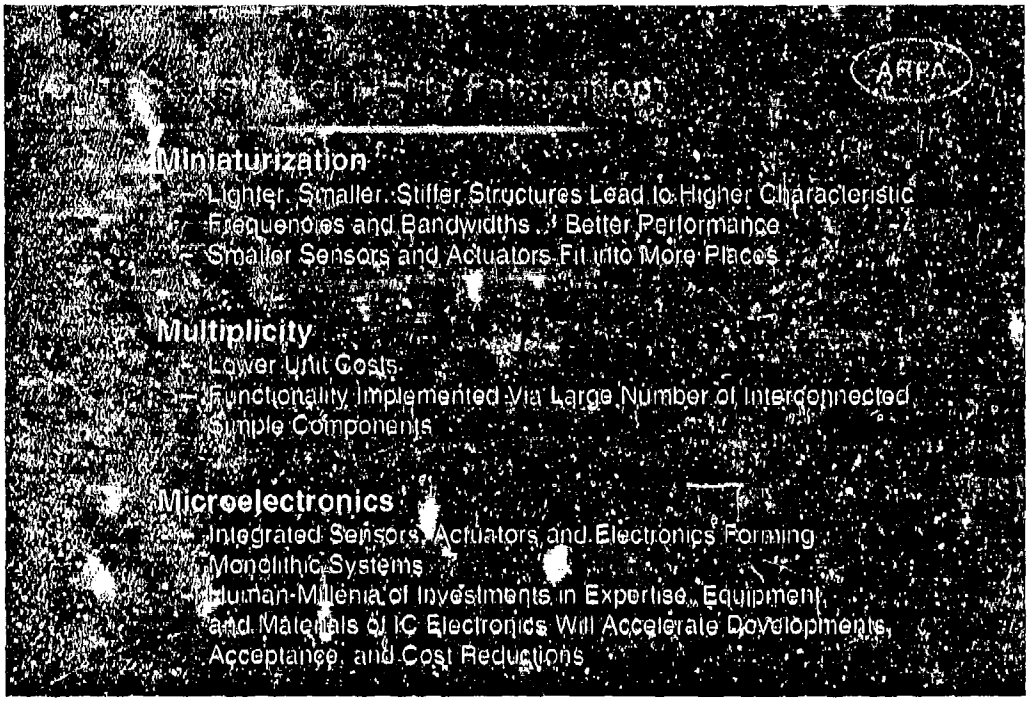
One of the application areas to which MEMS is relevant is Fluid Sensing and Control, or Analytical Instruments. Examples of this include a bulk micromachined gas valve, being developed by Redwood Microsystems, with a 0.1-1500 ml/minute flow rate control. The Fluistor, shown here in a size comparison with a regular flow control valve, can withstand up to 200 psi, which is the specification for the Porter Valve shown. Thus, you are effectively looking at two versions of the same valve, the only differences being mass, cost to produce, and convenience to install/portability. It is evident that the MEMS device is clearly advantageous for a number of reasons. The Fluistor works because a silicon diaphragm is heated ohmically when a current flows as a result of a switch being thrown; the control liquid within the cavity expands and causes the diaphragm to bow outward, which in turn cuts off the output flow of fluid. When current is zero, the liquid cools down, allowing the diaphragm to relax which in turn allows free flow. One disadvantage of this scheme is that the response time of reopening the valve could be a bit longer than a purely mechanical switch...depending on the thermal properties of the control liquid, and the amount used, however, this specification can be, and is being, improved upon.



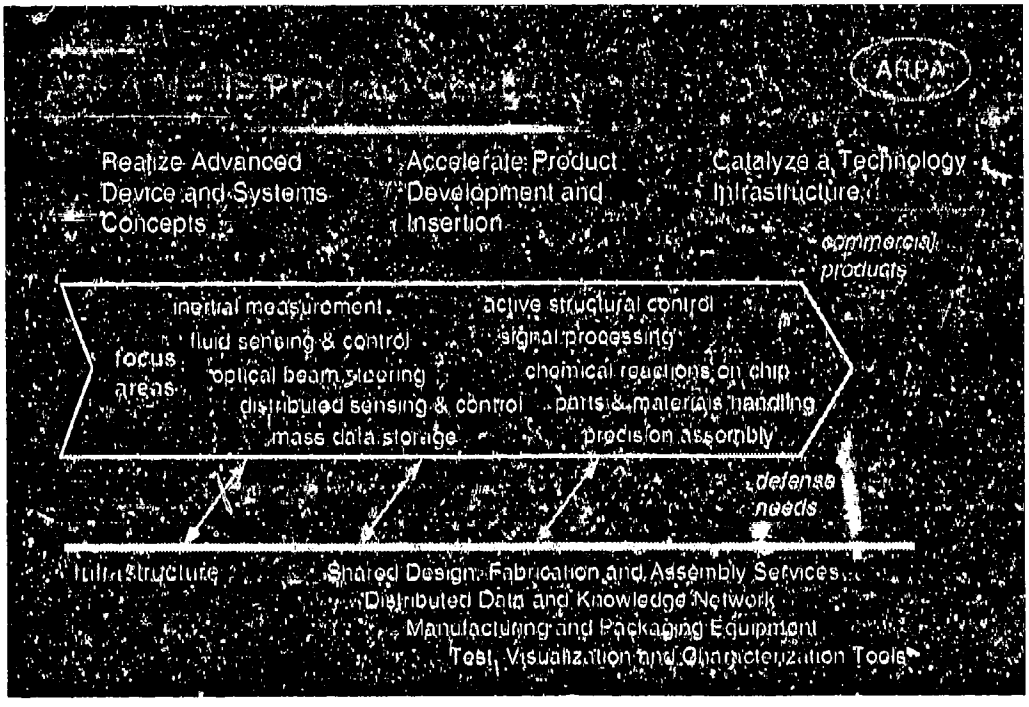
Inertial Measurement is a major contributor to the development of MEMS. The High-Dynamic Range Accelerometer under development by Draper Labs and the Monolithic Surface Micromachined Accelerometer, a product of Analog Devices, Inc., have both shown remarkable success as MEMS devices with potential high-end applications in both defensive and commercial systems. The High-Dynamic Range Microdynamic Accelerometer has withstood up to 100,000g's in flight...the electronics and other associated parts of the accelerometer tend to malfunction as a result of high acceleration before the actual accelerometer does. There are clearly advantages from a military perspective of installing the accelerometer within a long-range missile. 10X reduction in ordinance, less chance of fratricide, etc.



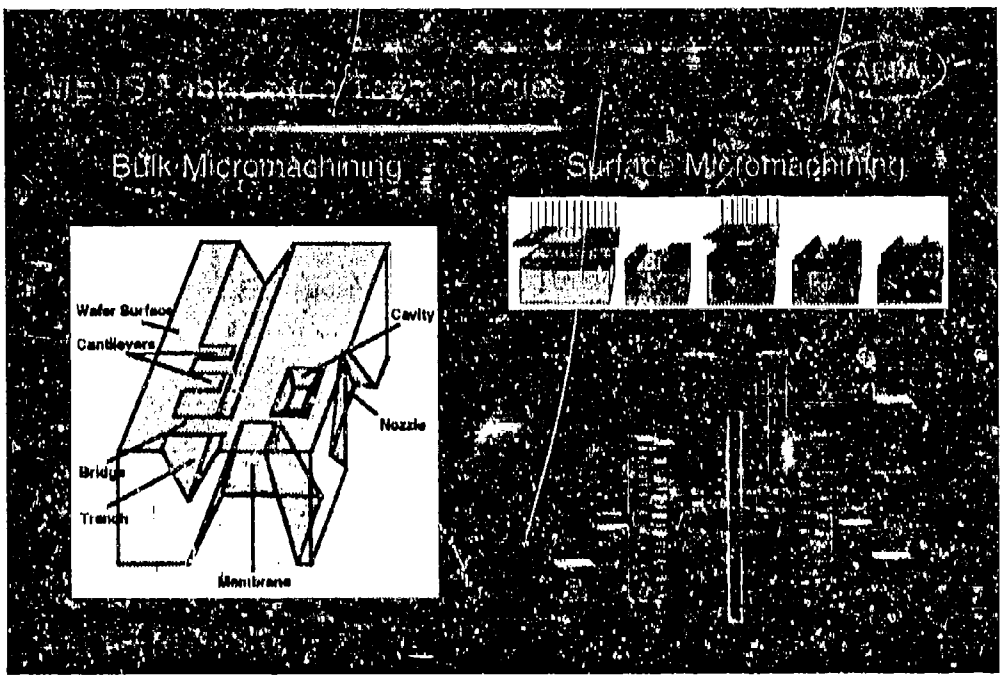
Analog Devices has developed the ADXL50 chip, which is presently installed in 1994 Saab Automobiles. Analog Devices has leveraged from their ADXL50 fabrication process, proceeding to develop from this technology a potential common, commercial and defense fabrication and manufacturing process. In addition, the advent of TRP will emphasize dual-use technology as new devices are developed and prototyped for application insertion.



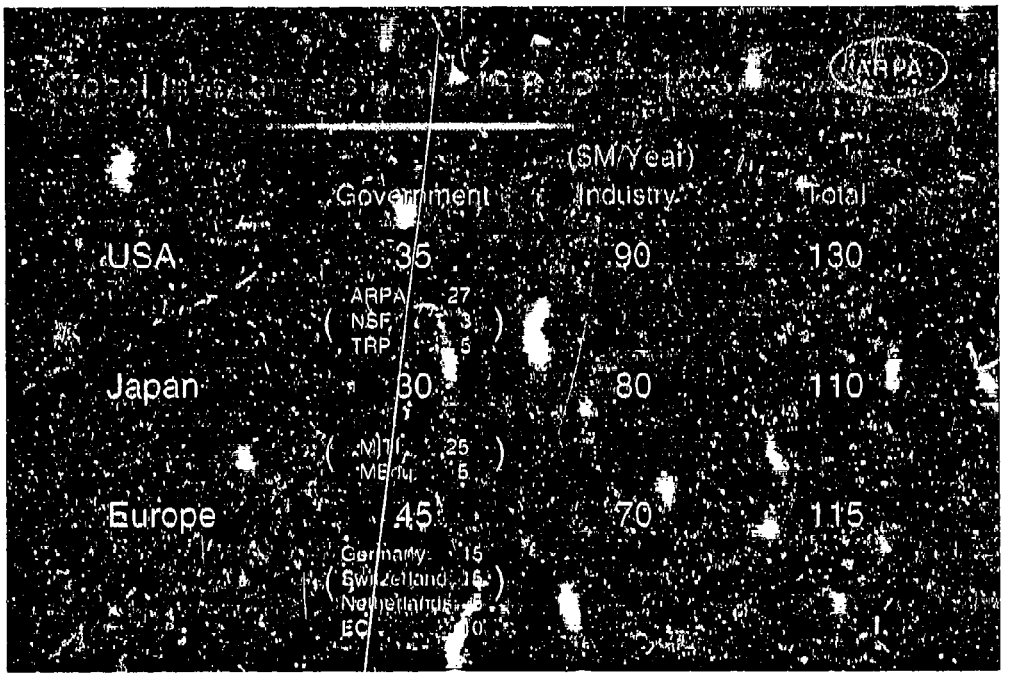
Although most people would tend to associate MEMS with miniaturization, it is crucial to realize that miniaturization is only one of the advantages that MEMS has to offer. Multiplicity leads to lower unit costs, and higher functionality implemented via a large number of interconnected simple components. Additionally, microelectronics technology is being used for the purpose of developing mechanical systems, which leads to better integration of systems, such as integrated sensors, actuators, and electronics forming monolithic systems, as well as the fact that human-millenia of investments in expertise, equipment, and materials of IC electronics will accelerate developments, acceptance, and cost reductions.



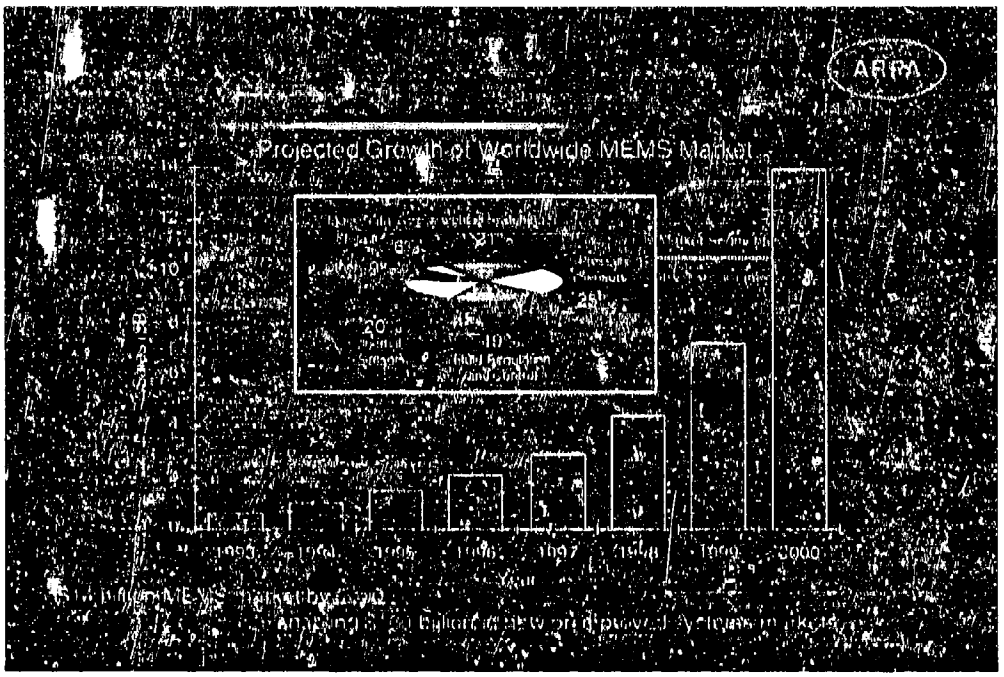
Within ARPA's MEMS program objectives and plan, are intentions to realize advanced device and systems concepts, to accelerate product development and insertion, and to catalyze a technology infrastructure. For these focus areas (inertial sensing, distributed sensing and control, optical beam steering, etc.) to eventually reach insertion levels in both commercial products and defense needs, it is essential that a strong infrastructure be established, consisting of elements such as shared design, assembly and fabrication services, a distributed data and knowledge network, and the development of manufacturing and packaging equipment, as well as testing, visualization, and characterization tools.



This slide depicts two types of fabrication technologies for MEMS, bulk micromachining and surface micromachining. Bulk micromachining consists of anisotropic etching of silicon wafers, which allows for only constrained geometries and limited IC compatibility; however, it is a very low-cost process. Surface micromachining consists of alternating, deposited thin-films. This allows for free-form, planar geometries, and better IC compatibility than bulk micromachining.

