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United States Department of Commerce
Technology Administration
National Institute of Standards and Technology

NIST Special Publication 877

Proceedings of the Manufacturing Technology Needs and Issues: Establishing National Priorities and Strategies Conference

April 26-28, 1994

Gaithersburg, MD

Cheryl Albus, Editor
J. D. Meyer, Editor

GOVERNMENT
MANUFACTURING
TECHNOLOGY
INDUSTRY
ACADEMIA

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- Information Systems

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[1] At Boulder, CO 80303.

[2] Some elements at Boulder, CO 80303.

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Manufacturing Engineering
National Institute of Standards and Technology
Gaithersburg, MD 20899-0001

Sponsored by

U.S. Department of Defense and
National Institute of Standards and Technology

February 1995

U.S. Department of Commerce
Ronald H. Brown, *Secretary*
Technology Administration
Mary L. Good, *Under Secretary for Technology*
National Institute of Standards and Technology
Arati Prabhakar, *Director*

National Institute of Standards
and Technology
Special Publication 877
Natl. Inst. Stand. Technol.
Spec. Publ. 877
461 pages (Feb. 1995)
CODEN: NSPUE2

U.S. Government Printing Office
Washington: 1995

For sale by the Superintendent
of Documents
U.S. Government Printing Office
Washington, DC 20402

Introduction

These are times of unprecedented challenge and opportunity in manufacturing. The current combination of market drivers - decreasing cycle times and costs, and increasing product differentiation, quality, and global competition - is unique in the history of manufacturing and is creating exceptional adversity. At the same time, as the manufacturing community learns more about the physics and chemistry of processes and about process control, starts to grasp how technology and people can be integrated, and incorporates the revolution in information technology, new opportunities are opening up. Manufacturing is an arena where technology truly is changing all the ground rules.

The many challenges and opportunities confronting manufacturers were addressed at the conference described in these proceedings. The breadth and depth of interest in these issues was reflected by the numbers and types of organizations and individuals involved. The conference was cosponsored by 45 federal agencies and industrial organizations and attended by more than 700 registrants. Presentations were made by representatives from a host of manufacturing industries, each of which has been trying to chart its course for the future by developing a “road map” of technology directions and needs.

The conference was a unique opportunity to examine the spectrum of manufacturing industries, identify the commonalities and differences, and start assessing the value of road maps. The conference also provided a glimpse of the full spectrum of government programs in manufacturing technology. By comparing the industrial activities to the range and the scope of government efforts, some perspective could be gained on the “fit” between industry needs and government programs.

The ultimate goal was to develop a plan for moving forward to assure that the United States maintains a strong, dynamic manufacturing sector that is globally competitive and capable of meeting national challenges. Among other themes, the papers reflect growing government collaboration with industry, increasing cooperation within and among federal agencies, expanded technical agendas in government, and experimentation with innovative government programs.

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Semiconductor Industry Needs

Owen Williams
Vice President of Technical Staff
Semiconductor Products Sector
Motorola, Inc.

I will review how the Semiconductor Industry Association (SIA) put together a very successful technology road map that has fostered consensus about the direction our industry needs to go in research and development (R&D). The industry's history put us in an ideal situation for developing a road map. The SIA recognized almost 12 years ago that we were up against a very tough competitor in the Far East and that we needed to join forces in precompetitive areas to enhance our ability to compete in those areas. We formed a consortium, the Semiconductor Research Corporation (SRC), with the intent of funding research at universities to foster advances in semiconductor technology.

Five years later, we found our manufacturing capabilities were falling behind our competitors' and we formed another consortium, SEMATECH, to establish and improve our manufacturing infrastructure for semiconductors. Then, in 1992, we found we needed an industry-wide strategy so that all the organizations pursuing R&D in the semiconductor field would have a common set of goals. In November 1992, representatives from industry, government, and universities throughout the United States met in Dallas to integrate all the activities of SRC, SEMATECH, the universities, and the government, to produce a quality database outlining the needs of the semiconductor industry.

We think about $5 billion is spent on semiconductor research in the United States each year. Industry spends about $4 billion of that, focusing primarily on the current generation and the next generation of factory processes and technologies. The national laboratories spend about $1 billion. SEMATECH spends about $180 million on preparing for the third generation of semiconductors. The universities and the SRC also focus on this futuristic type of research. They have, compared to industry, less money to spend but a greater number of alternatives to investigate. These options are becoming very, very expensive to pursue.

The objective in developing our road map was twofold. First, we wanted to set forth the needs the semiconductor industry has to meet in order to compete in the next 15 years. Second, we wanted to identify critical technical elements that had to be proven before a complete solution was developed and commercialized. In this way, research dollars could be applied in the proper places rather than wasted developing systems that might not work.

The term "road map" is actually a misnomer. We don't know where the technology is going, we don't know which options will be selected, and therefore, we can't be sure of the path we want to take. So the road map only goes so far; there are some trails off to either side, there are some claims in the mountains, and there are some twinkles of gold way up in the hills. The question is, which claim is the mother lode? The SIA does not want to try to predetermine which solutions should be pursued. We want to look at all solutions, because we don't want to stymie innovation or creativity.

We started out by looking at all the elements that go into a semiconductor factory. We eventually put together 11 different road maps. Each road map outlines generic needs, specific needs, and potential solutions. Thus, our road maps are linear projections of where we've been and where we're going. The road map has been published, and 10,000 copies were mailed out to the industry.

The specific needs are what we consider to be the deliverables from the research community. We are not suggesting solutions but rather telling researchers what needs their solutions or creative concepts would have to meet. We also list potential solutions. We got into trouble here by not listing "new innovations," because some people thought they couldn't work on anything that wasn't listed. Each of the basic road maps also has recommendations, a narrative identifying the "show stoppers" and critical success factors. We also identified and described pervasive, cross-cutting competency needs in process control and quality, modeling and simulation of materials, metrology, software, contamination-free manufacturing, sensors, and cost.

The road map was put together by a subgroup of the SIA Board of Directors, the Technology Strategy Committee. Reporting to that committee is the Roadmap Coordinating Group, which includes representatives from industry, government, and universities. There are also eight working groups of representatives from other advisory groups in industry, government, and academia. The road maps are reviewed and renewed every other year through a consensus process, in which the semiconductor community can critique and suggest changes to the roadmap.

Auto Industry Needs

Tim Adams
Director, Partnership for a New Generation of Vehicles
Chrysler Corp.

The Partnership for a New Generation of Vehicles (PNGV) is an effort to achieve technological breakthroughs that would permit the volume production of vehicles generating up to three times today's fuel economy, or roughly to 80 miles per gallon. I will provide background on this venture and address some of the manufacturing issues it raises.

The effort is a partnership of the U.S. government, led by the Department of Commerce, and the "Big Three" auto companies -- General Motors Corp. (GM), The Ford Motor Co., and Chrysler Corp. The industry share of this effort has been folded under the umbrella of the U.S. Council for Automotive Research (U.S. CAR), a joint venture of the three auto companies to develop precompetitive technology. Within U.S. CAR, there are 11 or 12 consortia that pursue development in areas such as materials, emissions, and recycling. "Precompetitive" refers to technology that will not become a competitive differentiator in the marketplace; these are areas we agree to work on together, where we can reach a consensus, and there is sufficient competitive pressure to make sure we do it well.

The PNGV is evolving and will have to include other constituencies, such as the supply base, which will be extremely important to the ultimate success of the program.

President Clinton provided the basis for the partnership in his new technology plan.[1] In early 1993, the chief executive officers of the Big Three began discussions with the Administration that resulted in the signing of a declaration of intent to form the partnership in September 1993. The overall aim is to reduce demand for nonrenewable fuels from foreign sources and to strengthen the competitiveness of the U.S. auto industry, which has a significant impact on the nation's economy. For example, the auto industry is responsible for producing as many as one in seven U.S. jobs.

The structure of the PNGV includes steering groups that focus on policy-level issues. The steering group for the government side is chaired by Dr. Mary Good. On the industry side, the co-chairs are the technical vice presidents of the three companies. We've also formed

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[1] Technology for America's Economic Growth: A New Direction to Build Economic Strength, February 22, 1993.

technical task forces that include representatives from the major government agencies and laboratories and, on the industry side, myself and my counterparts from Ford and GM. This structure seems to work extremely well in facilitating not only communication but also issue resolution. The partnership represents a potential model for further industry-government cooperation.

The PNGV has three broad goals. Goal 1 is to advance manufacturing technology to improve competitiveness, in terms of not only cost, but also lead times. Goal 2 is to achieve near-term advances in fuel efficiency and emissions. And Goal 3, which is long term -- and the one getting the most attention -- is to achieve the kinds of breakthroughs that will permit the volume production of vehicles achieving up to three times today's fuel economy.

To make Goal 3 meaningful, we need to define parameters for the end product. Clearly, one parameter is cost; the target vehicle must cost no more to own and drive than today's vehicles. The program is not merely a fuel research exercise intended to produce an interesting concept car for auto shows. Rather, we intend to design a vehicle that can be mass produced, so we really can reduce, for example, U.S. dependency on foreign fuels. This means we have to meet the parameters for today's vehicles in terms of cost, performance, size, utility, safety, and emissions. To help clarify this objective, we created a composite based on existing mid-sized cars (the Chrysler Concorde, the Ford Taurus, and the GM Lumina).

We have a broad time line for the program. We hope to create a vehicle concept within approximately 6 years, roughly by the end of the decade, and a mass-producible prototype vehicle by roughly the year 2004.