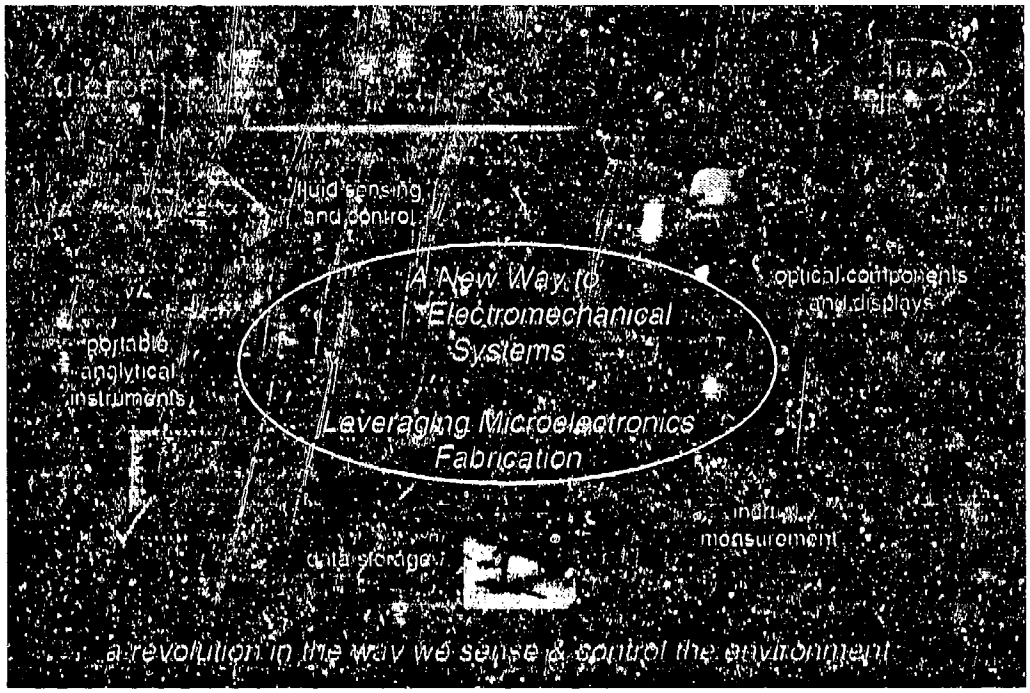


This slide depicts the projected total global investments in MEMS research and development in the calendar year 1995 in the US, Japan, and Europe.

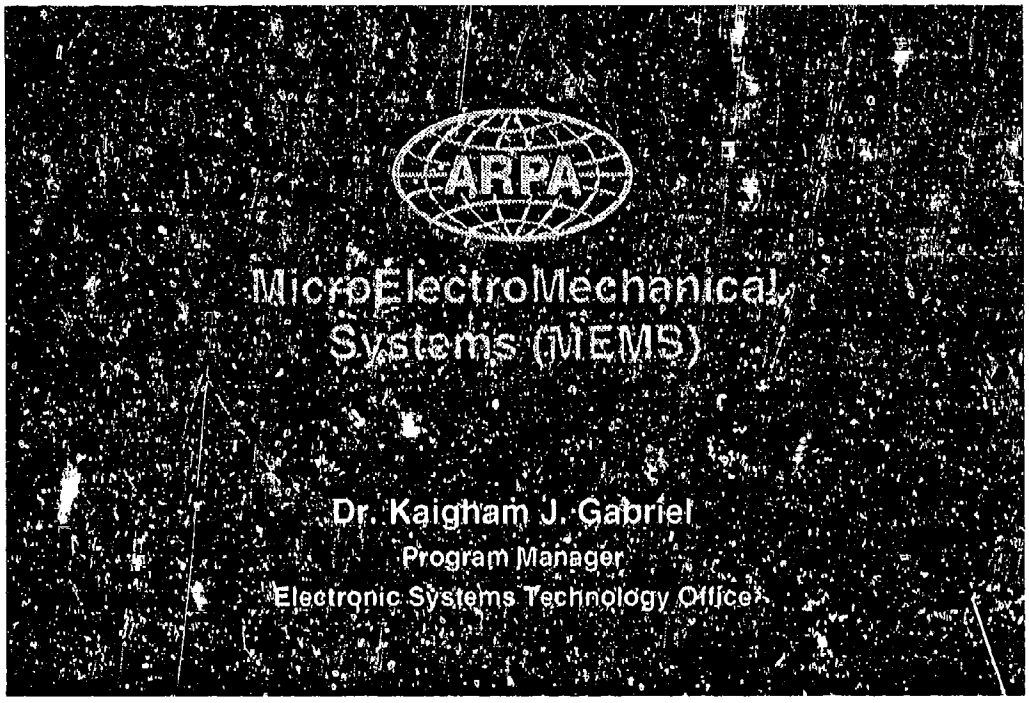


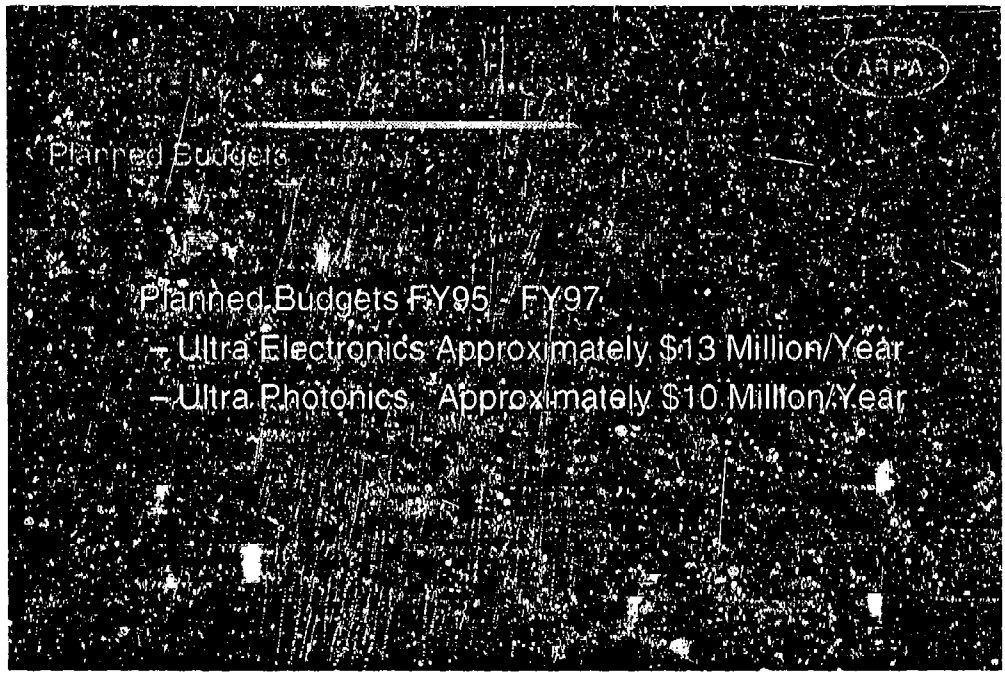
The projected growth of MEMS as a market factor is made difficult by the fact that MEMS technology is enabling in nature; it is not foreseeable to what extent MEMS will actually affect everyday electrical and mechanical devices and components in products both commercial and military. A conservative study conducted outside of ARPA has shown that MEMS is capable

of enabling $100 billion in new or improved systems by the year 2000.

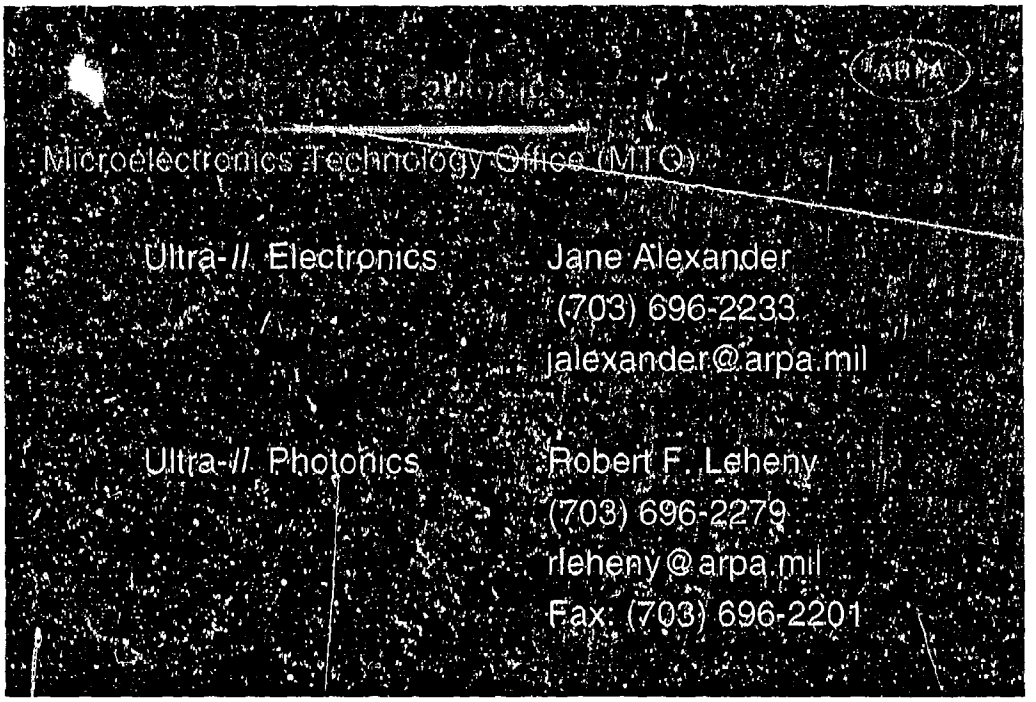


Microelectromechanical systems are the new enabling technology which will allow industry to leverage microelectronics fabrication for the purpose of making electromechanical systems. This enabling property of MEMS, particularly in areas such as fluid sensing and control, optical components and displays, portable analytical instruments, data storage, and inertial measurement, will provide revolutionary changes in the way we sense and control the environment.

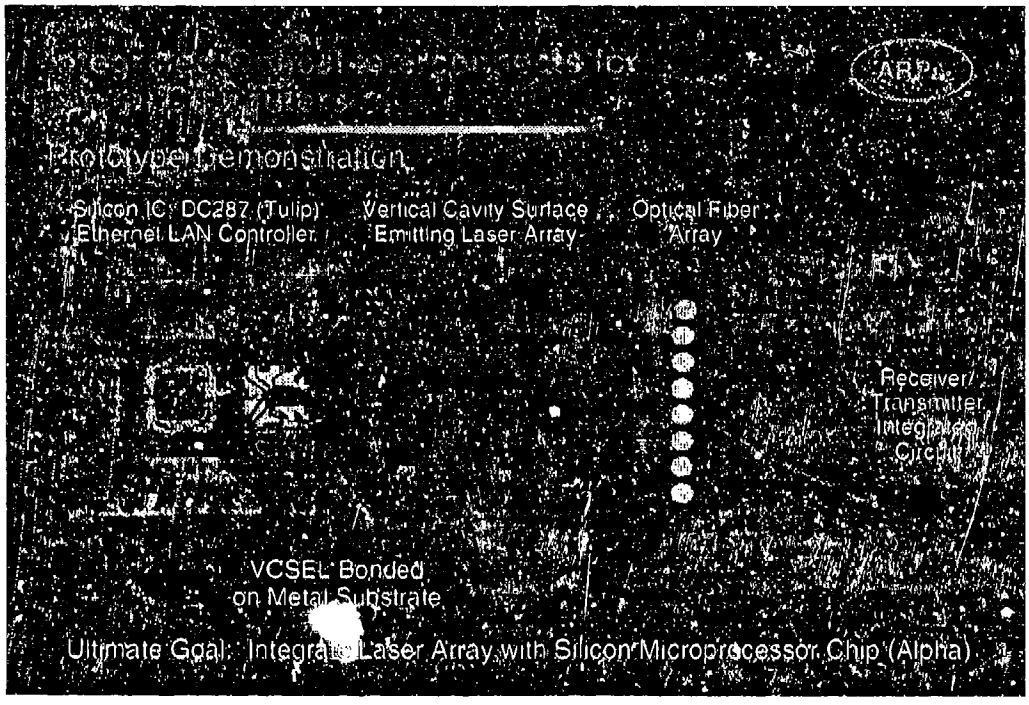

ARPA
MicroElectroMechanical Systems (MEMS)
Dr. Kaigham J. Gabriel
Program Manager
Electronic Systems Technology Office



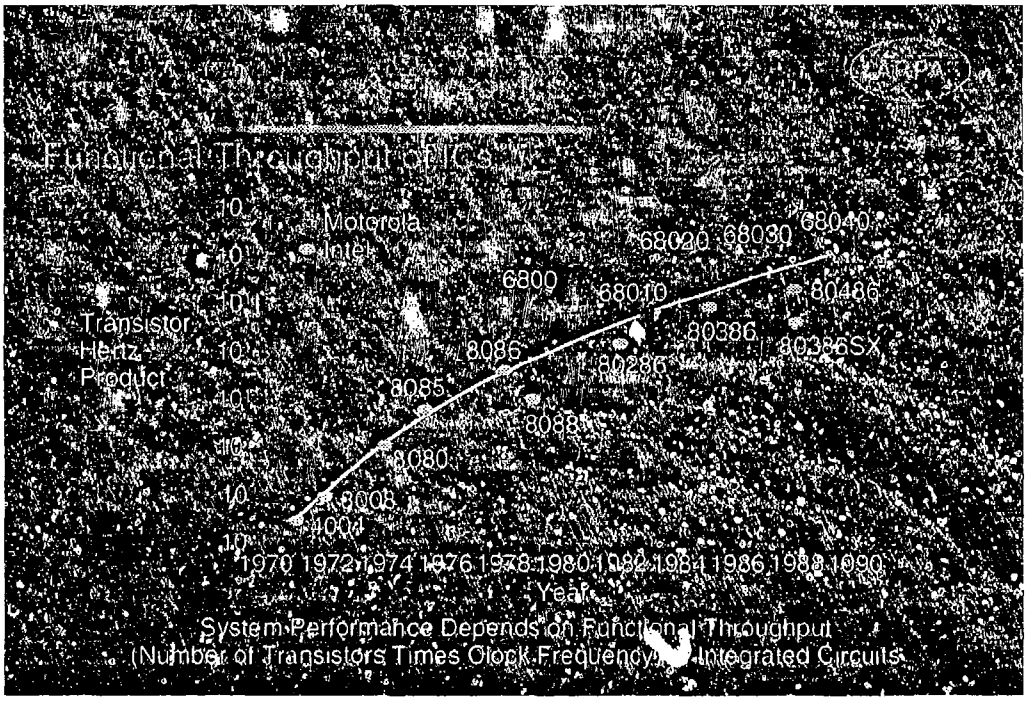
The goal of continuing the historic increase in electronic systems performance, beyond the point where conventional approaches break down, is a significant challenge. The budgets to address this challenge for the Ultra-Electronics and Ultra-Photonics programs are approximately, $13 million per year and $10 million per year, respecti /ely. This represents a substantial investment in the development of alternative technologies for future information processing systems.



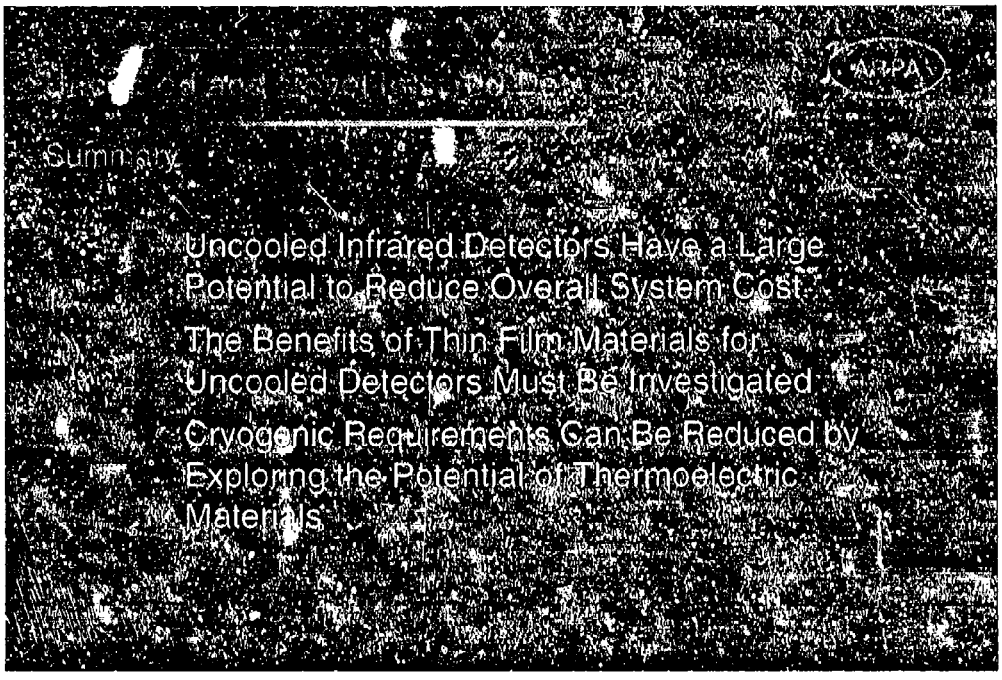
The Ultra II Electronics and Photonics program is an extension of the Ultra I program. The objective of the Ultra program has been to develop materials deposition techniques, material processing techniques and novel devices. The program goal is to meet the challenge of maintaining the trend of increasing electronic systems performance, beyond the point where conventional silicon IC technology breaks down. The program has two thrusts, Ultra-Electronics managed by Jane Alexander and Ultra-Photonics managed by Robert Leheny.



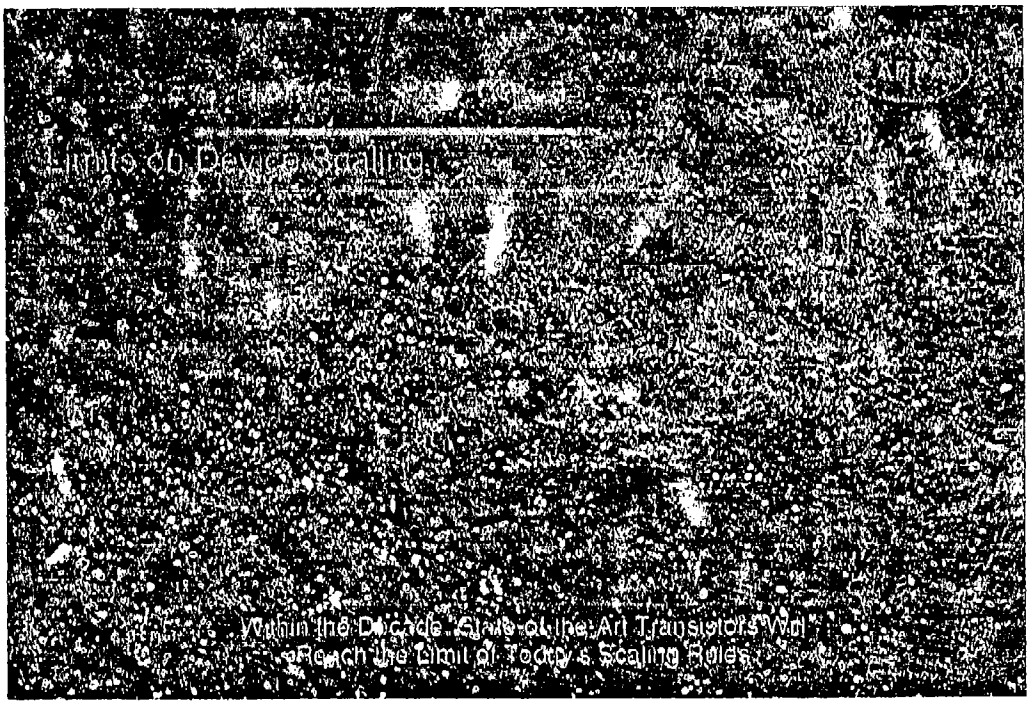
One method of reducing the drive power required for transferring data between computer subsystems is to convert the signal to optical format and use fiber cabling. The load on the output driver is now a laser transmitter rather than a length of cable. Since the silicon chips currently in use don't emit light, we are investigating the mounting of a "lifted-off" laser transmitter chip directly on the silicon, in a type of multichip module, that allows processing the final metalization of the combined chip just as if it were all silicon. Key to this application are arrays of low threshold surface emitting lasers.



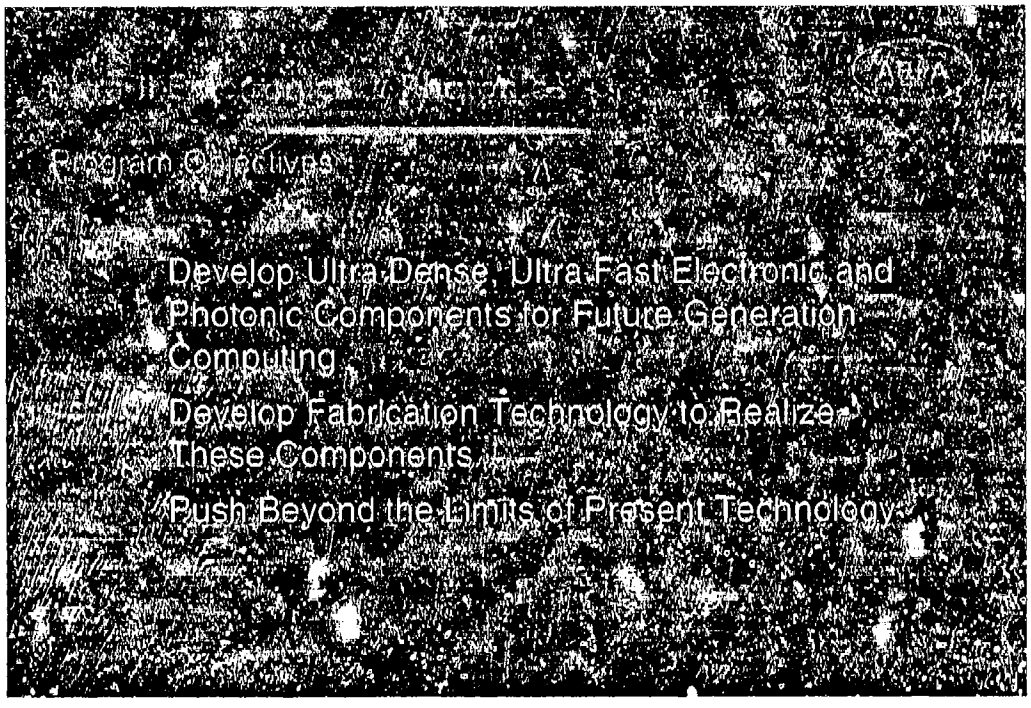
Over the past three decades the continued performance increases of electronic information processing systems has been directly related to the increased performance of silicon ICs. Performance at the IC level can be measured by the product of transistor count, or density, times clock frequency. Transistor count translates directly to the number of logic functions that can be performed per chip. Clock frequency translates to the number of times per second the logic gates can be cycled. Historically, these performance parameters have been directly related to the dimension of the individual transistors. In this way increased performance at the systems level has directly related to shrinking device size.



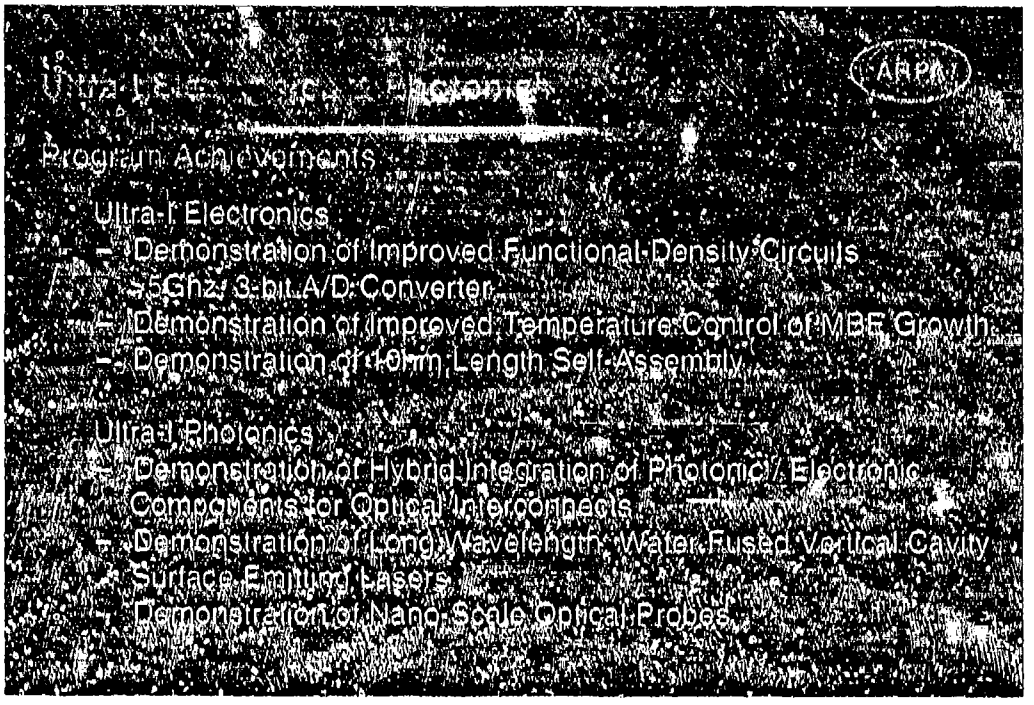
Novel infrared detection devices must address affordability as well as improvements in performance. The largest impact in affordability is through reduction in cooling and packaging cost. Advances in thin film uncooled devices offer a large pay-off in system performance at an affordable cost. Other material advances thermoelectric materials can also play a major role in reducing cost for systems requiring cryogenic operation.



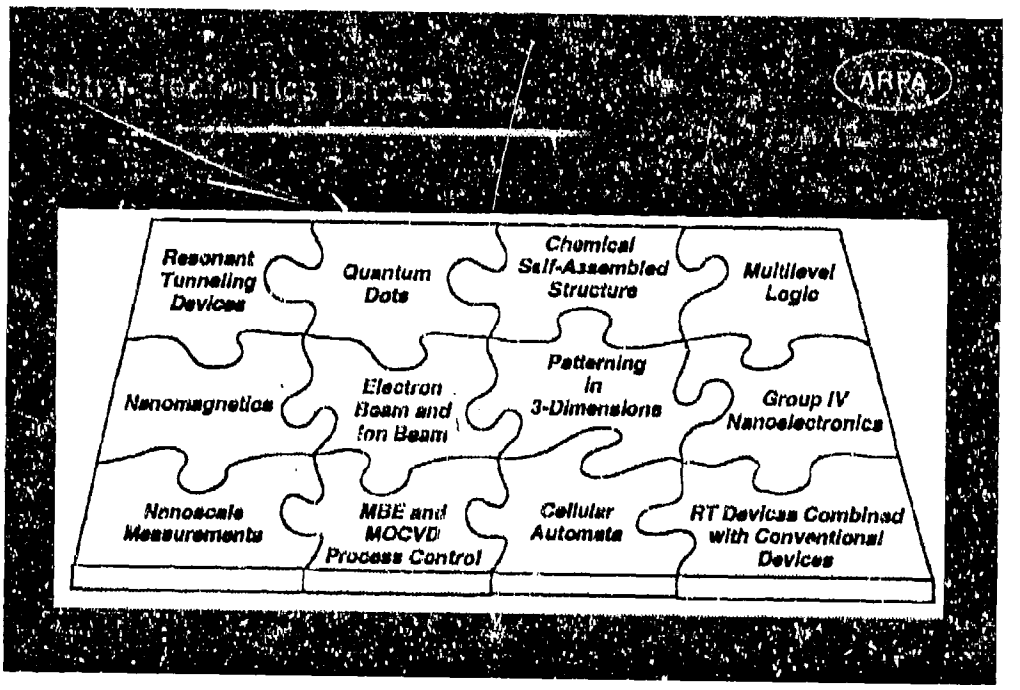
Within the coming decade, the scaling laws that have guided designers in shrinking transistor dimensions will begin to run into physical constraints as the size of state-of-the-art transistors reach the point where quantum effects become significant. However, the transition will be gradual. Initially, before reaching the point where only quantum devices can operate, there will be a transition region were novel approaches to combining new quantum devices with more traditional devices will satisfy performance requirements. Experience with these hybrid ICs will guide development into the next generations where quantum devices will dominate. Ultimately, electronics based on interaction at the atomic level will be required to achieve the highest possible performance.



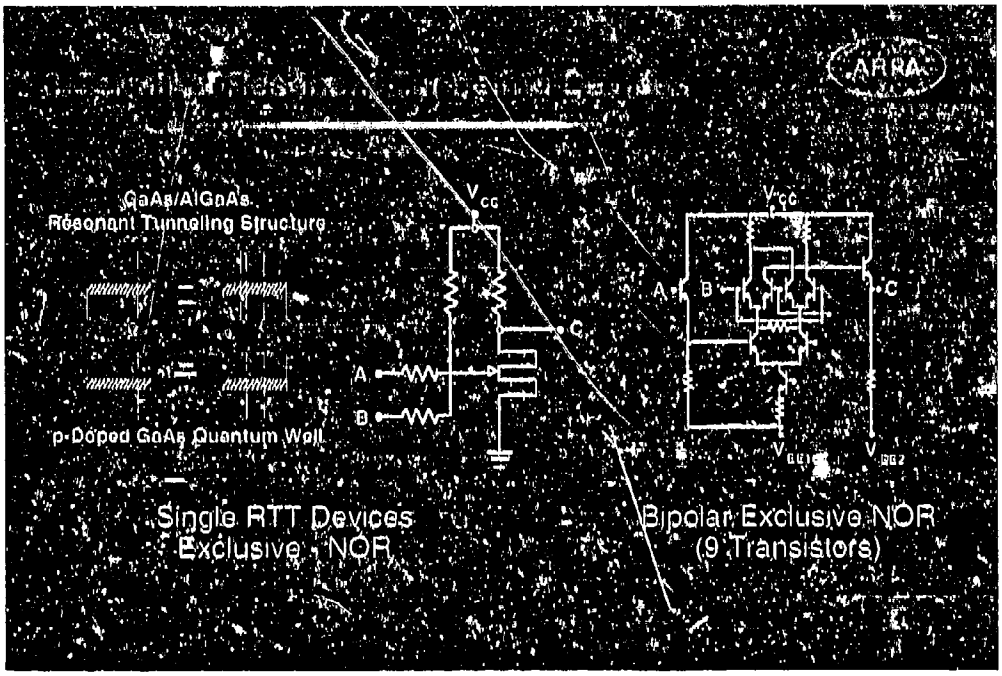
The objectives of the Ultra program are to develop ultra dense, ultra fast electronic and photonic devices based on quantum well materials and devices and to exploit non-traditional approaches to material integration. Both objectives are aimed at realizing the novel components required for future generation computer applications. Advancing the state-of-the-art in material deposition control and material fabrication technology are just two ways to meet these objectives. In addition, this program strives to advance device performance, beyond the limits set by parasitic effects in today's technologies, to achieve performance at the very physical limits of the materials being employed.