Like the Semiconductor Industry Association, we have a road map and are defining research priorities based on needs, not solutions. In the beginning we are considering all technologies that could become part of the ultimate solution. To achieve Goal 3, we are establishing a construct that permits us to examine the interactions of factors, such as vehicle mass and energy efficiency, to create a matrix of solutions. This matrix will be used to generate the requirements for each technology, to help to focus the research priorities.

It is clear that, as we move down the road, we will have to narrow the range of technologies under consideration. The identified needs and requirements will be used to measure the progress of the various technologies and help make the "neck down" decisions. This "neck down" process allows for more than one cycle for maturation of some of these technologies. We will be able to pursue continued development of the technologies selected for the concept vehicle and then reintroduce those technologies, as they continue to mature, into the production prototype process and ultimately into the mass production process.

To help explain the requirements of the auto industry, it may be useful to draw some comparisons with the aerospace industry, which often is perceived as using the types of technologies that will be needed in new-generation automobiles. Both industries are very capital intensive and involve product development processes with long lead times, but the similarity basically ends there. The car business is characterized by high volume and low per-vehicle cost, while the aerospace business is the opposite -- low volume and relatively high cost. More importantly, the automotive industry has to make products that meet the requirements of relatively unsophisticated owners/users, who give relatively little consideration to the maintenance cycle requirements of their vehicles. The auto industry, therefore, tends not to be able to afford the redundancies incorporated into aircraft.

In addition, the environmental requirements for cars and trucks are severe. We also have to work very hard to service the needs of our customers, who have become less and less brand-loyal in recent decades; to get repeat buys, we must be very sensitive to their perceptions of the value of our products. And finally, we have to take even bigger risks than does the aerospace industry. A major auto product program can cost up to $5 billion. We can spend several hundred million dollars on relatively minor changes in vehicle platforms, and lead times of 3 to 5 years are typical. We're serving an increasingly niche-oriented market, with continuously evolving customer requirements and, on top of that, social demands for continuous improvement in fuel efficiency, safety, emissions, and recyclability.

Now for some details about how the PNGV works. First, we need to combine efficiently all the relevant activities under way in government and industry. The government side is taking an inventory of relevant work being pursued throughout the national laboratories and agencies. The relevancy will need to be confirmed and, where necessary, activities redirected or enhanced to be compatible with our program. The same process is ongoing in the industry, which tends to focus on near-term requirements relevant to Goals 1 and 2. We are depending on the national labs for the longer-term, higher-risk work that would be relevant to Goal 3.

For all three goals, we are beginning to identify priorities and the technologies to pursue and, as I mentioned earlier, to examine the relationship of the supply base to this process. As we build the construct and identify priorities, we are going through a process of identifying the detailed needs and the metrics.

The effort to achieve Goal 1 has two components. On one side are generic competitiveness issues. If we can reduce lead times and increase flexibility with techniques such as rapid prototyping, then we can apply those kinds of techniques across a wide range of manufacturing processes. But we also have to consider the manufacturing issues as enablers for Goal 3 technology. We need to start addressing these issues up front and pursue them on a parallel path with technology development if we're going to design something we can produce in volume. We can't afford to wait until we make technical breakthroughs to address issues of manufacturability, cycle time, and cost.

I think our objective in the PNGV is very, very challenging. But I think those of us directly involved in the program, on both sides, are encouraged by the attitudes and the cooperation we've achieved so far. I think we have a much better chance of achieving the ultimate objective if government and industry work together than if industry were to continue to pursue incremental gains on its own.

Question: How much is the auto industry doing with and for small business, and is that community interested?

Answer: The industry has a long history of supporting small business activity. Our requirements tend to be very demanding, not only in terms of technical, testing, and engineering support requirements but also in terms of volume. So our industry presents a challenge for the supply base. But small businesses have been participating in our industry for a long time.

In the PNGV, we are open to ideas and input from all corners. To echo something Owen Williams said, we are not trying to identify solutions up front, but rather to identify needs. We are encouraging all constituencies to bring us their ideas, so from that standpoint we're encouraging the small business community to come forward.

Question: It looks like you are making things really hard on yourself. On the one hand, you want to achieve these technical goals. Yet you want to keep the cost, performance, and size the same as in today's cars. Don't you think the customer is willing to make some tradeoffs? That is, if you offered them a car with three times the fuel efficiency, wouldn't they be willing to give up some acceleration or something?

Answer: We don't think so. We've discussed that a lot. I think we have big hurdles to overcome to produce a vehicle that consumers will want to buy in volume. There's very little evidence that, at today's fuel prices, even a threefold improvement in fuel economy will increase significantly the perceived value of a car and consumers' motivation to purchase it. There's quite a bit of data to support that position.

I'll also answer that question from another angle. To achieve our goal, we will have to reduce vehicle weight significantly, maybe by 30 to 40 percent. Our information suggests that such a weight reduction creates a problem with consumers' perceptions of safety. If today's car is placed side by side with a car that is 30 to 40 percent lighter, and the prices are the same, it is not clear which one consumers will decide to buy. We believe that consumers will be reluctant to sacrifice utility and functionality. If we go into this project assuming we can achieve our goals with a significantly compromised product relative to today's car, then I'm afraid we may fail.

Question: Do you have published goals outlining what you wish to achieve as a function of time?

Answer: We have the broad timetable, and we are developing a set of more detailed priorities, which will be used to establish a work plan with timetable objectives. We have probably two more levels of detail in our work plan than I was able to discuss today. But it will be some time before we're ready to publish a detailed plan.

Question: I understand that, a few months ago, the major automotive industries in Europe and America signed an agreement to have their suppliers use the Standard for the Exchange of Product Model Data. Ford was the only company that did not sign. Was there any reason for this? Does Ford prefer some other standard?

Answer: I cannot speak for Ford.

The National Center for Manufacturing Sciences Road Map

John DeCaire
Vice President, Advanced Manufacturing Technology Programs
National Center for Manufacturing Sciences

First, I'll provide some background on the National Center for Manufacturing Sciences (NCMS), one of the not-for-profit research consortia established under the National Cooperative Research Act. We have about 180 corporate members; about 25 are among the largest U.S. corporations and the rest are small and medium-sized enterprises.

The NCMS began in the late 1980s with an emphasis on the machine tool industry but now represents a wide range of industry types. We do not conduct any research and development (R&D) internally but rather provide technical and administrative support to facilitate collaborative research and accelerate the development and exploitation of technologies. Our mission is to enhance both the global competitiveness of manufacturing industries and national security. A major portion of our funding comes from the Department of Defense through the Air Force Manufacturing Technology Office.

At any one time we typically have about 100 projects going, totaling some $150 million annually. All projects are co-funded by industry. In fact, over two-thirds of the resources are provided by industry, mostly in the form of in-kind resources although some portion is in cash.

Each NCMS project is really a vertical and horizontal consortium in itself. The basic core of each project is a set of technology users and technology providers. We involve an end user, a set of relevant vendors, and a research center of excellence, probably either a university or a national laboratory. Each project typically has five to eight participants who are signatories to a collaborative agreement. Through Cooperative Research and Development Agreements, contract-type arrangements, or even informal working relationships, we typically leverage each project with another eight to 10 contributors who do not sign the collaborative agreement.

Our agenda is developed through a member-driven process, a combination of a top-down, bottom-up flow of activities. The NCMS Board of Directors consists of about 20 representatives from member companies. We also have a Technology Review Board, which consists of another 20 or so manufacturing technology generalists and strategists. Companies are usually members of other consortia activities as well. The board establishes strategic directions and sets project selection criteria.

The board also creates strategic initiative groups, of which we now have six: production equipment and systems, manufacturing processes and materials, computer-integrated operations, management practices, environmentally conscious manufacturing, and electronics manufacturing. Each group includes a planning committee of 12 - 15 specialists in that particular focus area, an inter-industry mix. They create specific project teams, tactical action groups consisting of the technical principal investigators from the participating companies.

The NCMS tries to strike a balance between near-term and longer-term directions. The Technology Review Board has adopted an agile manufacturing strategic vision as the general precept for the competitive enterprise of the future. We tend to select projects that solve a reasonably near-term problem for the collaborators while also moving us forward toward the agile manufacturing competitive enterprise. With the Agile Manufacturing Enterprise Forum, we are fleshing out the vision of agile manufacturing; Rusty Paterson will discuss that research agenda and road map in detail.

We always allow for what I call "radical" technologies, because you never know when someone will come out of the blue with something that's high payoff and worth doing. We try to set aside about 10-15 percent of our overall agenda for those kinds of surprise activities and follow up on ideas that are driven by opportunities rather than needs.

The agile manufacturing strategic vision includes 4 basic types of requirements. One key requirement is flexibility. A second is environmentally conscious design, engineering, and production capabilities. Concurrent development systems will be needed, as well as traditional and nontraditional processes to make use of new types of engineered materials. Third, systems will have to be interdependent and interoperable; agile organizations and agile practices will require virtual shared capabilities and capacities, the so-called networked organization. The fourth requirement is interactive customer and enterprise relationships. Some people refer to this as the consumer- or customer-integrated enterprise; customer interaction and satisfaction is the key driver and will be very important in the long term.

Each NCMS strategic program initiative typically has a lifetime of 3 to 5 years and probably has three to six projects associated with it. Let me provide some examples of how our mission of achieving global competitiveness and national security tracks through each area.

In materials and manufacturing processes, the fundamental drivers of competitiveness have been identified as flexibility, time to market, rapid product realization, quality, and environmental consciousness. Four research focus areas have been identified. One focus area is quick prototyping. You can build up a model of a product directly from the design files and then use it to do castings, molds, or dies. A number of direct, free-form fabrication processes are evolving, using metal and other materials. The whole area of nontraditional processes, such as water-jet machining and abrasive water-jet laser processing, is fundamental to manufacturing advancement. Representative ongoing projects are focusing on thermal spray coatings and "intelligent" cold extrusion, adaptive process control for composite materials, microwave flow monitoring, and predictive modeling for complex processes.

In the computer-integrated operations area, there is a strong focus on software, particularly top-level controls -- autonomous agent technologies, platform enablers, and factory controls. We have been very active in open-architecture controls and next-generation controller and sensor-support systems. We think object orientation and agent-based types of programming are absolutely essential to the future, where the emphasis will be on connecting reusable objects and agents instead of developing new ones from scratch every time. In other words, we will move from deductive to inductive software programming. It's interesting that, when you ask manufacturing people about their top 10 problems, software rarely is listed. This suggests a low level of awareness that new machinery advances often depend more on software than on hardware.

We also are working on networking applications -- the virtual capabilities for the National Information Infrastructure and concurrent development processes. Our major thrust there is an Advanced Technology Program (ATP) project addressing automated concurrent engineering.

Management practices warrant a mention as well. We have a focus here on what we call "The Big M" extended enterprise, which incorporates all functions of the enterprise from the cradle to grave, rather than just "The Small M" shop-floor manufacturing activity. The activities we pursue in the management area are diverse. The aspect I want to address here is people. We have a strong education and training initiative, which we think must be coupled with technological advances. We have a mobile laboratories program that brings a hands-on technology experience to students in K-12 and beyond. We think training, in terms of deploying the technology infrastructure and brokering the expertise to small and medium-sized enterprises, is absolutely essential.

We also are trying to bring Total Quality Management (TQM) to educational institutions. We're starting to work with the National Alliance for Business to incorporate TQM in educational activities.

In the environmentally conscious manufacturing area, there are many activities focusing on treatment, remediation, and minimization to remedy a backlog of problems common to many industries. For the long term, there is a move toward preventing environmental harm in design and practices. In the next few years, hazardous materials probably will dominate the agenda. Eventually we will address multiple pollutants, closed systems, and a full industrial ecology systems basis for working on environmentally conscious manufacturing issues.

Electronics manufacturing is the newest strategic initiative group. They are working their strategic focus and have established a taxonomy. The cornerstone is an ATP project on printed wiring boards that is producing significant results.

Finally, NCMS has established an infrastructure to support the information base, a number of studies on and advanced deployment of information services. We have four support services for the technology program. One service identifies technologies throughout the world so that, rather than reinvent the wheel, we could turn to foreign sources, laboratories, universities, or other consortia. We also have a deployment management activity, which establishes partnerships with technology integrators, consulting organizations, and others in the business of helping other companies.

Third, in partnership with the Manufacturing Extension Partnership (MEP), we have piloted some activities with shared-use "teaching factories" that we hope will be a valuable complement to the MEP. And finally, we have a Manufacturing Information Resource Center, which has compiled a tremendous amount of manufacturing-related information that is used to support the overall agenda.

We have experienced a number of problems in developing the agenda. Vision clarification, for example, is difficult when you are buried in day-to-day manufacturing problems. The long-term vision needs to be reasonably detailed, yet you can't specify solutions. We deal with this challenge by targeting program focus areas.

Another major challenge is getting the right participation -- that is, from the strategic thinkers in the right positions in a company. Usually, these individuals are also the busiest and don't have time to travel to meetings and workshops. So we are piloting an electronic conferencing system that will allow them to participate when they can find time.

We also are challenged continually in our efforts to integrate product engineering and product manufacturing, balance short-term and long-term activities, define areas of and rules for collaboration, accommodate the differences in priorities and timing among participating companies, and renew the agenda.

In summary, we have a relatively significant agenda, but it is only a start, and we would like to see development of a national manufacturing R&D agenda.

Question: Could you elaborate on the foreign technology sourcing activity?

Answer: The initial focus has been on the former Soviet Union. We've visited a number of science institutes over there, looking particularly at technologies they developed in their Cold War defense activities. We've identified three specific technologies to work on. One is electron-beam fabrication -- physical vapor deposition using electron beams. Another is high-frequency microwave radiation processing. The third is very lightweight anisotropic force materials.

Question: Could you elaborate on the dual-use aspects of your work?

Answer: One of our project selection criteria is that the technology of emphasis must have both military and commercial applications. Like any other activity, our projects eventually focus on whatever the collaborating partners agree to work on. But we force them to address dual use applicability up front, subject to management review and approval.

Question: Are the results of your projects publishable and can we obtain them?

Answer: Yes, with a time caveat. Because we are member driven and provide preferred treatment to members, in some advanced projects the participants have approximately 18 months to use the technology exclusively. We then provide another 12 months of access for the membership before results are released into the public domain. However, many of our projects are not protected in this manner, and the collaborators are willing to release results in real time. So, you can obtain results of the higher-technology projects on a time-delayed basis, and the results of many other activities -- in areas such as environmentally conscious manufacturing and computer integration -- in real time by participating in workshops or obtaining reports directly from NCMS.

Agile Manufacturing Road Map

Robert (Rusty) Patterson
Operations Strategy Manager
Texas Instruments Defense Systems and Electronics Group

I will explore the concept of agile manufacturing, describe the road map for it, and explain how you can take advantage of some of its evolving elements.

The basic premise is that the concepts of manufacturing are changing dramatically, and there will be a complete shift in the requirements for competitiveness. Our old concepts of mass production will not support us as we move into the next century, whether you focus on the year 2000, 2005, or 2010. It doesn't make any difference whether you are a large corporation or a small business. It doesn't make any difference whether you are in the defense industry, which is being driven by world events such as the breakup of the Soviet Union, or you are in the commercial sector, which is being driven by practices such as the development of a brand-new model of Walkman every single week of the year. Successful manufacturers will learn how to deal with change and turn it to their advantage.

In addition, quality and customer satisfaction will be evolving concepts. No longer is quality a competitive advantage; it's a prerequisite for entry into the market. You either have zero defects or you are not a player in the marketplace. Similarly, customer satisfaction used to be considered only at the point of the sale. Now it is beginning to mean meeting the customer's evolving requirements throughout the life of the product. This leads to the concept of upgradable, reconfigurable products. Many new products on the market, whether in military or commercial use, have failed because they do not have those characteristics. And we've all seen the trend -- not only because of laws, but also because it makes good business sense -- toward environmentally and socially conscious products and processes.

If you assume that every manufacturer will have outstanding quality and meet the customer's requirements throughout the lifetime of products, then you must recognize that rapid response and reduced cycle time is absolutely imperative to survival going into the next century. And you must incorporate these elements regardless of the type or size of your industry. You must be able to pick the aspects that apply to your organization and tie them together in such a way that you can compete. The precise definition of "lean" or "agile" is not the point; rather, the point is to take the best pieces out of these concepts and put them into a road map.

The key word in the definition of agility is *thrive*. An agile organization is able to thrive -- not just survive -- in an environment of constant and unanticipated change. An agile organization can turn change into a competitive advantage and come up with market-driven, value-based, customer-oriented products to support the market as it evolves.

The Agile Manufacturing Enterprise Forum (AMEF) is a non-profit, industry-led corporation whose mission is to help U.S. industry make the transition so it can compete in the coming environment where change is a given and must be turned into an advantage. The forum is actually a collaborative effort of industry, academia, labor unions, and the government to develop an industrial policy -- to establish an environment where we can compete, and to help provide a road map for carrying out the necessary research and concept validation. I am the voluntary president of the forum until this summer; the president changes every year. A full-time staff is based at our headquarters in Bethlehem, Pennsylvania on the Lehigh University campus.

Our program has several phases. We have developed a vision, which is evolving. This is a continuing process. You don't just come up with an idea, find a way to implement it, and say you're done, as has been done in the past. We're constantly evaluating where the world is and where it's moving. If it's changing rapidly in particular area, then we've got to take advantage of that. So we're trying to come up with common tools and measures.

We're also proposing an agenda of research that needs to be addressed by industry in pilot projects. The Advanced Research Projects Agency (ARPA) and the National Science Foundation (NSF) that have come forward with Broad Area Announcements (BAAs) to put these plans into action. We also have Agile Manufacturing Research Institutes (AMRIs), teams of universities that band together to conduct research on concepts of agility. The NSF has awarded funds for three AMRIs so far, one led by the University of Illinois, one by Renssalear Polytechnic Institute, and another by the University of Texas at Arlington. The results of their research on concepts can be validated in pilot projects by teams of companies. Thus, the research program is collaborative.

As we go through each phase of development, there has to be feedback. Our agility forum, Agilenet, is a computer system into which we load all the concepts, thereby forming a database complete with names and telephone numbers. This system enables us to reach and link all the investigators who are doing the actual work, in order to develop a better understanding and perhaps gather more data. We also are aligned with the Microelectronics and Computer Technology Corporation (MCC) and the Enterprise Integration Network (EINET) so that we can participate in development of the National Information Infrastructure. In this way, we can make sure all our agility concepts can be disseminated to every enterprise in the country.

The AMEF is not a membership organization; it doesn't cost anything to participate or obtain information about the concepts developed. We are trying to provide, in addition to an industrial policy, a mechanism for reaching and providing information to all of industry.

We have several categories of activities. One category is for small to medium-sized enterprises, because they have to be involved if we are to maintain a robust national economy and take advantage of all these concepts we're developing. We are presenting training programs, workshops, and case studies and working with other organizations to get the word out to small to medium-sized businesses. We work through either a host company in a major metropolitan area or a number of other mechanisms, such as the Manufacturing Technology Centers and the Manufacturing Extension Partnership.