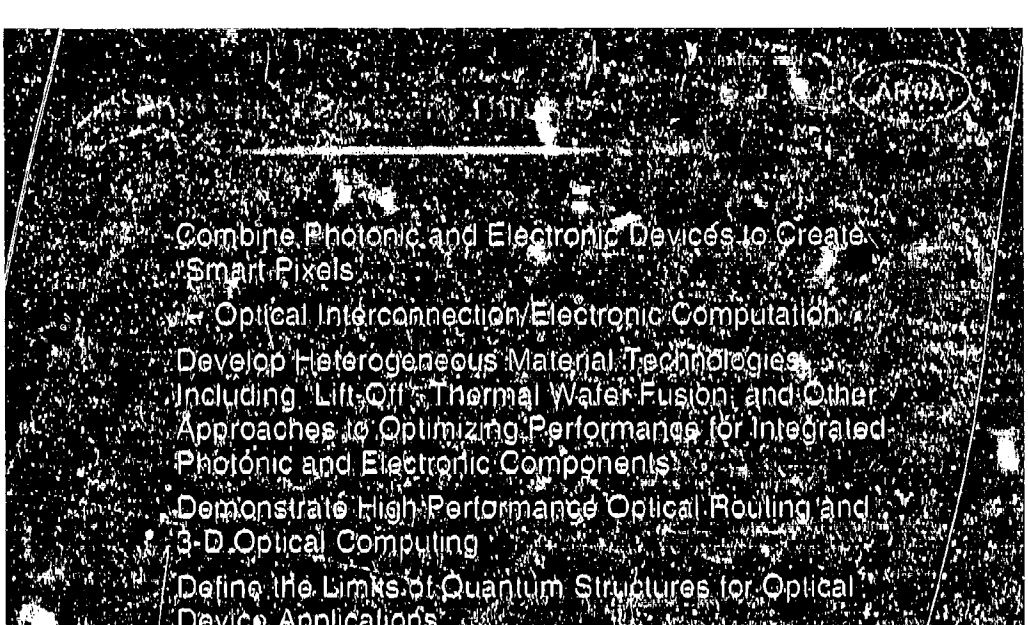
The Ultra-I electronics program has already successfully demonstrated improved functional-density circuits in the form of a 3-bit A/D converter with greater than 5 GigaHertz frequency performance. It has also demonstrated methods to improve the substrate temperature control for MBE growth and demonstrated self-assembly of electronic material structures with 10nm length. The Ultra-I Photonics program has successfully demonstrated the advantages of hybrid integration of both photonic and electronic components for parallel optical interconnects. It has demonstrated the application of thermal fusion of dissimilar materials to realize a novel Vertical Cavity Surface Emitting laser operating at 1.3nm and the use of optical probes to measure the temporal response of nano-scale structures on a femtosecond time scale. It is on this base of accomplishments that the Ultra-II program will build.



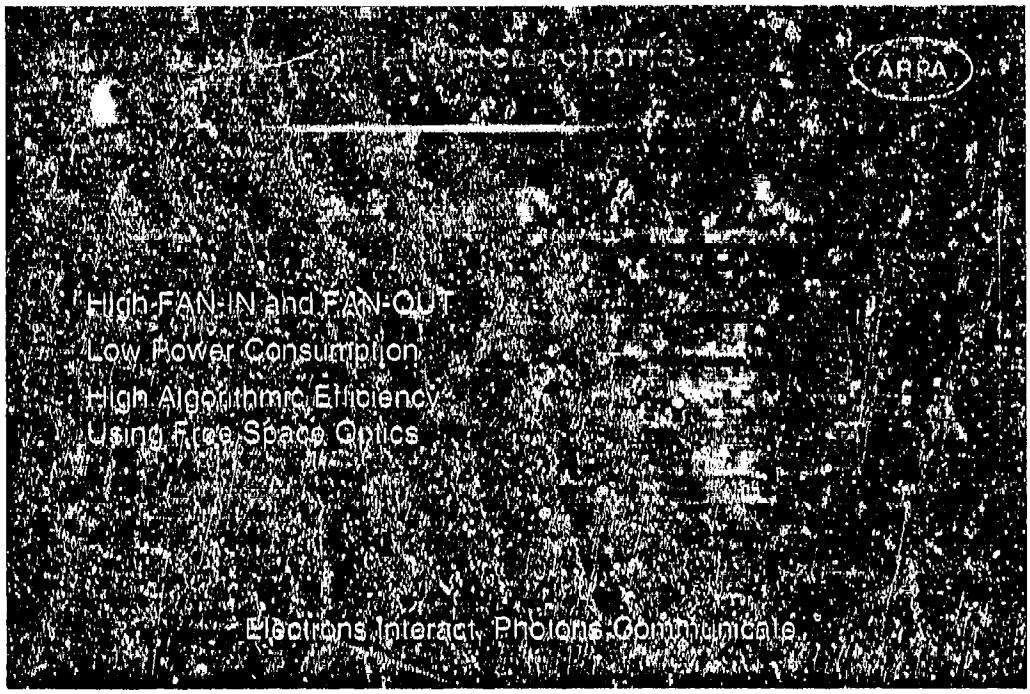
The principal thrusts of the present Ultra Electronics program are illustrated here. Each element is being explored on its own merits: resonant tunneling devices, process control for material deposition, chemical self-assembled structures, etc., with the aim of establishing the physical properties and limits of each element for application to electronic circuits. Ultimately, a successful strategy for realizing useful circuits, with performance that exceeds that achievable with conventional approaches, requires that these various elements be successfully integrated to form a viable technology base. This is the ultimate objective of the Ultra Electronics program.



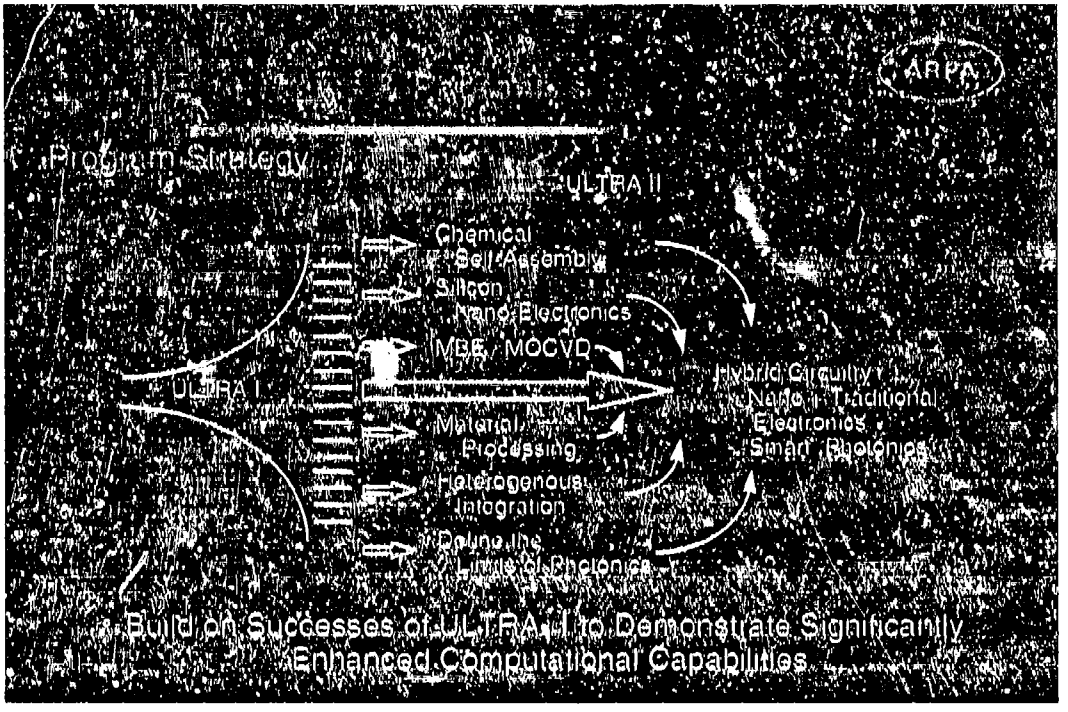
Resonant tunneling devices exhibit a unique current-voltage relationship which can be used to perform logic functions. Simple resonant tunneling devices suffer from limitations common to all efforts aimed at using two terminal devices in complex circuits. However, by introducing a third control terminal, resonant tunneling devices can be fabricated that exhibit a combination of bipolar and tunneling response. Using these novel devices it is possible to realize a simple exclusive-NOR circuit with a single active element that can functionally replace a bipolar version that requires nine transistors. The result is a significant savings in the space and power required to realize this important logic function.



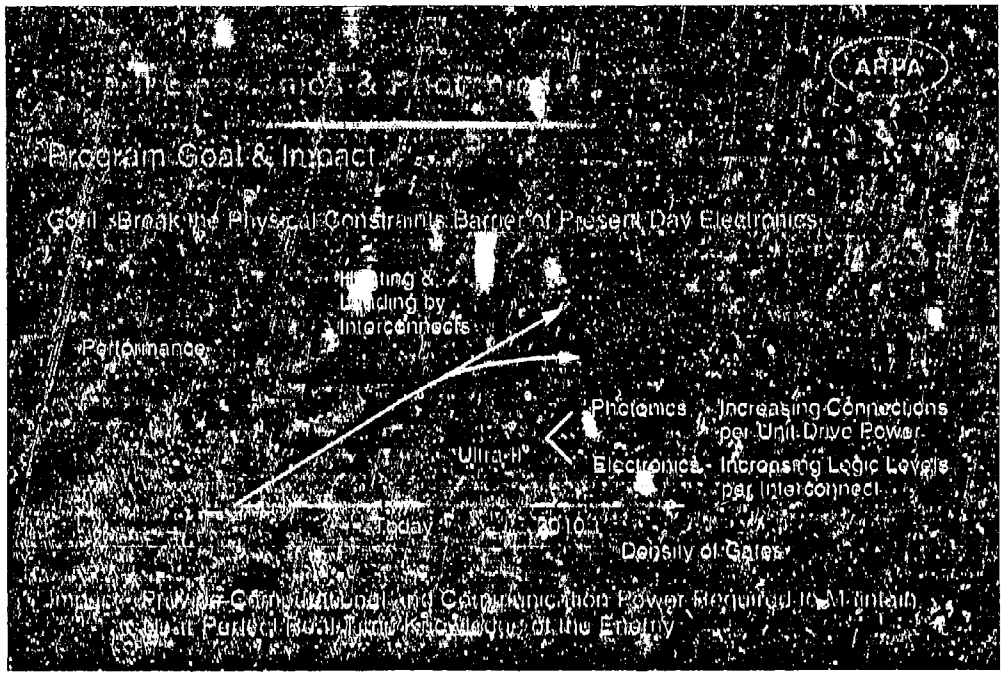
At the core of the Ultra Photonics program is the integration of photonic and electronic devices to create "smart pixels". Smart pixels integrate optical detector and transmitter elements with sufficient electronics to allow limited logic functions to be performed on detected signals locally. The results then determine the output optical signal. Given the very different materials requirements for photonic and electronic devices, one approach being explored is to separately optimize both optical and electronic functions. This approach uses separate material structures that are heterogeneously integrated, for example, through "lift-off" of epitaxial films. Arrays of "smart pixels" are being studied to realize high performance optical routing for optical interconnection and 3-D optical computing. A longer term goal of the Ultra Photonics program is to determine the limits of quantum structures for optical device applications.



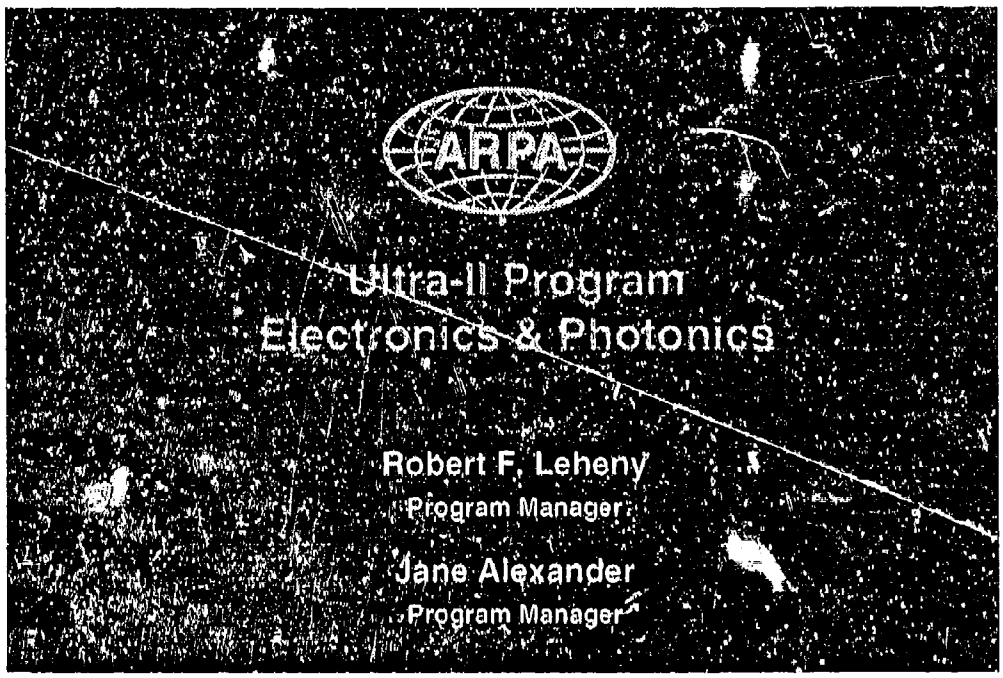
Two dimension arrays of optical beams, where each beam can be modulated and directed independently, provides the possibility of large signal FAN-OUT and FAN-IN. In principal, a very large number of channels (100's-1,000's) can be manipulated this way with very little power consumption per channel. The use of free space optics, with beams crossing, allows high algorithmic efficiency. This is particularly true when one considers that the number of optical connections to a given node doesn't influence the capacitive loading on that node. A key advantage is that unlike electrons, which strongly interact and thereby limit interconnect performance, photons don't interact but are excellent carriers of information.