We have a number of education and training concepts. This summer, we will unveil three modules designed to educate the executive level in an organization, the senior management, and the work force. We have piloted the three courses, and we are trying to make them adjustable to individual companies, regardless of size or background. We also are working on two videos that will help explain what the courses cover. One is a "pre-agile" video. The other is a much longer general overview of concepts and ideas, with anecdotal references so viewers can grasp the type of structure we're talking about.

Another category of activities is focus groups. A couple of years ago, we established seven to nine focus groups. We had, literally, 100 companies come together to wrestle with the issues, and they did outstanding work. But we didn't have a process to take advantage of that information -- to replicate it and tie it all together. So we formed a Strategic Analysis Working Group (SAWG) of more than 20 individuals from labor unions, industry, academia, and government to help put together a research agenda and a road map. The members each have a one-year term to help focus the agenda, update priorities, and put in place focus groups. We have individuals such as Peter Brown from the National Institute of Standards and Technology, and John DeCaire of the National Center for Manufacturing Sciences (NCMS). The SAWG will complete its final work for this year by September. The focus groups concentrate on four areas: agile people, agile operations, business practices, and virtual enterprises. We're putting in place groups of individuals from a couple of hundred companies to examine these four areas in depth, to flesh out the concepts and take the broad agenda to the SAWG, which then can develop a more detailed concept that can be disseminated and useful to a broad spectrum of users.

To start the process, the SAWG developed a set of agility issues and provided a framework and resources. We sent this information to 500 focus group participants a few weeks ago. The first of four groups will meet at Oak Ridge National Laboratory starting tomorrow; the rest will meet within the next 30 days. The focus groups will begin to develop a very detailed agenda and identify a number of issues that require quick further refinement. Then we will put together small project teams of dedicated and knowledgeable individuals who want to work on those issues. These small projects, which will be finished within a year, will help verify that we have the right concepts and the right technologies in place.

The agenda for each focus group is rather lengthy. As an example of the types of concepts examined, the focus group on agile people will address questions such as, "Does having self-directed work teams make you agile?" The answer is, not necessarily. Many organizations have self-directed work teams; the key is how these work teams are used. The emerging environment of change will be characterized by a highly mobile work force, and companies will have to move in and out of different market and product areas and form and re-form teams very fast. Thus, agility depends on how work teams are employed, on whether and how the organization is reconfigured over and over again. Another concept being addressed is best practices; we added the idea of partial best practices, because in most cases no one organization has all the answers.

Regarding agile operations, some of the requisite technologies were outlined previously by John DeCaire. We're fortunate to be able to work with a number of different consortia and have their representatives serve on the SAWG, so we can tie all the elements of agility together. The forum is trying to provide an overall umbrella and integrate all the different concepts into a roadmap, so we all can see how the pieces fit together, which areas need to be funded, and where activities already are under way.

In virtual enterprise area, a key issue is how to integrate all the concepts and ideas, and hundreds of companies, to develop a process model that makes sense? We've identified four key areas for any enterprise. An example is agile customer-supplier relationships.[1] In discussing this concept, it becomes clear that a virtual corporation must be able to develop instant contracts. The enterprise must be able to put together a joint venture quickly, rather than relying on two teams of lawyers to produce 6 inches of documents in 9 months. We have encouraged individuals in the legal community to come with ideas on how to do that and identify the laws that must be changed.

Each agility issue will be divided into subtopics, which will continue to be researched. In this manner, we're starting to develop a pyramid, deepening the understanding of what is needed is all areas so we can develop a complete agenda.

To validate this research, pilot projects will be conducted. We're fortunate that Stan Settles at NSF and Mike McGrath at ARPA brought forward some ideas we could build upon to

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[1] This topic was addressed in the recently published first monograph in AMEF's agility series. These publications are reviewed by an editorial advisory board, most of whom are not members of the AMEF but are recognized experts from across the country. The board is continuing to review the work done by focus groups, so we can make sure we have a valid, detailed, acceptable, methodology for discussing the terms.

develop a process model. The model integrates the AMEF research agenda and priority road maps and the research activities coming out of different organizations, so that we can come up with concepts and requirements for validation. The actual design work will be carried out by different organizations, sometimes AMEF, sometimes the AMRIs, or consortia such as NCMS, MCC, and the Consortium for Advanced Manufacturing International, or individual companies.

Based on that detailed design work and the outputs of the focus groups, BAAs will be developed to allow teams of organizations to conduct pilot projects to validate the concepts, technology demonstrations, or pathfinders.[2]

I think our process model will allow us to validate concepts, feed the information back into the research agenda, and put in place the industrial policy we need to succeed in the future. The model still is being articulated, but it eventually will provide a feedback loop to get the information and validated concepts to all the different arenas that need them.

We're trying to establish the idea that there are good programs across the country; I have mentioned just a few. The AMEF would like to be the repository of all the successes and failures and be able to update the road map and feed the information back to industry, so that we can create the environment we need to take advantage of all the great programs discussed at this conference.

Question: I really like what's happening in agile manufacturing, but I'm concerned that it's very difficult to teach an old dog new tricks. How much attention is given to start-up companies, so that all these ideas could be disseminated at the very beginning level in manufacturing? I don't see anything like that happening, and it sounds like your organization could help.

Answer: I think you've got a very accurate vision. In most cases, there is no problem convincing executive management and lower-level workers to adopt the new concepts. The problem, whether in companies, labor unions, the government, or academia, is middle management -- people who have been there for 20 or 25 years and have achieved some level of success. The concepts I'm discussing could threaten the way they've done business, even their careers. Our training modules try to help individuals get over that fear and help put in place a career development scheme that assumes change is how people grow. In other words, we try to convince them there is no longer a corporate step ladder but rather a corporate step stool, and they are valued based on the tools they bring to the party rather than the number of people they supervise.

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[2] Pathfinders are U.S. Air Force (USAF) activities associated with the USAF 2005 Program.

We have a Chief Executive Officer Leadership Steering Committee, which gives us strategic guidance. Some of the members will speak at this conference: Thomas Murrin, dean of the School of Business and Administration at Duquesne University, and Thomas Malone, president and chief operating officer of Milliken & Co.

You're absolutely right that the key will be convincing people that it makes sense to employ the new concepts. We need to show people that it makes economic sense to do this, and that their success depends on it. You can draw an analogy to 30 years ago at a filling station, where a guy is pumping gas, and you show up to explain why a self-service pump is a good deal for him. You can explain that there will be car washes, mini-marts, and 20-minute oil-and-lube operations and all these other things -- that whole new industries will be created. You need to give people a sense that they are not losing their jobs, they are creating new industries.

Product Data Exchange Road Map

Ian McEwan
Executive in Charge
Quality, Reliability, and Durability Validation Center
General Motors Corp.

We hear a great deal about the National Information Infrastructure (NII), mostly about its entertainment possibilities, such as 500 television channels. But the real value of the NII to manufacturers is as a means to produce or manufacture the television sets to watch those channels, as well as the trucks and cars for television workers to drive, and the trucks, trains, aircraft, and ships to transport those televisions and thousands of other goods to every corner of the global marketplace.

The ability to exchange product data by digital means is the key to making the information age a time of productivity and prosperity. Digital product data exchange makes the information highway useful and relevant and enables effective, concurrent engineering and effective computer-integrated manufacturing. Product data exchange fosters the re-engineering of our processes and the modernization of our plants and supply systems. If we focus our efforts on speeding development of this capability, it will provide U.S. industry with a competitive set of tools.

We all know that profits to go those who minimize production costs. Complex products, such as automobiles or aircraft, require enormous inputs of information at every stage, from design and manufacture through maintenance and disposal. We need information standards and technology to support industrial products and processes throughout their life cycle, from concept through recycling. With digital product data exchange standards, vendors, manufacturers, and suppliers can share information in a way that will shorten development cycles, enhance the quality of products, and reduce costs.

Today, as never before, the competitive edge goes to enterprises that can communicate rapidly and accurately, both nationally and internationally. Increasingly, manufacturing teams are geographically dispersed. Yet engineering, manufacturing, and service companies must work together to design, manufacture, and support products. Information also must flow freely within corporations and, in joint projects, across corporate boundaries to and from manufacturing partners and suppliers.

The Boeing Co. recently summarized the problem by noting that they had something like 30 to 60,000 different suppliers, depending on the size of the product being made. And just one supplier had 17 different computer-aided design (CAD) systems. Boeing said this doesn't make sense, that it adds no value to American products. We agree.

At General Motors Corp. (GM), we ran into the same problem soon after we started the C4 Program, which was aimed at providing a single technology product design platform for the corporation worldwide. As with all programs of this type, the initial concern centered around the technology to be used. The users quickly formed camps to defend their own favorite hardware and software. However, as we installed more and more workstations, local area networks, and wide area networks, users quickly focused on their real problem: They could not exchange data with their customers and suppliers.

While they had physical connectivity, they could not read the data they received without massive manipulation. They could not send out data without long consultations with the person receiving it, even when they were using the same software. The problem obviously went far beyond the technology. Not only did they need compatible data formats, they also needed to prepare that data in a consistent manner. They had to store the data in recognized locations, provide for both access and security, and provide outside directories so the data could be found.

We instituted programs to define corporate standards for data preparation, filing, and retrieval. To address the data format problems, we standardized all software and hardware packages and developed custom translators where necessary. Even so, data exchange remains our biggest challenge in integrating all the company's activities.

We would not expect to run our businesses today without telephones, which can connect with virtually anyone, anywhere in the world. Yet in the data exchange field, there is too often no network, no connectability, no common language.

GM and every other major manufacturer in the industrialized world wants out of the translator business. We need to be able to move our data from one system to another, from one location to another, from one manufacturing site to another, from one user to another, without having to convert it. This can happen only if we have both a standard data format and a single data network.