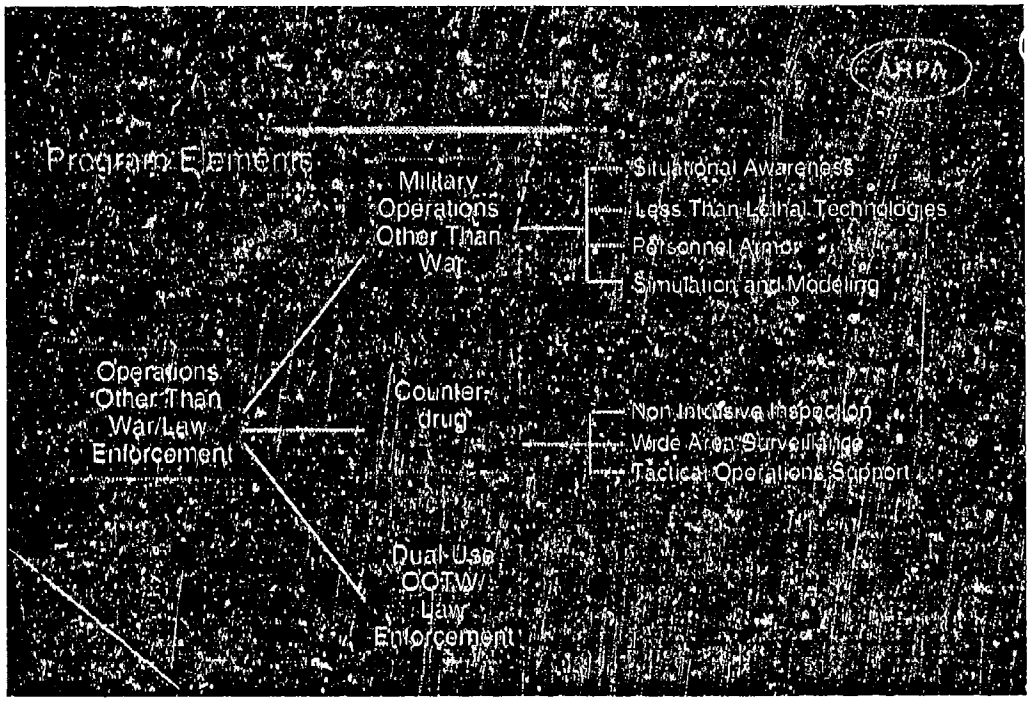
The strategy of the Ultra-II Electronics and Photonics Program is to build on the successes of the Ultra-I Program. The principal thrust will be to exploit hybrid circuitry, combinations of nano electronics with traditional electronics and electronics with photonics in the form of "smart pixels". At the same time, the program will support near term research on deposition and processing in support of this thrust. Longer term research in the area of electronics will include work on silicon versions of III-V nano-electronics, for eventual full integration on silicon, and chemical self-assembly for fabrication of devices with atomic dimensions. For photonics, the program will include integration based on heterogenous materials and device structures and research defining the physical limits of devices for information processing.



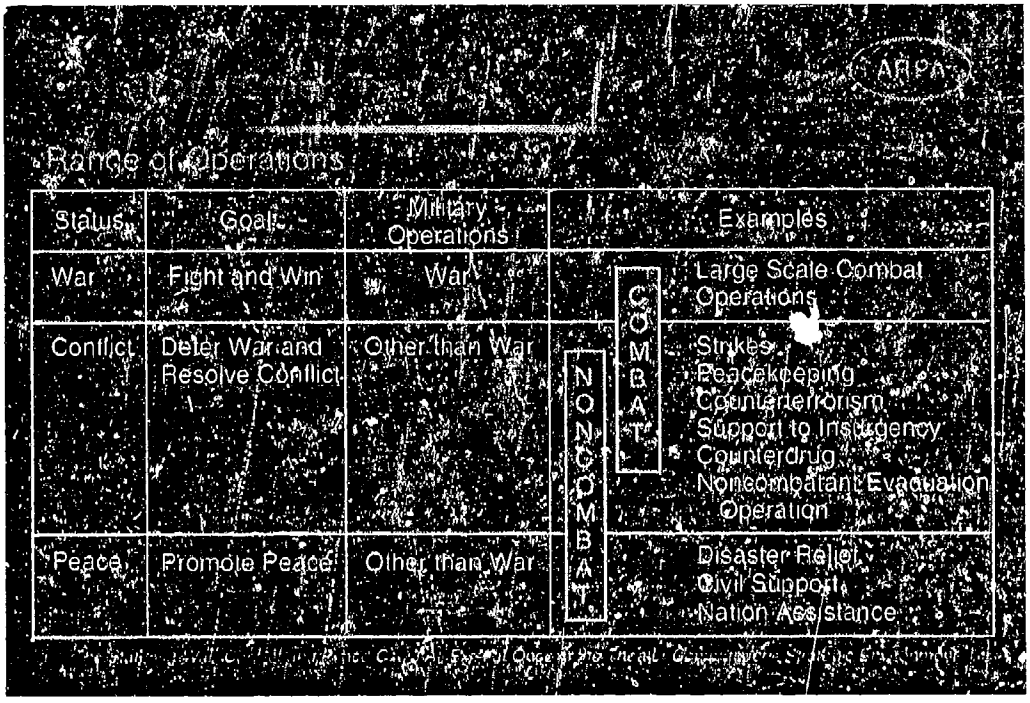
The principal DoD goal of the Ultra-II Electronics and Photonics program is to minimize the impact of physical constraint barriers on the performance of critical electronic information systems. High performance electronics are critical to maintaining the computational and communication power required for near perfect real-time knowledge of the enemy and his environment. Two principal physical constraints have an obvious bearing on limiting future electronic IC performance. One constraint is heat dissipation at high device density. The other is reduced response time as current drive power shrinks with shrinking device dimensions. The Ultra-Electronics program seeks to deal with these issues through increasing the computational density of ICs by introducing multilevel logic devices relying on quantum effects. The Ultra-Photonics program deals with these issues by providing a means to increase interconnections without increasing capacitive loading. Ultimately future systems will combine the best of both approaches to achieve optimum performance.



Good afternoon, my name is Bob Leheny. I am one of two program managers responsible for ARPA's Ultra program. My objective this afternoon, is to provide you with the vision and direction of ARPA's Ultra II - Electronics and Photonics program.

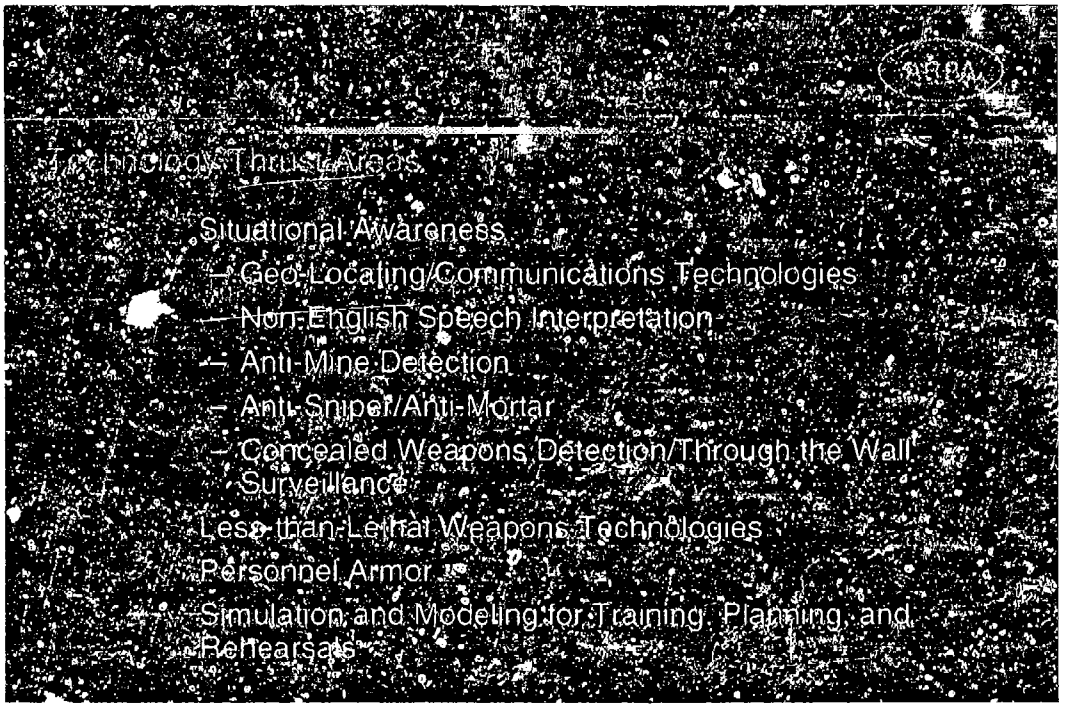


The ARPA OOTW/LE program consists of three distinct program elements: military operations other than war, counterdrug, and law enforcement. The OOTW effort is funded out of arpa mission accounts and supports general military operations, and also provides potential dual use technologies for the civilian law enforcement agencies. The Counterdrug effort is funded through a separate account provided through the DoD drug coordinator. The ARPA Counterdrug effort directly supports the national counterdrug strategy and the DoD counterdrug mission, and provides dual use technology to the civilian law enforcement agencies. The LE effort is managed through a mou between the department of defense and the department of justice that I will explain in detail later. These three elements are closely related in terms of technology. requirements, technologies to address the requirements, identified users/customers, and program management and support.

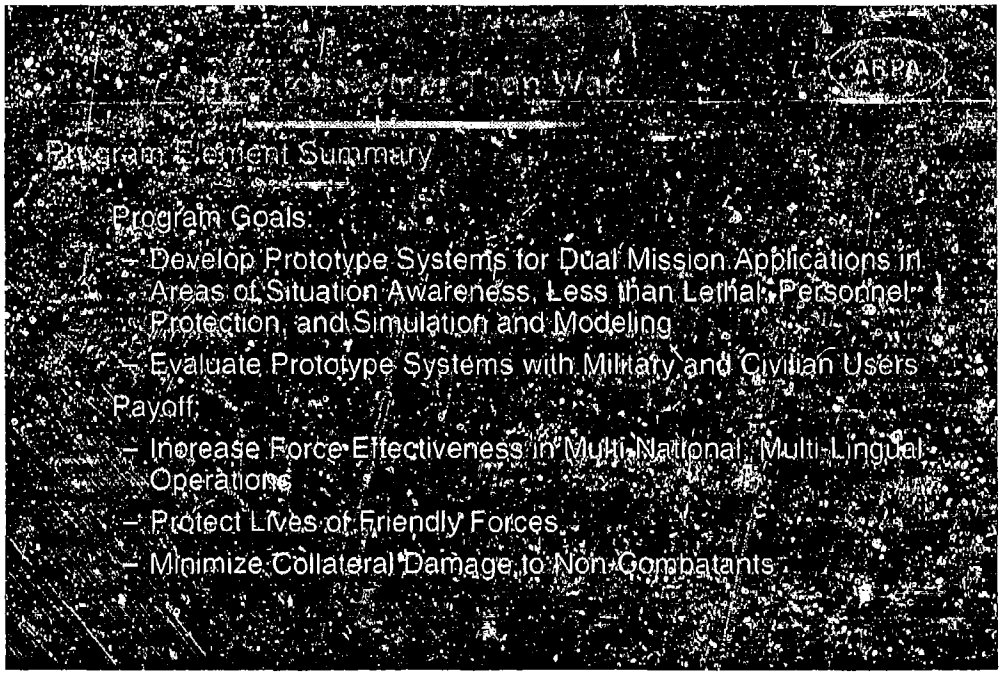


Military Operations Other Than War (OOTW) encompass a wide range of activities where military power is used for purposes other than large scale combat operations. Examples of these operations include disaster relief, military counterdrug operations, peacekeeping, and even surgical strikes. With the passing of the cold war era, our armed forces are being given missions that are different from the traditional wars of attrition and destruction. Although preparing to fight and win the nation's wars has always been the paramount objective for U.S. Forces, ensuring a stable peace has taken on increased importance. Special tactics, training, and equipment are demanded to meet objectives.

Some of the factors that make OOTW different from combat operations and contribute to the technological challenges are: 1) they are often conducted as part of a multi national coalition where the us is not in charge, 2) there are restricted rules of engagement that limit full application of military capability, 3) urban operations often present large crowds of civilians and language barriers, 4) operations are decentralized and consist of small units, and 5) there are intense political pressures to minimize casualities and collateral damage.



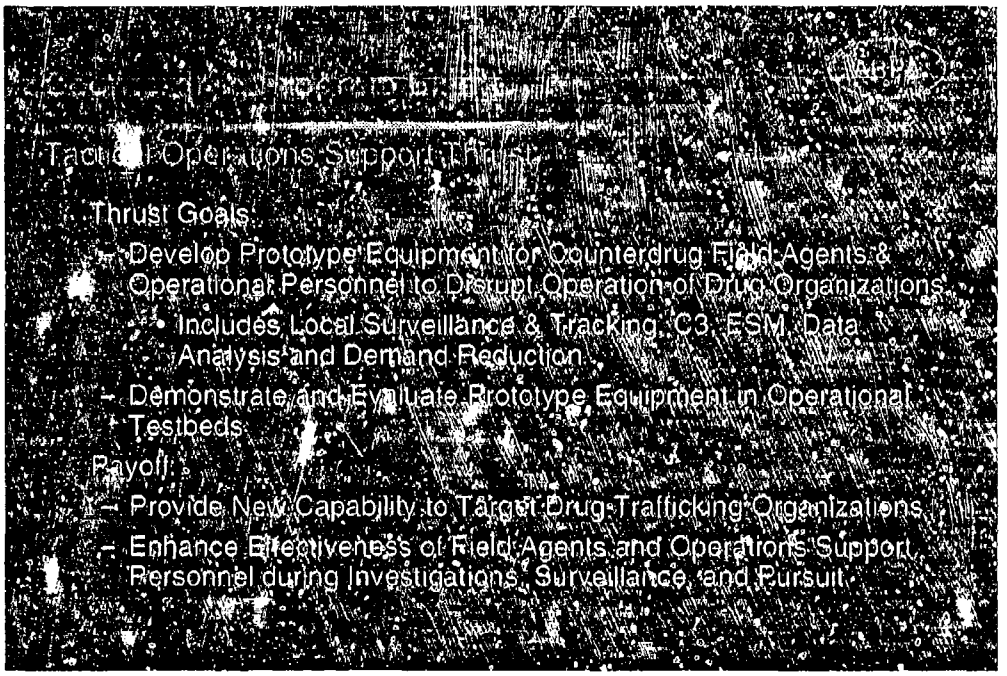
Within the military OOTW program element, we are currently concentrating on the following technology thrust areas: situational awareness, less than lethal technologies, personnel armor, de-mining, and simulation. ARPA's advanced electronic design and fabrication techniques such as multi-chip modules (MCM), micro-electro-mechanical-systems (MEMS) and low power consumption circuits will be used to miniaturize systems for geo-location, navigation, and data transfer. Advanced computerized speech processing and interpretation technologies will provide a near term tactical translator. The initial capability will be limited to korean/english words and phrases suitable for use in a tactical hq environment. Other languages, additional vocabulary, and a hand held configuration will follow in future developments. The mine threat will be addressed with the development of improved mine detection and location capability and mine removal and neutralization techniques. This will address both tactical anti-mine operations and the peacetime clearing of the more than 100 million mines left behind in the world. Wall penetrating imaging and small weapons detection equipment will address hostage situations, terrorists, and guerilla threats. Improved personnel armor will exploit new materials and fabrication techniques to reduce the large number of ootw casualties to small arms fire and fragments. Improved simulation techniques will be sought to enhance training for OOTW unique environments and tactics.



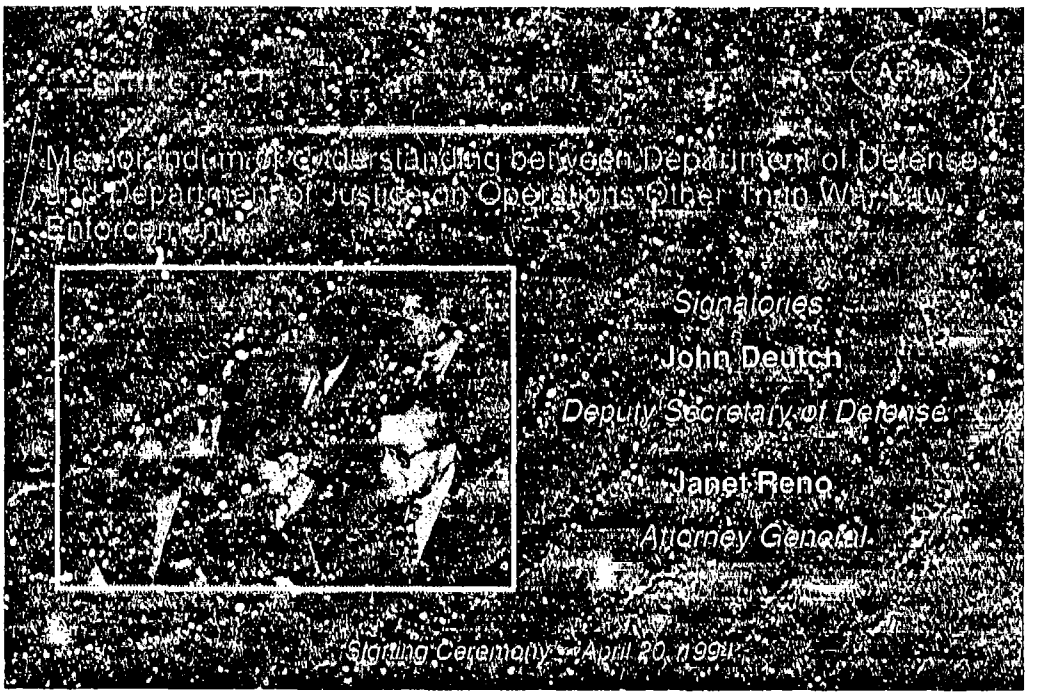
Based upon the assessment of military OOTW requirements and current equipment capability, we formulated an ARPA R&D program to address the shortfalls. The program strategy reflects a multi-office effort to increase military effectiveness in multi-national and multi-lingual OOTW operations through affordable advanced technologies. Those technologies that maximize response to achieve goals, protect the lives of friendly forces, and minimize collateral damage to non-combatants will be emphasized. Dual use military and civilian applications are also sought.



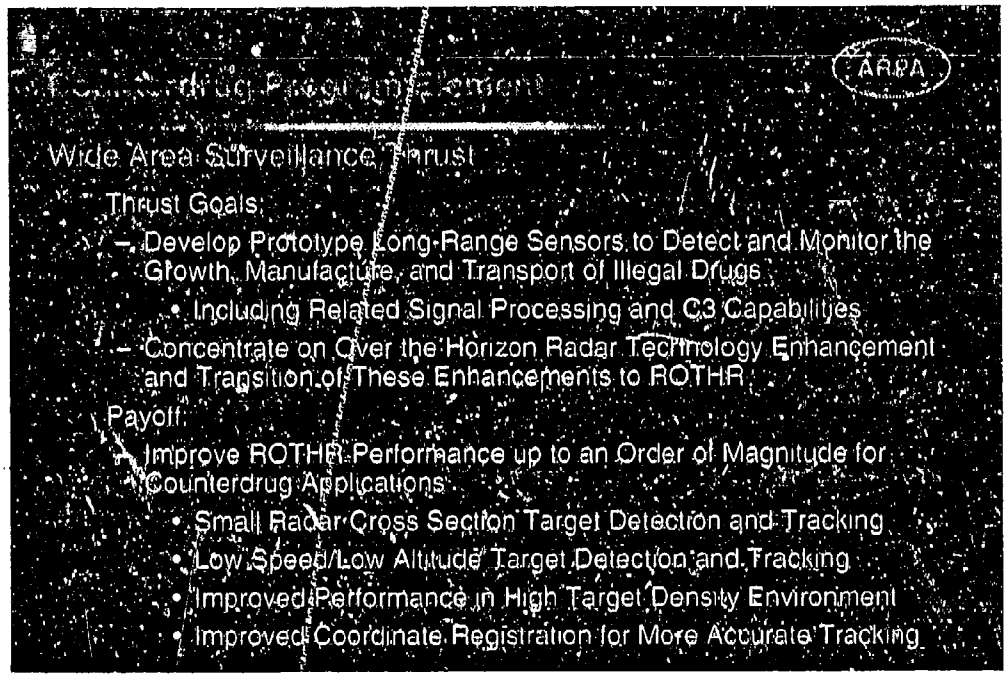
An analysis was conducted of OOTW operations and current system capabilities. The operational shortfalls that we felt could be addressed by arpa technology development are shown here. Situational awareness shortfalls include ability to assess status and position of both hostile and friendly forces. Light weight man-portable sensors are needed that can be operated and supported in OOTW small unit scenarios. Body and vehicle protection needs reflect the widespread use of simple weapons such as rifles, mortars, and mines by OOTW threat forces. Restricted rules of engagement and the emphasis to minimize casualities on both sides make many conventional weapons and tactics unsuitable. This is because they have the potential for excessive collateral damage and/or casualties to non-combatants.



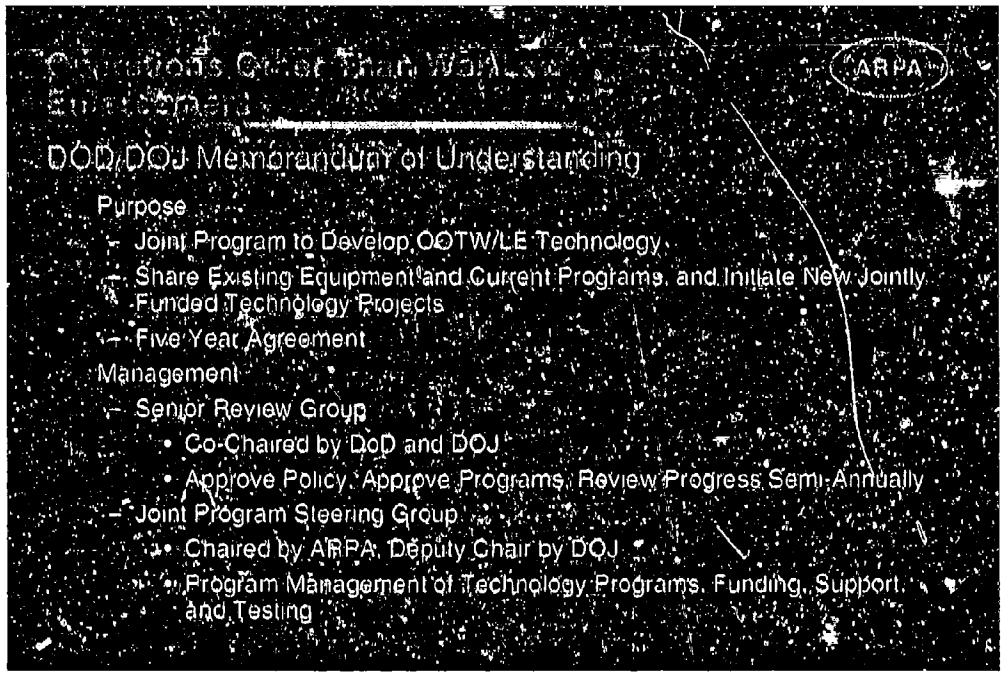
The goal of the tactical operations support (TOS) thrust area is to develop prototype equipment for use by field agents and operational personnel during investigation, surveillance, and pursuit of suspected drug trafficking personnel, vehicles, and organizations. In the electronic surveillance measures area are technologies to intercept new communications media such as fax and cellular radio. In the data analysis area we are developing improved capability for the FBI to analyze computer storage media seized during arrests, and we are also working with the Department of Treasury to increase the speed for processing bank secrecy act forms using a massively parallel computer. Surveillance and tracking efforts have resulted in the development of a micro-gps 6 channel c/a code receiver using multi chip module construction, a solid state miniature audio recorder capable of storing up to four hours of conversation, and automatic facial recognition algorithms with a 90% probability of correctly identifying a target face to within 1% of the data base population. Other efforts include covert radar beacons for aircraft, and tracking tags for special counterdrug missions. The demand reduction effort will investigate techniques to improve dod procedures for field collection and laboratory testing for drug use.



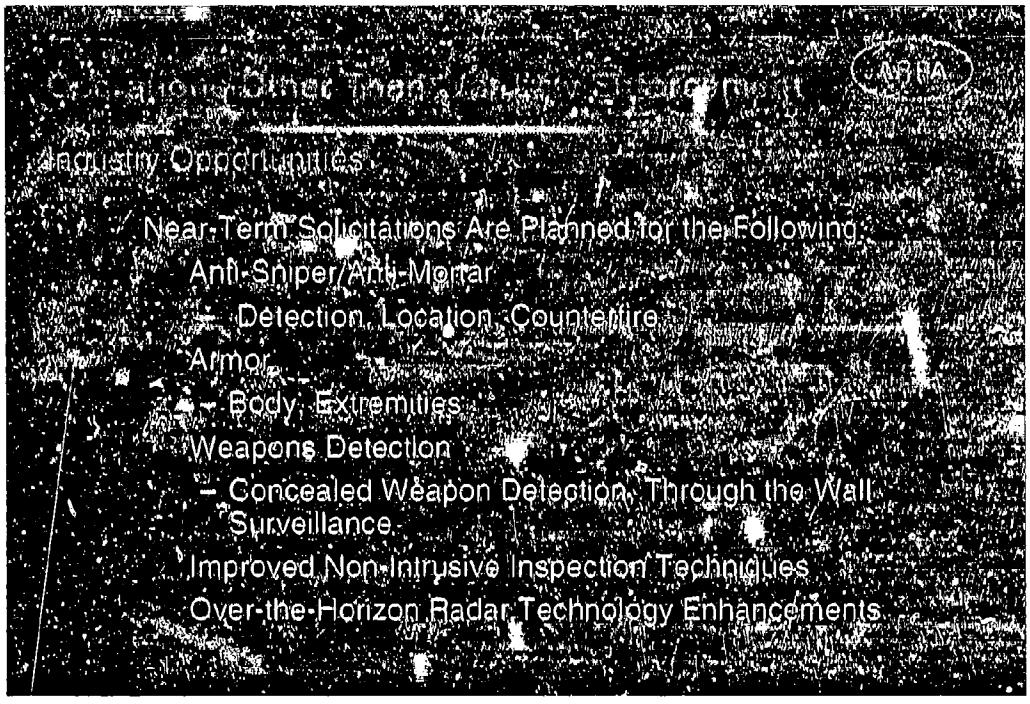
This opportunity for a natural partnership between the Department of Defense and Department of Justice was formalized in a Memorandum of Agreement signed on 20 April, 1994, by John Deutch, Deputy Secretary of Defense, and Janet Reno, Attorney General. Although there is a long history of technical cooperation between defense and law enforcement, this formalization will make cooperation more effective and efficient.



The current emphasis in the wide area surveillance (WAS) thrust area is technology enhancements for over-the-horizon radar. The enhancements are specifically oriented toward the DoD relocatable over-the-horizon radar (ROTHR) used in support of counterdrug missions, although the technology has application to oth in general. Technology enhancements are being investigated in the following areas: atmospheric noise reduction, tracking of low speed low altitude targets commonly used for drug trafficking, coordinate registration, equatorial clutter reduction, beacon assisted tracking, altitude determination, and imbedded communications. Efforts to date have resulted in a 4/1 improvement in tracking accuracy using a tracking beacon, 25% increase in track duration, and 10 db improvement in lightning noise suppression. The track continuity enhancements are currently being transitioned to the Navy ROTHR.



The MOU defines areas of common interests, and establishes a framework for three categories of effort. The first area is to identify and make available existing equipment from the DoD that can be useful in law enforcement missions. The second area is to share results of on-going technology programs at both defense and justice. The third area is to identify new joint technology programs to receive funding from both departments. During development for projects in this latter category, each department will fund the integration of the resultant products into its operations. Initial efforts under the mou will be to survey OOTW and LE requirements, applicable technologies, and ongoing programs. During FY 95, a small program organization will be put in place at arpa to refine program plans, shift selected existing programs in the desired direction, conduct concept demonstrations, initiate solicitations for advanced technologies, and begin managing programs that are already in place. Programmatic decisions will be made by a joint program steering group (JPSG). The JPSG will be chaired by DoD, and consist of both Defense and Justice technical personnel physically located at ARPA. Overall guidance will be provided by a senior review group at the department deputy level.

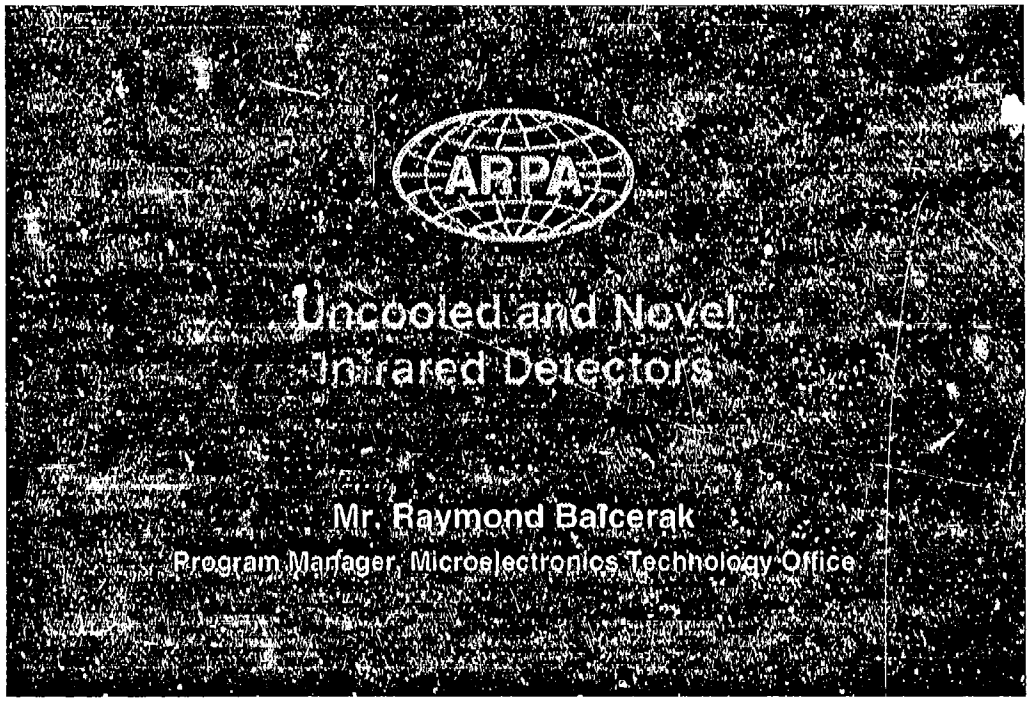


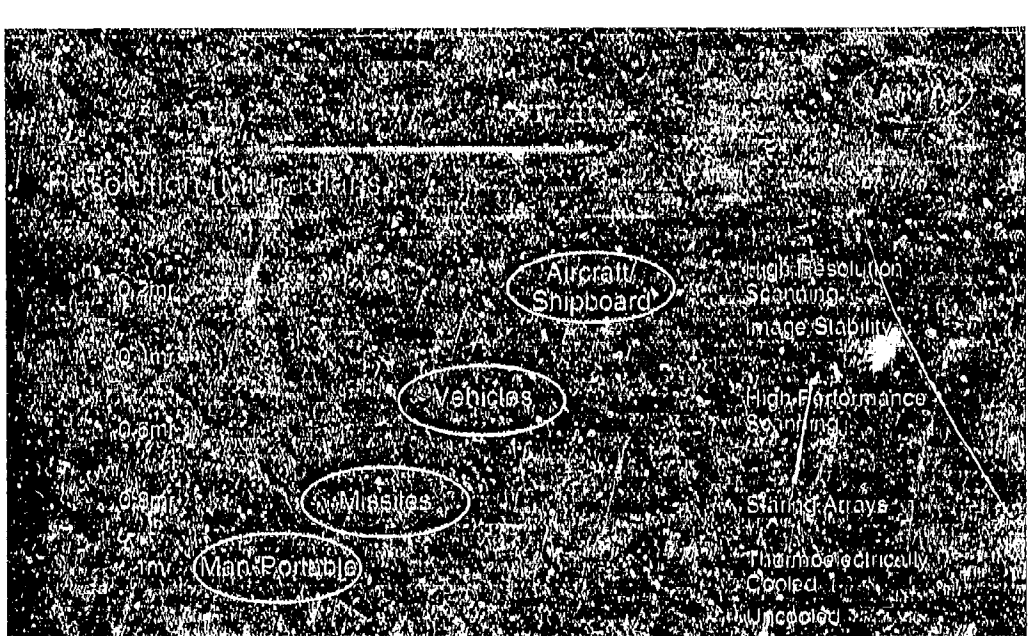
As this new program is initiated, there will be a number of new opportunities for industry participation. This chart provides an example of a few of the areas of interest. We will be soliciting for prototype systems to detect, locate, and bring counterfire to sniper, small arms, and mortar threats. Counterfire techniques using both lethal and non lethal (i.e. Laser dazzle) are sought.