The Standard for the Exchange of Product Model Data (STEP) is the digital standard that will allow us all to move our data wherever we want. As a neutral standard to which all product data exchange software can adhere, STEP will facilitate multi-enterprise, multi-vendor, multi-supplier manufacturing efforts. The emergence of STEP is a triumph for industry-government partnerships. Those who are putting together the NII would do well to study and learn from these ongoing examples of industry-government partnerships aimed at keeping U.S. industry competitive.

The automotive, aerospace, electronics, construction, and process industries are implementing STEP projects. Much of the groundwork for the international standard was established in Product Data Exchange Standard (PDES), a voluntary U.S. standards organization, through the efforts of individuals from more than 200 companies. The U.S. Technology Advisory Group (TAG) spearheaded the campaign last year in Italy to gain international standard status for STEP from the International Organization for Standardization (ISO). The head of the U.S. TAG is Dick Justice from the Automobile Industry Action Group, whose members are GM, Ford Motor Co., Chrysler Corp., Lamborghini, and 700 suppliers in North America.

Brad Smith of the National Institute of Standards and Technology (NIST) is chair of the International Standards Committee for STEP. More than 25 major corporations and government agencies have joined resources in PDES to accelerate STEP development. PDES pursues STEP development efforts in sheet metal projects, electronic circuit boards, and mechanical parts. With funds and staff from its member companies, PDES also evaluates commercial STEP tools and provides education, training, and hands-on experience for member company employees in STEP standards development and intercompany project management.

PDES also has been a leader in urging increased commercialization of CAD, computer-aided manufacturing (CAM), and computer-aided engineering products based on STEP. Last month, PDES and the executive board of the National Initiative for Product Data Exchange (NIPDE) hosted a special meeting, where 17 American and European computer software vendors told business leaders of their plans to incorporate STEP in their products. The fact that commercial STEP products are being produced by the computer software industry -- including giants such as IBM Corp., ComputerVision Corp., cisco Systems Inc., Digital Equipment Corp., EDS Corp., Intergraph Corp., and Hewlett-Packard Co., as well as smaller firms -- bodes well for our ability as a nation to compete and thrive in the emerging post-Cold War world.

STEP is also an important part of the National Center for Manufacturing Sciences (NCMS) effort in rapid response manufacturing. That program is helping manufacturers shorten manufacturing lead time dramatically. Participants include GM, Ford, Texas Instruments, United Technologies Corp., and Martin Marietta Corp. All told, there are more than 400 ongoing product data exchange research and development projects, accounting for approximately $50 million to $70 million in annual corporate and government expenditures. That estimate comes from NIPDE, an industry-led, government-facilitated partnership based right here at NIST.

The NIPDE was established two years ago to bring order and focus to the field of product data exchange. This is being done by accelerating product data exchange research and implementation efforts through the coordination of hundreds of activities. The plan for NIPDE was initiated, reviewed, and implemented by senior executives in industry and government;

members understand that each has nothing to gain and much to lose if individual efforts and expenditures are duplicated.

The participants include representatives from individual companies and consortia, which represent many other organizations and corporations. I am a co-chair of the NIPDE Executive Committee along with Dr. Mary Good, the under secretary for technology at the Department of Commerce (DOC). U.S. industries have a common goal in digital product data exchange, and at last, through this forum, we're learning to work together to achieve the common vision. The NIPDE is expected to have a lifetime of 3 years; the executive board and steering committee are working on a transition plan to institutionalize functions that need to be continued.

Industry and government staff members work full-time here at NIST on the milestones and deliverables defined in the NIPDE plan. The initiative staff has developed a baseline of all product data exchange activities that is available on the Internet. This directory lists more than 400 projects addressing standards development, testing, software development and deployment, education and training, and communications. Program managers use this database to identify both gaps and interdependent activities. Along with representatives of participating organizations, they plan workshops, advocate priorities, and establish and carry out action plans to establish the needed product data exchange capabilities.

The NIPDE participants and staff also have developed a road map to guide national efforts in product data exchange. This process involved reviewing the relationships among different projects, determining the actual capabilities for exchanging product data provided by these projects, and examining how these capabilities related to the business objectives, modernization strategies, and requirements of different manufacturing industries. Participants in this effort were from six major industries: aerospace, apparel, automotive, electrical, shipbuilding and construction, and software. And this road-mapping technique can be extended easily to other industries. Companies can use the methodology to evaluate product data exchange strategies, establish plans for implementing these strategies, and monitor how well they help achieve specific business goals.

The NIPDE is working with participants on plans to use the road-mapping methodology to develop product data exchange capabilities in a wide range of areas, including digital mock-ups, electronic component information, electronic printed circuit assemblies, form features, sheet metal composites, process plants, scientific and engineering data, technical publications, and testing.

All these cooperative activities form the basis for the development of a master plan, which will provide all U.S. industries with a summary of current activities, priorities, and schedules that they can use to meet their specific requirements and to help coordinate and leverage their implementation of product data exchange technology. Organizations interested in participating should contact the NIPDE office at NIST.

Our national efforts to spur STEP development are not taking place in isolation. Rather, they complement work under way in Great Britain, Japan, Germany, and even China, which recently opened up a center to promote this most modern of manufacturing technologies. The vital nature of STEP was recognized in a memorandum of understanding (MOU) signed last year by Audi, BMW, Chrysler, Fiat, GM, Mercedes Benz, and Opel, and in the U.S. construction industry's creation of a new STEP development organization.

Someone asked earlier why Ford did not sign the MOU; I can report that Ford has become very active in STEP, and I believe their signing is imminent. Ford has produced, in cooperation with AlliedSignal Inc., a connecting rod part that is an early example of how STEP can be used in the translation of data.

One of the most significant recent developments has been the discussions involving the Executive Advisory Council of the Computer-aided Acquisition and Logistics Support initiative, the NIPDE executive board, the DOC, the Department of Defense, the Department of Energy, and the National Aeronautics and Atmospheric Administration. A study team, which I chair, was established under the oversight of NIST to explore issues relating to a single industry-government board. The meeting was very positive and a proposed approach will be reviewed in mid-May. Joint boards are discussing future activities, such as electronic data interchange, electronic commerce, the NII, and other key issues critical to U.S. manufacturing industries.

I believe we already have achieved major successes in the field of product data exchange and that we're on the threshold of major improvements in connectivity that will make it possible for us to truly use the NII in manufacturing.

Question: Why will this program be any more successful than the Map Top program, which a decade ago was supported by GM, IBM, and Deere & Co. with the same enthusiasm you describe now?

Answer: Timing. I think industry is much more ready now to accept this type of program, and the technology is much more advanced and used on a much wider basis. Map Top had only three companies participating; STEP has some 400 companies, so it has a much larger volume and much greater interest. So while Map Top laid some groundwork, we also learned some lessons from it. We learned that you have to have sufficient interest and a sufficient number of people, and that interest has to spread. STEP is an international standard now, it's not just in the United States. In fact, the United States has to get its act together quickly, because Europe and the Far East are pursuing STEP vigorously, and we could get left behind.

Question: How will this technology be deployed to the small business community, which probably can least afford it?

Answer: That's one of the major questions that drove GM to its C4 Program. Our suppliers are also Ford's and Chrysler's suppliers, and their very reasonable complaint was that they had to have different CADCAM systems for each of us, a significant financial burden. We believe STEP will allow suppliers to use any software and hardware they choose to provide data to any auto company, because STEP allows data to be moved in and out of any system. Of course, they will have to install some technology.

There is no question that we're moving toward transferring data in individual bits. We are moving away from paper. GM no longer pays paper invoices; we do everything electronically. We still have to link our digital design data to that electronic system, so suppliers will have to make some investments. But it should be one set of investments, and not 3, 5, or 17. So STEP is aimed at helping smaller businesses as well as corporations.

Question: Are there small software vendors out there who pride themselves on providing differentiation in their market niches?

Answer: That phenomenon is not limited to small software vendors. We do need differentiation. Our problem in the C4 Program was everyone had their favorite piece of software that handled their favorite activity. That software is a lot less useful when the user can't send data to anybody. We have found it's far better to focus on obtaining common data rather than specific pieces of equipment.

The challenge for all software vendors, large and small, is to provide something unique but at the same time to produce a standard data set. This approach can be turned into a market advantage. Because if you can sell us a standard data set, we will not focus on whether your differentiation makes your data useful. We will take your data simply because we can plug it automatically into our current data sets. As computers become more powerful, our ability to produce compatible data will continue to improve. (Both users and manufacturers are challenged by trends in the computer industry: New workstations double in power and have their prices cut in half every 18 months.)

Question: What is the schedule for release of STEP software?

Answer: We posed that question to 17 software companies we invited to South Carolina earlier this year. We should recognize that we had to wait for international acceptance of the third part of the STEP standard, and that STEP is a very complicated standard, so we've only released the first part officially. I think all the software companies are working on it now, so we should see new STEP products certainly by the end of 1994.

Question: How are you dealing with the legacy systems that exist in all companies?

Answer: Very badly. Legacy systems are a major problem. Our vehicles are in production for six or seven years, and some of our trucks even longer. In addition, we're required to keep that data for 10, 15, 20 years afterwards. We're wrestling with how to keep the old software and the updates available. As GM moves into new products, many of the parts carry over, but we also have a lot of new parts. Our approach is to handle the new parts in the new system and to carry over the old parts in the current system, unless the old parts are similar enough to the new parts to make translation into the new system worthwhile. We make that judgment on a part-by-part basis.