Improved de-mining capabilities are sought, including existing systems that could be evaluated in a field test and also new technology. Capabilities include mission planning, wide area detection, precise location, removal, and neutralization.

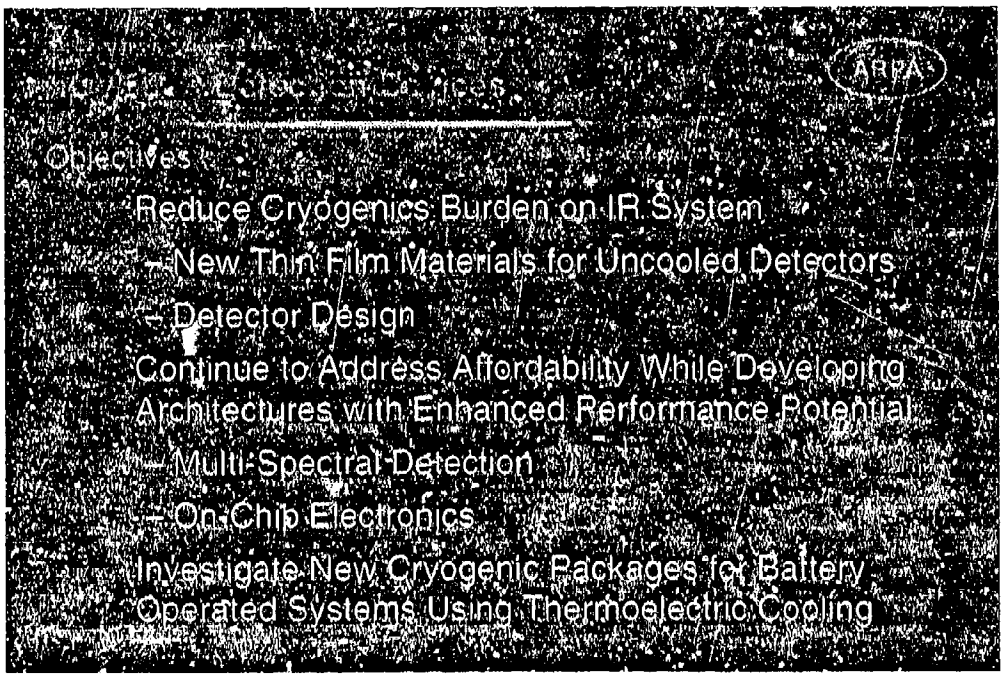
In the armor area, we seek new materials and fabrication techniques for body armor and also for extremity protection. A relatively low cost and safe device that would detect small arms hidden on a person or in a small package is sought. This would be used for urban warfare, crowd control, and building security. Also sought is a wall penetrating imaging system to be used primarily for hostage situations.

In the OTH radar area, we seek additional technology enhancements. Improved NII techniques are sought using nuclear, x-ray, chemical or other methods.

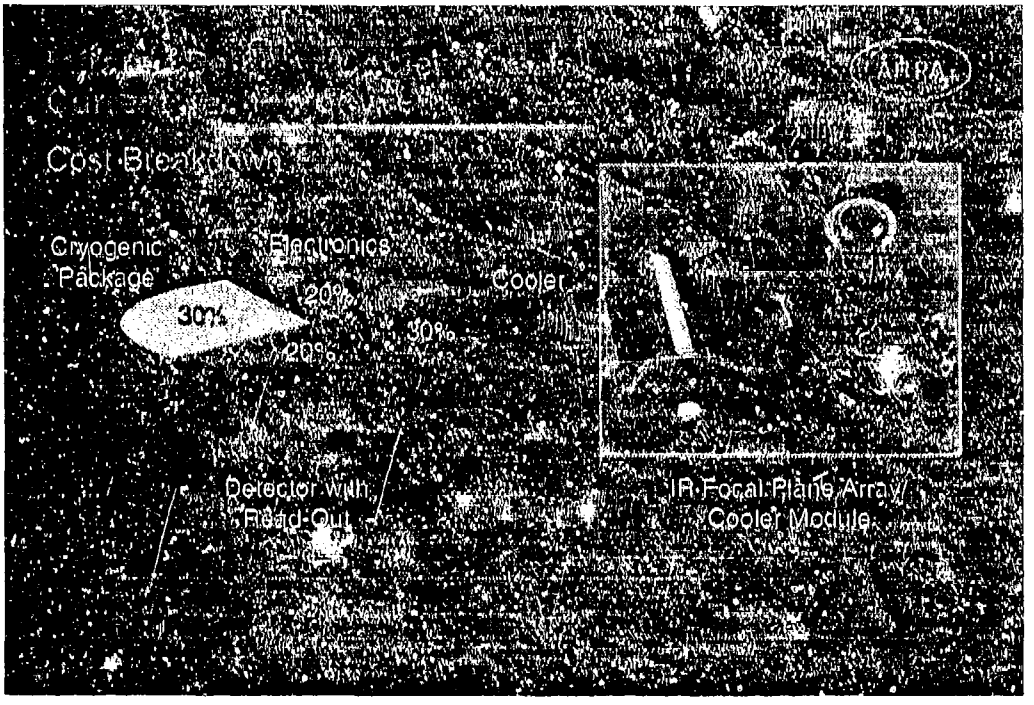

ARPA
Uncooled and Novel
Infrared Detectors
Mr. Raymond Balcerak
Program Manager, Microelectronics Technology Office



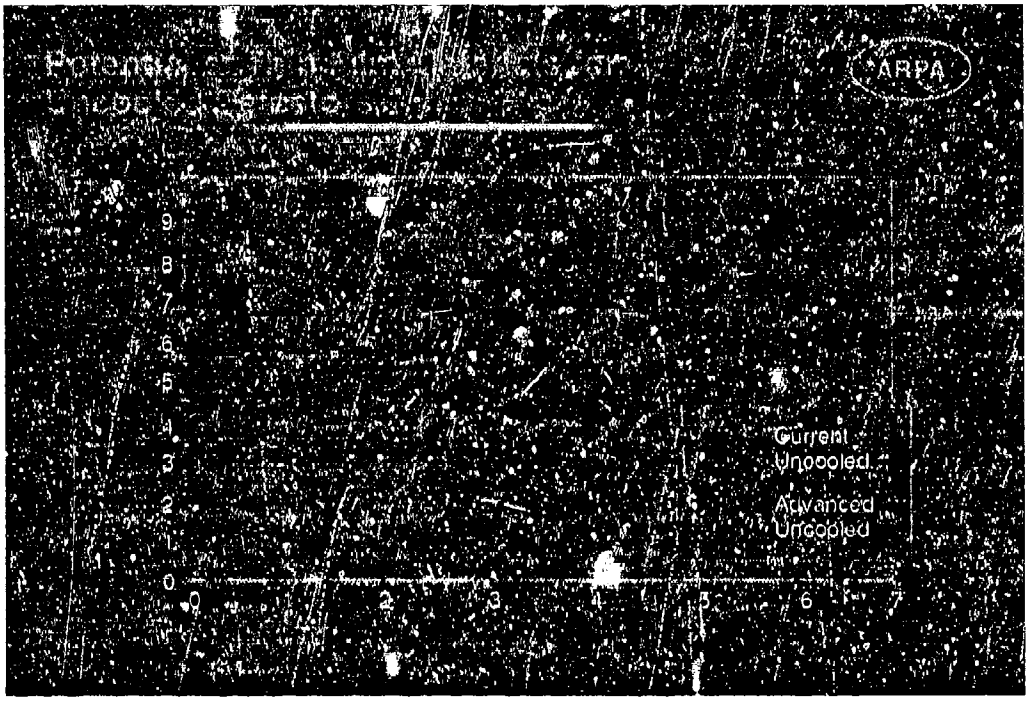
The infrared sensor performance requirements for the various application areas are determined by the resolution and thermal sensitivity. For the generic application areas of aircraft, vehicles, missiles, and man-portable / support vehicles, the resolution ranges from approximately one-tenth of a milliradian to one milliradian, and sensitivity from one tenth of a degree to one hundredth of a degree. Cost for this broad range of specifications can be from a few thousand dollars to several hundred thousand dollars. The lower cost systems are generally staring arrays with minimal cooling requirements; and the higher cost arrays are generally higher resolution scanning arrays which require cryogenic cooling and a high level of optical stabilization.



The objectives of novel detector development are to reduce the cryogenics burden on infrared systemms, and continue to address affordability while enhancing performance as much as practical. Novel cryogenic packaging will also be investigated to further reduce the cost for the arrays requiring cryogenic cooling. These new cooling techniques will be based upon battery operated thermoelectric approaches to infrared detector cooling.

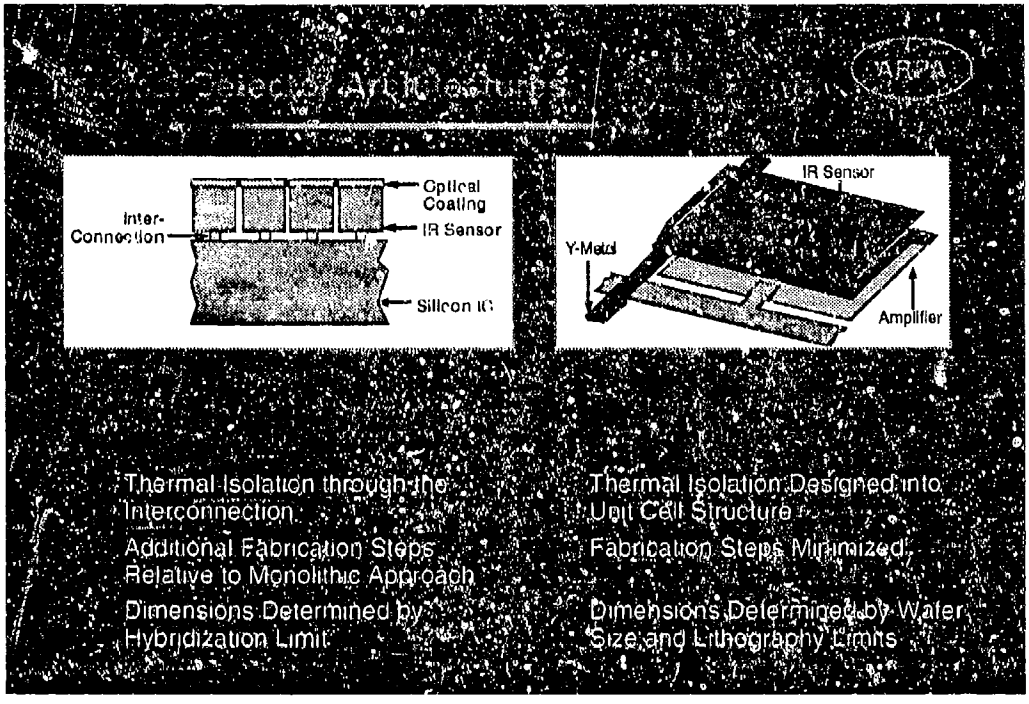


The cost of the current technology of infrared detection devices are driven by the cost of the cryogenics, which consists of the cooler and cryogenic package for the focal plan array. This assumes that the detection device itself is produced in quantities of approximately one hundred per month. Since the detector is produced using a semiconductor manufacturing process, its cost can be reduced considerably through volume manufacturing. The assembly of the cryogenics, however, is difficult to reduce even with volume manufacturing. The assembly processes for the cryogenics are more labor intensive and difficult to automate. Elimination of the cooling is the ultimate solution to IR system cost reduction. However, this requires considerable improvement in IR detection technology to achieve comparable performance between cooled and uncooled detectors.