We certainly are not automatically translating all our legacy parts into the new system. That would cost hundreds of millions of dollars, and it would not necessarily be worthwhile, because the machinery and equipment for making the old parts is tuned to the current system. But we have been removing legacy systems division by division, as we standardize the C4 system and generate more new parts in new systems.

Question: How do you calculate and sell the return on investment in this activity?

Answer: The C4 Program we sold specifically on its ability to shorten cycle lead time. We were able to calculate how much we could shorten our time-to-market cycle by moving to standardized software and hardware and to digital data. Our financial data show that the program more than paid for itself, based on improved efficiency, shorter time to market, and faster reaction times. Now, this transformation also requires changing the processes that drive the time-to-market cycle. We often talk of 10-fold reductions in cycle time for a first design, and up to 100-fold reductions for a repeat version of it. Design engineers love this, figuring they now have time to try 24 variants. So you have to change your cycles, to give them less time to reiterate their designs.

Question: Rusty Patterson talked about agile manufacturing and the virtual enterprise, which require very large systems integration efforts. You've been involved in that effort. Could you reflect a bit on our abilities and what it will take, from your perspective, to develop a virtual enterprise?

Answer: John DeCaire captured the essential steps very well. It's a big challenge. You start with a vision. You have to get the key players together, and they have to agree on what they want to do. Management has to pull this program; it can't be pushed by the underlying technologies. There have to be business requirements and good business sense. You also have to place limits on your vision. You should not bite off too much, and you should not get into technology for technology's sake, which is a great danger with a program of this type.

You have to recognize that people are very territorial and are afraid of change. Someone else talked about the problem of middle management. As we began to put all the CADCAM systems into drafting offices, the individuals most threatened were the supervisors who had begin their careers on the old drafting tables, whose expertise was in the old-style drafts. Now this information is all in a tube, through a sort of magic these individuals neither comprehended nor had any real expertise in.

You also have to recognize the differences among professionals in various fields. We worked with a state university on a study that identified clearly the cultural differences among engineering, manufacturing, and supply communities. Engineers love new hardware and software and want to have the latest and greatest. But manufacturers don't want new technology, because it has to be de-bugged, and they think it breaks down frequently. They want "something we can use a sledgehammer and blow torch on." Their customers have to *tell* them to use new technology. And the supply community is caught in between. They feel a need to use new technology but fear the cost of it.

KEYNOTE ADDRESS:
Setting National Priorities for Science and Technology Policy

John H. Gibbons
Director
Office of Science and Technology Policy

Ian McEwan spoke of how people resist change, and he's right, change is discomforting. How many of you have changed professions at least once? It may have been discomforting at first, but it probably was enlightening later on.

President Clinton keeps saying that his administration was "sent here to help change things." Manufacturing is one of the areas where change is needed. It is heartening to see the kind of enthusiasm evident at this conference for advanced manufacturing technology, which we consider absolutely essential to the nation's economic future and to the creation of not only profitable and resilient industries but also good jobs.

I will discuss the new direction and new ideas for science and technology developed under the leadership of President Clinton and Vice President Gore. Traditionally, U.S. science and technology policy was aimed primarily at supporting basic science and defense-related research. That was fine for the years when we were engaged so deeply in military activities and keeping the peace and we dominated the world economy at the same time. But that time is past, and a new paradigm is needed. Obviously, we need to maintain our historic support for fundamental science and we have to continue to invest in advanced technologies to equip the world's finest fighting force. We must maintain the defense technology base that keeps us free. But the Cold War is over; today the challenge that unites us is the fight for economic prosperity.

The administration sees technology as an indispensable engine for economic growth, and science as the foundation on which all technical progress is based. Technological advancement fuels economic growth and creates productive jobs. Furthermore, if we choose carefully, technologies for energy efficiency and resource conservation will produce not only a cleaner environment, but also expanded markets and increased profits. Technology also promises new educational tools that will challenge and reward all our children and provide innovative training that will help make our work force the best in the world.

These are noble ambitions, and we're trying to pursue them with a government we inherited that is deeply in debt. We're heading toward a third successive year of a shrinking annual deficit, but we're still in a pretty deep hole. As an ex-physicist, I have to derive a theory of holes. The first principle of the theory of holes is that, if you're in one, you ought to stop digging. So we place heavy emphasis on deficit reduction, and that means -- especially at a time when we're already fairly heavily taxed -- we have to be very careful about expenses. In the past couple of years we really have tightened the screws on Federal spending. We hope there are more places to cut, because we're playing a zero-sum game. If we start anything new, we either will have to terminate something else or increase our productivity to the point where we have extra resources.

The second principle of the theory of holes is that, if you're in a deep hole, you have to devise ways to climb out. One of the most important ways to climb out is to invest in science and technology. There are other means as well: Investments in infrastructure and people are examples. But it will be crucial to invest in science and technology, and to shift our emphasis on defense technologies toward a balance of roughly 50-50 between defense and civil investments.

In contrast to some prior administrations, we also feel that economic growth and progress are not inconsistent with environmental progress. If we choose carefully and are elegant in the use of technology, then we can provide not only for robust economic growth but also for improvements in environmental quality.

We further believe there is ample opportunity to reinvent government, just as the private sector has been transforming itself so impressively over the past decade. So we devised the National Performance Review (NPR), which involves working agency by agency to take advantage of the opportunities offered by technology to increase productivity and become more client oriented or user friendly. The NPR also reflects a broader concern about government being a productive partner with the private sector. In aiming toward opportunities where public and private interests are aligned, we find opportunities for joint investments.

All of this leads up to the fact that a key element in this Administration's vision for science and technology policy is support for advanced manufacturing. Of course, the idea that science is fundamental to technological progress is not new. The transistor, for example, came out of fundamental research in solid-state physics, which in turn was informed by basic work on quantum mechanics performed years before. But we're reaching frontiers in manufacturing technologies where scientific advances clearly are more important than ever before.

What is new is the recognition that the relationship between science and technology is not linear. The model emerging now is not a straight line but rather a complex set of feedback loops. Technologies hit barriers that cannot be overcome without an infusion of new scientific knowledge. New demands for technology applications inspire scientific investigation, and, conversely, scientific studies are enabled by the tools provided by technological advances.

A recent discovery demonstrates how scientific studies are enabled by advances in technology. A planetary system was discovered around a dead star, in the first direct observation of planetary systems beyond our solar system. This discovery was derived from elegant measurements of the time variations in the rotation of a neutron star. The small variations in this repetition frequency, which reflected changes in the neutron star's position due to the orbiting of several planets, was made possible by our ability to make extremely accurate time measurements. This work came out of the National Institute of Standards and Technology (NIST).

Fascinating as it is to examine the outer reaches of the universe in the images that originated billions of years ago, an equally amazing world lies within the Earth-based realm of manufacturing. Let me offer a somewhat speculative example of a new world to explore in the inner sanctum of manufacturing technology.

Quantum mechanics provides access to this sub-submicron territory. An intellectual concept once confined to theoretical and experimental physics, quantum mechanics is now an everyday engineering tool. It even appears in undergraduate engineering courses. Nanoscience has become an engineering practice, thanks to recent theoretical and experimental advances, and precise atomic and molecular control in the synthesis of solid state, three-dimensional nanostructures is now possible. The volume of such structures is about a billionth of that of micron-scale structures.

The next step is the emergence of nano-technologies with unprecedented features. The stage is being set, I believe, for a wide variety of range of custom-made products based on the emerging capability to manipulate individual atoms and molecules during the manufacturing process. We are learning to synthesize devices such as molecular wires, resistors, diodes, and photosynthesis elements for insertion into nanoscale machines.

Already, the use of optical materials assembled at the molecular level has reduced response times and energy losses and increased transport efficiency in nanoscale materials. A not-so-remote possibility now is molecular manufacturing for mass production of miniature switches, valves, motors, or accelerometers, all at affordable prices. This new technology could fuel a powerful economic engine, providing new sources of jobs and wealth and technology stores.

Fundamental understanding of basic physical phenomena at the quantum level will be needed to understand and exploit these types of technological opportunities. New knowledge must be gained with regard to superlattices and multi-quantum wells, localization effects of electron and light waves, flux patterns and their pinning, the dynamics of superconductors, and mechanical analysis of nanostructured systems. This basic scientific understanding will find a very broad range of technological applications, from energy storage and generation to magnetic storage and recording to supercomputers.

To an ex-physicist like me, these prospects are exhilarating. But our new understanding of the complex, symbiotic relationship between basic science and technology draws attention to the need to build strong bridges to cross that gap. The transformation of leading-edge technologies into practice is a risky and arduous process. It's a long, long way from invention to profitable production. Cooperative efforts by government and industry to advance technology can help bridge that gap. One of this Administration's top priorities is to form closer working partnerships with industry, as well as universities, state and local governments, and workers to strengthen U.S. industrial competitiveness and create jobs.

The Clinton Administration defines competitiveness as the degree to which a nation, under free and fair market conditions, can produce goods and services that meet the test of international markets while simultaneously maintaining or expanding the real income of citizens. This definition comes from a 1985 report of the President's Commission on Industrial Competitiveness,[1] and I think it's a good guide for us. We want to boost the performance of U.S. industry and see that it compares favorably against the best in the world. And we want to accomplish this through increased productivity, improved quality, and rapid response to customer demands -- not by pinching the wages of American workers, or driving the dollar down so far that our living standards fall, or degrading the environment.

Advanced manufacturing technologies are key to achieving the better, cheaper, faster, and greener production we need to keep up with the rest of the world and set a good example. These technologies are the focus of many of our partnerships with industry. Cooperation and cost sharing often are indispensable, we believe, to getting high-risk but potentially very-high-payoff technologies off the ground. The reason is that, despite their potential for producing significant societal benefits, high-risk technologies often don't promise a high enough rate of return to individual firms to encourage investment and foster development. Without government as a partner to share some of that risk, the investment might never be made.

This may be the case with nano-technologies for molecular manufacturing, which seems to hold out possibilities for overall industrial growth but could be prohibitively expensive for individual firms to pursue alone. Another example may be new pollution-reduction processes, which could help preserve the environment but might not attract industrial interest without government support. So there are natural environments for public-private partnerships that can produce positive results on both sides. I'll mention a few of the partnerships of this type we've undertaken recently.

The Technology Reinvestment Project (TRP), a cornerstone of the President's defense conversion effort, offers technology extension services for manufacturing businesses. It has

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[1] President's Commission on Industrial Competitiveness. 1985. Global Competition: The New Reality. Washington, D.C.: U.S. Government Printing Office. January.

proven highly popular with industry, universities, community colleges, and state and local agencies. In the first call for proposals, the TRP drew almost 3,000 responses offering over $8 billion in private funds, which more than matched a relatively modest government investment of roughly $500 million. In four rounds of awards extending into the fiscal year (FY) 1994 budget, the TRP has granted a total of $605 million for 212 well-qualified proposals selected strictly on merit. Every TRP project is cost shared, usually 50-50, and all have dual-use applications.

Incidentally, we have succeeded in incorporating into the language of the international General Agreement on Tariffs and Trade (GATT)[2] that 50-50 sharing is permissible under GATT. These GATT changes are being considered by the Congress.

Many projects awarded TRP funds are focusing on advanced manufacturing technologies. One project involves a team effort to develop manufacturing processes for multichip modules, a method of interconnecting integrated circuits on a common substrate (as opposed to the current approach of packaging them separately and then having to wire them together). The goal of the project is to lower manufacturing costs by achieving all the needed technology advances simultaneously. Project teams members include GM Hughes Electronics, IBM Corp., Micromodule Systems, Motorola Inc., nCHIP Inc., Polycon (a small business), Texas Instruments, and Sandia National Laboratories, which will establish a test bed for the newly developed technologies.

Another TRP award went to a team headed by Bath Ironworks, a shipbuilder for the Navy and the major employer in its location in Maine. Shipbuilding is a moribund commercial industry in this country, except for the defense business, but the industry might well be revitalized by new manufacturing technologies. Bath Ironworks intends to create a globally competitive shipyard with the aid of new technologies, such as computer-aided design, process simulation, flexible automation, robotics, and real-time systems for process control and production planning.

Another award related to shipbuilding went to a team headed by CYBO Robots, Inc. The project team intends to integrate technical advances in the design of three-dimensional vision and weld sensors, to create a mobile robot welding system that can be programmed, for example, to help build ships. The project could cut the cost of these robots in half, and the system would be able to do three-quarters of the welding work needed on ships inexpensively, effectively, and accurately. The robot system also could be used in other activities, such as bridge construction.

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[2] GATT, which has 117 member nations, is aimed at reducing trade restrictions through the gradual lowering of trade barriers, such as tariffs and government subsidies, during the next 50 years.

Just as exciting to me are the TRP projects in manufacturing education and training. These are practical programs that prepare engineers and technicians for the real world of the factory floor while making use of highly sophisticated education and training devices. For example, Mississippi State University is teaming with industrial partners to create a master's degree program in computer simulation for design and manufacturing. The New Jersey Institute of Technology, in collaboration with Massachusetts Institute of Technology, will devise computer-aided tools to teach engineering students systematic ways of developing clean manufacturing processes.

In Detroit, a coalition led by Project Focus Hope that includes six universities, the "Big Three" auto makers, and other industrial partners will develop modular courses for associate's and bachelor's degree programs in manufacturing. The emphasis will be on developing hands-on skills integrated with engineering knowledge. The project will recruit pre-college young people, especially women and minorities.

Another important partnership effort is the Advanced Technology Program (ATP) run by NIST. Like the TRP, this is a strictly merit-based program of matching grants, but it focuses on commercial and not necessarily dual-use technologies. Of course, almost all manufacturing process technologies are applicable to defense as well as commercial production. The Clinton Administration is committed to making the ATP a success. Despite our budget restrictions and the theory of holes, we've succeeded in working with the Congress to raise ATP funding from a pilot-level $68 million to $200 million in FY 1994, and we have requested $450 million for FY 1995.

The increased funding has enabled NIST to adopt a strategic approach to its investments in industrial technology. NIST is creating programs in five major technology areas for focused, long-range support. The government investment will total about $745 million over the 5 year lifetimes of these programs, and industry participants will match the government share. NIST also plans to continue its general competition for cost-shared proposals in any and all technologies.

The five focused programs, first identified from more 150 White Papers sent in by the private sector, were selected based on four criteria: (1) potential benefit to the U.S. economy, (2) strength of the technology ideas proposed by the industry, (3) strength of industry commitment to the program, and (4) potential for the ATP to make a significant difference.

Two of the focused programs directly target advanced manufacturing technologies. One will support projects to improve significantly the processes for and reduce the cost of making strong, lightweight, durable composite structural materials. These materials could be ideal for use in highly fuel-efficient automobiles, for example, or long-lasting and easily repaired bridges. At present, however, the cost of these materials is so high that it limits the market. Composites now are used mostly for military aircraft or high-priced tennis rackets or golf clubs. The full potential of these materials can be achieved only if we lower costs through improved manufacturing technologies.

Another focused program is in computer-integrated manufacturing for electronics. This program is intended to develop a flexible, software-based framework for streamlined manufacturing, improved productivity, and expanded product variety in the electronics industry. The goal is to enable U.S. firms to readily scale up and reconfigure manufacturing operations -- in other words, to become agile.

I've discussed at length the leading-edge and beyond-the-edge manufacturing technologies. But this is not the whole story. Equally important is the dissemination of existing best practice technology and knowhow, especially to the roughly 360,000 small and medium-sized U.S. manufacturing firms. Some of these firms are operating well below the state of the art, using technologies from the 1950s and 1960s. Often, owners and managers are simply too overwhelmed by day-to-day problems to learn about and invest in equipment and practices that might help them grow, increase their profits, create jobs, and supply their customers more effectively. The shortcomings of these suppliers then are passed on to their larger U.S. client companies, thereby limiting overall competitiveness. By contrast, some of the largest Japanese firms spend a fair amount of their resources helping their suppliers stay current with the state of the art.

Therefore, another top priority of the current Administration is to establish a nationwide network of industrial extension centers. Every one of our approximately 360,000 small manufacturers should be able to obtain the types of services these centers offer. The centers offer, for example, "house call" visits to individual plants. The centers also help firms find expert assistance in meeting needs, such as those related to worker training, use of new technologies, or solving environmental problems. Part of this network already exists and is operating very well. NIST directly sponsors seven Manufacturing Technology Centers (MTCs), sharing the costs with local governments and the private sector. Through the TRP, we are supporting 28 additional centers across the country, also on a cost-shared basis.

To sum up, this Administration places a very high priority on supporting advanced manufacturing technologies, as a means of achieving our overarching goals of fostering economic growth and creating productive jobs while protecting human health and the environment.

Our support has four components: (1) continuation of our historic support of basic science, with a new recognition of the complex interaction between science and technology; (2) strong support for cost-shared, competitively selected partnerships with industry to advance high-risk, high-payoff commercial and dual-use technologies; (3) assistance for small manufacturing firms in the use of best practice technologies, including training methods and environmentally conscious processes, and (4) improved manufacturing education and training for engineers and

technicians. Combined, these components form a well-rounded program of true partnerships between government and industry to strengthen manufacturing, which is the foundation of our economy.
Question: Is "industrial policy" still a dirty word? Can something be done about it without actually using this term?

Answer: I'll give you a personal response. I think industrial policy -- like competitiveness and sustainability -- means different things to different people. In the eyes of Thomas Jefferson or Ben Franklin, and the framers of the Constitution, industrial policy was a means of taking advantage of natural opportunities for society to protect and invest and encourage innovation and investment. The formal concept of an industrial policy emerged in the 19th century, with agricultural assistance programs and extension services.

In the 20th century, virtually every one of our successful industries has arisen from what I would call an industrial policy. Our work in aeronautics led ultimately to the space program, and our work in fundamental biology led to biotechnology. That's not to say we should invest in Chrysler Corp., for example, and not some other companies. Most of us would be put off by that approach. So there is good industrial policy and bad industrial policy.

This Administration believes in industrial policy -- at least my definition of it. We think the free market is strong and needs to be protected because it works so very well. But we also believe there are opportunities for aligning public interests with private interests in a way that makes for very productive partnerships and helps both sectors win.

Question: A few of us considered the decision to cancel the Superconducting Supercollider (SSC) unfortunate, given the cost of its shutdown. Is there any chance that decision might be revisited?

Answer: I would not bet money on putting an accelerator in that hole any time in the near future. The cancellation of the SSC arose from a variety of circumstances. First, it was turning out to be more costly than we had planned. Second, the project never was internationalized, perhaps because we started it during the Cold War, so we had no partners to help pay the bills. Third, the SSC hit the wave of cancellations intended to get the deficit down. The SSC was an easy target because, while it was supported by all 50 states initially, support dwindled after the decision to locate it in Texas. And finally, particle physics is an obscure field, despite the efforts of some eloquent people to describe the excitement of figuring out where mass comes from, and what the Big Bang looked like.

It is expensive to shut down the project, simply because of contracts, people, commitments to the State of Texas, and other things. The High Energy Physics Advisory Panel is in the process of determining the best way to go from here.