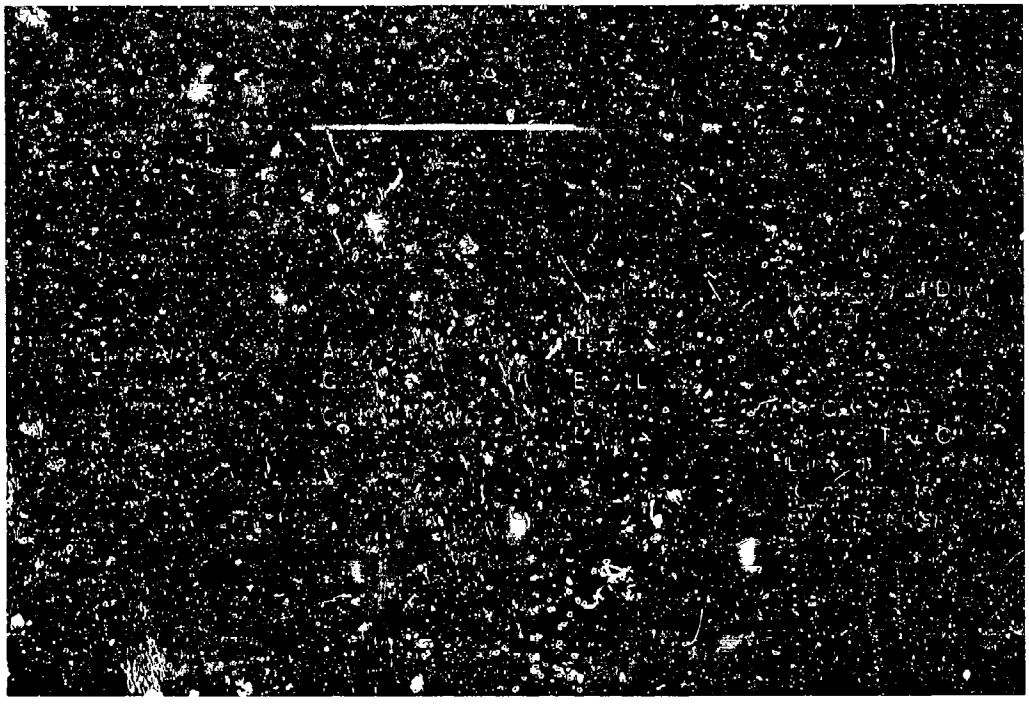


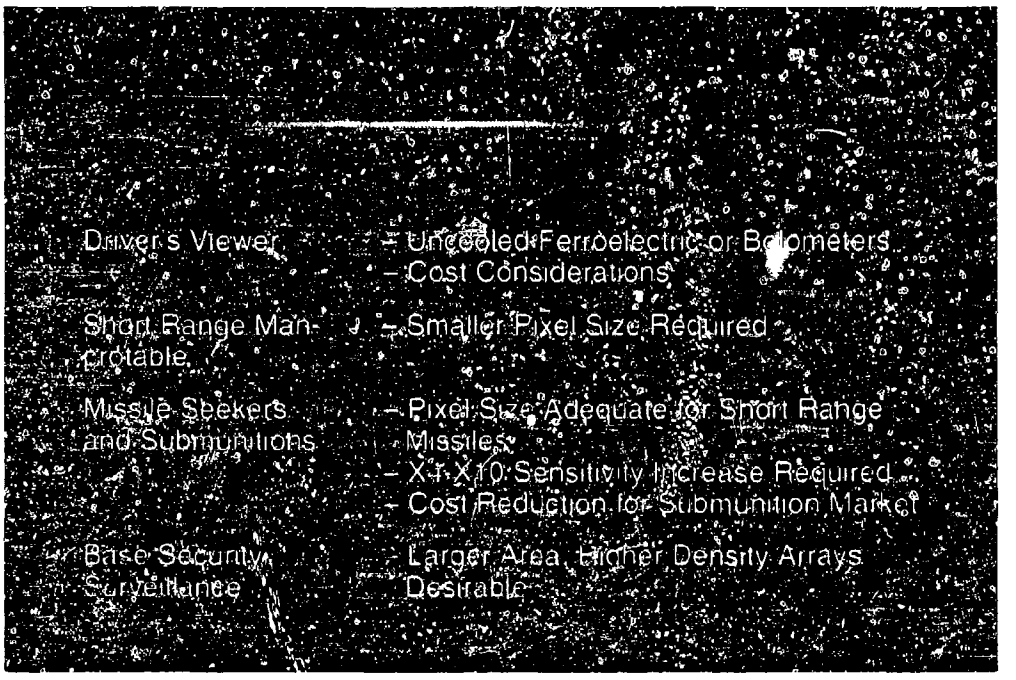
The current uncooled detector technology is limited insensitivity by the material technology. This limitation leads tothe need to provide a large optical collection aperture, which limits system resolution in order to stay with in practical size and weight constraints. With improvements in detector sensitivity, the resolution can be increased to provide both the thermal sensitivity and resolution necessary to increase therecognition range. This requires significant advances in uncooled material technology, a major challenge to material development.

Several material choices are available to improve the performance of infrared detectors. These include both theferroelectric and bolometer type materials. Some of the materials have been demonstrated the necessary properties in the laboratory, but few of the new materials have been demonstrated outside of the laboratory environment. Array technology with these new materials does not exist. The challenge in the materials area is to increase sensitivity about an order of magnitude with decreasing pixel size. Thermal isolation and goed radiation collection efficiency must be maintained which this larger fill factor.

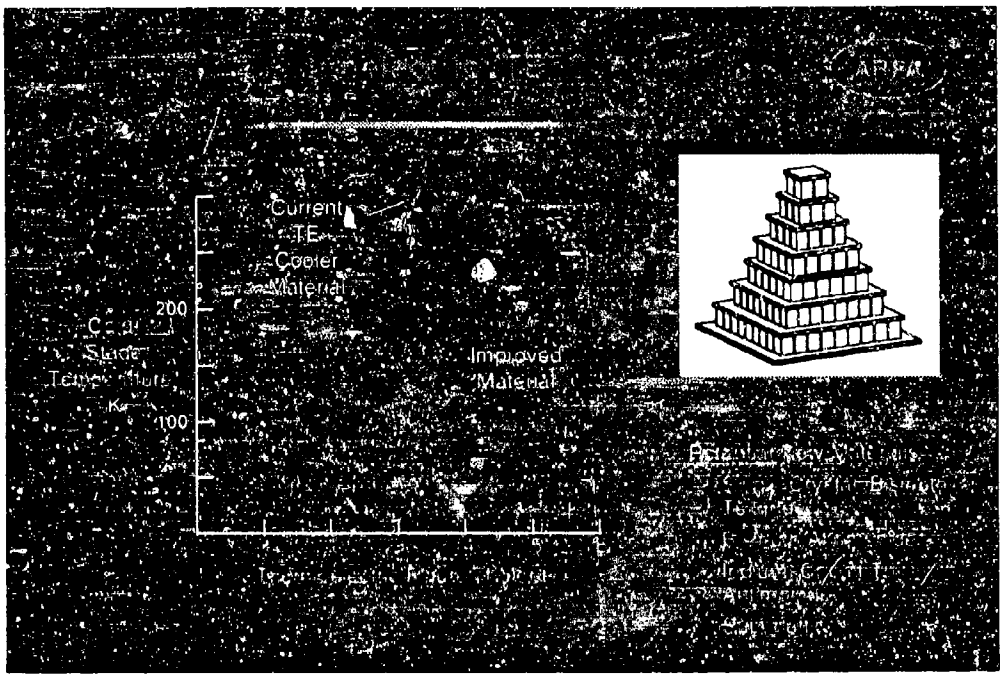


The design of the unit cell for the detector structure is important to the performance of the device. The thin film structure is built in a monolithic architecture with the detector material integrated with the signal processor. The current design of ferroelectric detectors is considered hybrid, where the detector and signal processor are fabricated separately and bonded together or hybridized.

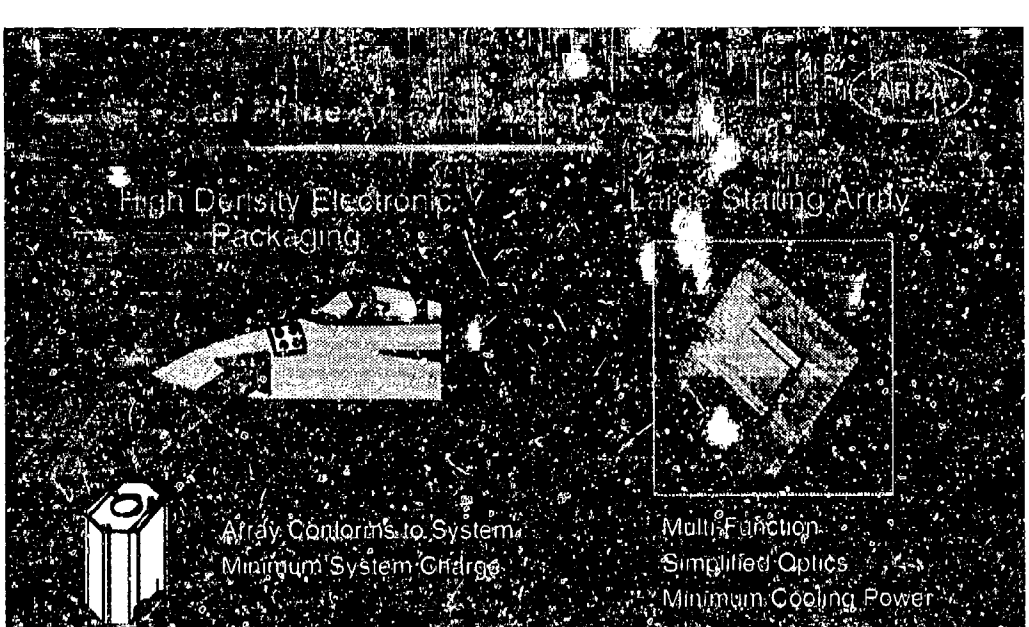




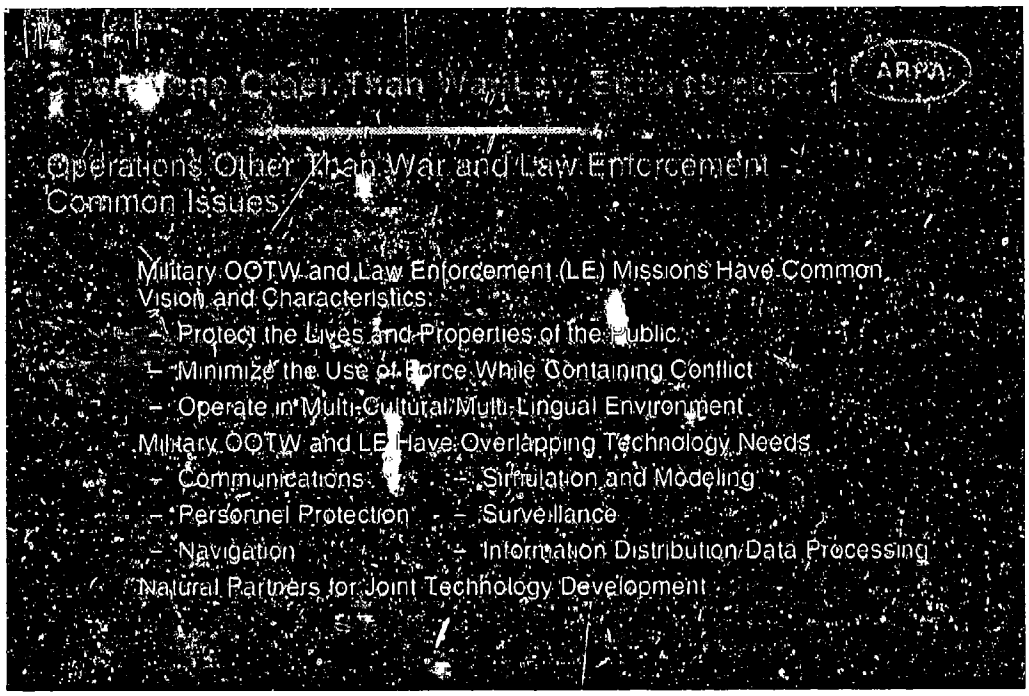
The military market for uncooled infrared sensor can be greatly expanded by increasing the detector resolution (smaller individual detector cells) and improved thermal sensitivity. Larger higher density arrays are important in many cases to provide large search coverage for base and perimeter surveillance. In some cases, such as missile seekers, approximately an order of magnitude increase in sensitivity is necessary. This improvement must be made with cost remaining a primary consideration.



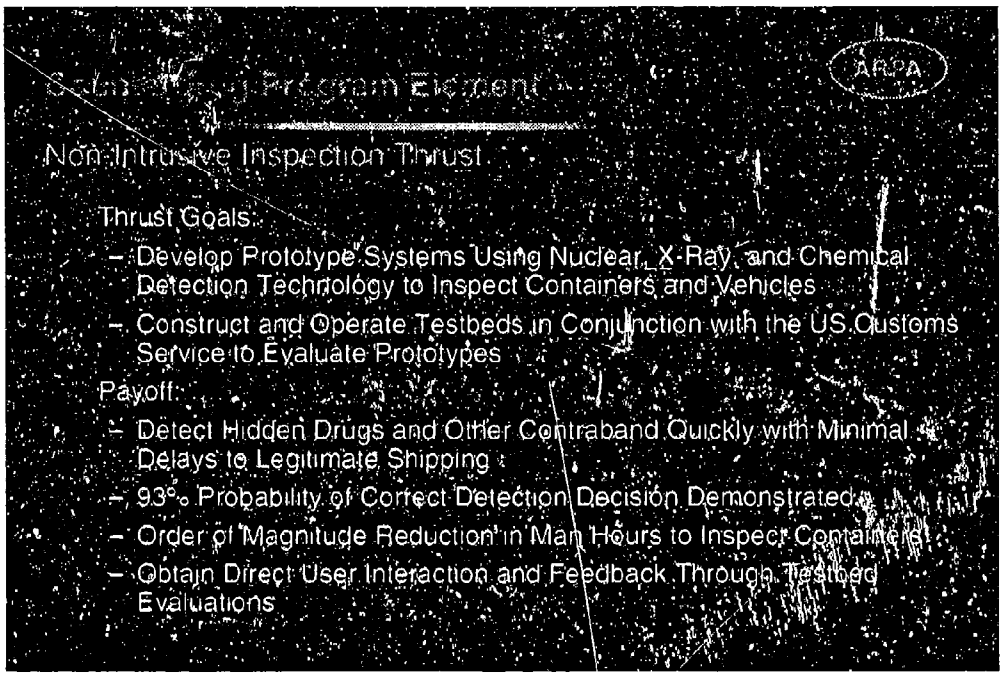
For infrared sensors that require cooling there are solid state cooling concepts to decrease the cost of the cooling system. These are based upon thermoelectric cooling which operates on battery power. Thermoelectric cooling can today cool to approximately 170k. This cooling is sufficient to operate some three-to-five micron infrared detectors, but is not generally applicable to all infrared systems. Thermoelectric cooling requires sufficient development of new material to improve the thermoelectric efficiency factor (ZT). Typical values of today are approximately 1.0. An increase of ZT to five will bring thermoelectric coolers into the temperature region (80K) where they are generally useful for infrared detection devices.



A future application area for infrared detection is in the multi-function forward looking infrared system. In many applications, the sensor must conform to the physical shape of the platform. In these applications reducing or minimizing the cooling is important to the mission functions and platform requirements.



Though they are different, there are strong similarities between OOTW and Law Enforcement. Widespread availabilty of increasingly powerful weapons, rising violence on our city streets, and continued distribution of illegal drugs have intensified the threat to law enforcement personnel. Meanwhile, the military rules of engagement for ootw place severe limitations on casualties and collateral damage often resulting in a set of options similar to those available to civilian law enforcement. This convergence of roles has stimulated discussion between DoD and DoJ users and developers alike. This provides opportunity for a natural partnership between defense OOTW and civilian law enforcement agencies to develop a joint technology base for common requirements.



Within in the counterdrug program element we have three major technology thrusts: non-intrusive inspection, wide area surveillance, and tactical operations support. In the non-intrusive inspection thrust area, we are developing systems that can detect drugs and other contraband with minimal impact to legitimate shipping. Crossing into our national borders each year are over 10 million cargo containers, 100,000 cargo ships, 120 million cars and trucks, and 600,000 aircraft. Only a small percentage of these entries can be inspected at the 300 ports of entry. Current inspection methods rely on unpacking and visual inspection, a labor intensive operation that requires approximately 20 manhours for large containers. New technology will enable a significantly greater percentage of inspections with far less manpower. Evaluation of the high energy x-ray system has shown a capability to provide a correct detection decision with 93% probability when inspecting large containers containing operationally significany amounts of cocaine. Current projects include a mobile/transportable inspection capability for the southwest border, chemical detection devices, and technologies for inspection of small packages. NII developments are planned, executed, and evaluated with the direct involvement of the civilian law enforcement agencies. As an example, in the evaluation of the x-ray system, personnel from the us customs service participated as part of a red/blue team operational test.