We should remember, however, that the SSC represented only half of our high-energy physics budget. The other projects continue. We're building a "B factory" (a high-energy accelerator) at Stanford University and we're upgrading the Department of Energy's Fermilab in Illinois. The SSC cancellation, if you want to make lemonade out of lemons, now gives us an opportunity to get together with other nations, probably the European Center for Nuclear Research[3] group, and start structuring a truly international long-term vision of where particle physics can go.

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[3] The center, known as CERN, is a multinational European consortium that operates high-energy research facilities near Geneva, Switzerland.

Textile Industry Needs

Thomas J. Malone
President and Chief Operating Officer
Milliken & Co.

I quote Dr. Jack Gibbons: "Competitiveness is in the eye of the beholder." In my eye, it's jobs and standard of living.

What an exciting event this is. What a wonderful conference with so many world-class "thought leaders" focusing on a fundamental driver of our nation's standard of living -- manufacturing. What a great opportunity for us to learn.

I am delighted to represent our very large, high-technology manufacturing industry -- the fibers, textiles, and fabricated products industry. The textile complex. Our industry is clearly a major-league player in the manufacturing game. The U.S. textile industry is world class in quality, productivity, delivery, safety, environmental concern, and customer satisfaction.

Like the other speakers representing various industries, I will share an overview of our key technologies, our vision of how cooperative research and technology efforts can affect our competitiveness, and our road map. However, I want to do this from a broad perspective in order to cover our very large, multi-level, totally vertical industry. The specific technology road map and needs are very different for each segment of our industry. We have developed those maps; however, I won't be showing them. I plan to try to give you insight into our big, complex industry, with a major focus on the lessons learned in driving our competitiveness and how we have organized to survive and be world class. I believe our experience has direct bearing on the overall success of manufacturing, and that such sharing will allow me to contribute the most to this conference.

Our industry is layered, like most U.S. industries. We have three major layers:

- synthetic fiber and natural fiber (cotton and wool) producers;
- yarn and fabric manufacturers; and
- makers of fabricated products, including apparel, home furnishings, and a wide variety of industrial products.

We are very typical of all U.S. manufacturing when we look at our textile complex by company size. A majority (61.3 percent) of workers are in the 0.7 percent of manufacturing companies with more than 1,000 employees. We have a "barbell" distribution of big and small companies in the United States. That's a key factor when we focus on the competitiveness of a total industry.

The textile fabrics industry is a carbon copy of America in general -- only 2.1 percent of textile manufacturers have more than 1,000 employees but they have 64 percent of the workers. In the fabricated products segment of our industry, 30.6 percent of the employees are with the 0.6 percent of companies that have more than 1,000 workers. This is the most fragmented part of our industry but it also is typical of U.S. industry in general.

Let's take a "big picture" look at the textile complex. How many of you ever have been in a textile plant? We have very sophisticated, high-speed, high-tech manufacturing machines and processes in our plants. The fiber through fabric-producing segments are very capital intensive and have very high productivity -- the highest of any nation in the world.

The fabricated products segment also has the highest productivity in the world, but it is still labor intensive, which makes it vulnerable to competition from parts of the world paying extremely low wages. Unfortunately, we have learned that loss of our labor-intensive fabricated products segment leads to loss of our very sophisticated and capital-intensive fiber through fabric segments within about 10 years -- a very important lesson.

We are a very large and important contributor to the U.S. economy. We have 26,322 manufacturing companies in our industry -- 39 synthetic fiber companies, 4,982 textile companies, and 21,301 fabricated products companies. We employ about 2 million people at plants in all 50 states; we provide 12 percent of the direct manufacturing jobs in the United States. We invest about $4 billion per year in capital equipment to reduce costs and improve quality, productivity, and consumer responsiveness. We pay about $4 billion per year in state and Federal taxes. We use close to 5.5 percent of all the energy used by industry. And we spend about $3.5 billion a year on research and development (R&D).

Our products are sold through 100,000 retail stores. Wholesale shipments to retailers total $137 billion per year; our consumer sales are the highest of any manufacturing industry, $219 billion per year. Our industry generates $55 billion in gross domestic product, more than any manufacturing industry except aerospace with $65 billion.

The market for our products has grown steadily for the past decade. Unfortunately, despite our major improvements in productivity, imports have grown much faster than have our markets since 1980, and our domestic production (in units) has declined steadily. In fact, the U.S. trade deficit in textiles and apparel was nearly $34 billion in 1993, only slightly less than the deficits in automobiles and oil. The net effect of these imports is the loss or failure to realize more than 1.2 million jobs. Our goal has to be to retain or recapture a significant proportion of these excellent jobs.

Some have said the textile industry should be a "sunset" industry. The primary basis for that argument has been the belief that other developed nations, such as in Western Europe and Japan, have dismantled their textile industries as their societies have matured. The facts do not support this argument. For years, no one studied the facts -- a lesson.

These are the facts: About 15 percent of all U.S. workers are in manufacturing, compared to just under 23 percent in both Europe and Japan. The percentage of these manufacturing workers in the textile complex (omitting cotton and wool growers) is just under 10 percent in the United States, 10.9 percent in Europe, and 11.5 percent in Japan. Thus, it is a great fallacy that these highly developed parts of the world have phased out their large and important textile industries. Another important lesson.

Our industry has a very important uniqueness, which I believe has enabled its survival when many thought it had no future in America. I also believe this may be a very important issue for other industries to think about. A possible lesson.

What is this uniqueness? It is the extraordinary integration, both horizontally and vertically, with several integrating organizations or consortia that have been in place 60 years or more. These organizations are funded almost entirely by the industry. They provide leadership; education; process R&D; technology road maps; technology assessment services; competitive technology transfer from around the world into the domestic industry; and ongoing assessments for their members of quality, cost, delivery, and environmental safety, educational capabilities, and performance.

These industry organizations or consortia have been led by our company leaders, who have a passion for driving our industry competitiveness while remaining ferocious competitors in the markets we serve collectively. Lesson: leadership at the top.

Over many years, we have learned how to cooperate and compete simultaneously. We have learned that consortia have to focus on process technology rather than on developing specific products, and that their contributions have to be visible and measurable over time. These have been crucial lessons for us.

In response to the dramatic increase in imports that started about 1982, the industry rallied together to form the Crafted with Pride Council in 1984. Funded entirely by the industry complex, the council was a totally vertical consortium tying all segments together. The council had several objectives. One was to study the industry as a vertical system, to determine how we best could increase our industry's competitiveness.

This initiative produced some stunning lessons. For example, despite the fact that each segment of the industry had the best quality and the highest productivity in the world, there was an enormous loss -- or waste -- in the vertical supply chain from manufacturers to the retailers and the consumers. These studies revealed that there was typically a 66-week apparel supply pipeline from raw fiber to the consumer. That long cycle resulted in a $25 billion loss in 1984 -- or 25 percent of our sales. These losses were a direct result of our industry's inflexible manufacturing and inadequate forecasting, planning, and scheduling capabilities. Do these conditions exist in other industries?

These studies led to the formal launching of "quick response" initiatives throughout our industry. Studies showed that at least $12 billion in costs could be eliminated. However, retailers had to invest about $3.6 billion to put in place point-of-sale information as the starting point for a "consumer pull" system, as opposed to the "manufacturer push" system that has prevailed in the United States. In recent years a new label has been given to this approach, Demand-Activated Manufacturing (DAM) -- the DAM against imports!

Despite our efforts, imports continued to increase dramatically in the late 1980s, creating chaos in our vertical industry. We had to do more. The enormous upheaval brought into sharp focus the need for additional resources from outside our industry -- resources that could make it possible for us to remain at the forefront worldwide by driving technology and its use. We concluded that we desperately needed collaboration between our total industry and our world-class government research laboratories and universities and other industry organizations.

We had in place the four industry research, education, and technology transfer organizations: Cotton Inc., ITT, [TC]^2, and TRI. Driven by the vision of expanded research, the National Textile Center (NTC) was established in 1991 with the four universities -- Auburn, Clemson, Georgia Institute of Technology, and North Carolina State -- that produce about 90 percent of the graduates in textiles and related industries. This is a unique consortium conducting cross-campus, cross-department research, with our industry leaders providing oversight and evaluating the results. Early results are very exciting and promising.

One year later, in 1992, our industry was one of four to be invited to the Department of Energy (DOE) Critical Technologies Workshop in Berkeley, California. Our involvement in that workshop led to the launching of the American Textile (AMTEX) Partnership. The partnership involves the entire textile complex, both vertically and horizontally, as well as a consortium of DOE labs. From the industry side, AMTEX is led by our four industry consortia and the NTC. These organizations have been driving our road maps for years. Every company in our industry has the opportunity to participate.

Working intimately with the labs, our industry has developed a broad vision of what we would strive to achieve, working together. Our vision was to develop "leapfrog" technology, or breakthroughs, as well as incremental improvements that would result in our total vertical industry providing the highest-quality, best-value products with an environmentally conscious DAM system that was world class in every aspect.

We are 2 years into this journey. It has not been an easy one; none of us expected it to be. We knew there would be many hurdles and lots of reasons to say, "It's not worth the effort." And that has almost happened several times. But we have not quit. The potential payoff is too great for our nation, our industry, and the world-class scientists, engineers, and labs that have made us the world leader in defense-focused research.

I believe we have dealt successfully with most of the many questions and problems we have faced. None has been insurmountable to date, because we always have fallen back on the basic premise that we're all trying to do the right thing for our country and our industry. AMTEX is a very exciting collaborative research initiative.

We have an excellent vision, or road map, for the future of our industry. We are major users of the generic manufacturing technologies identified by the Council on Competitiveness. We have exciting and important research needs and opportunities in the textile complex. We have enormous needs for dynamic simulations, high-speed computing and analysis, systems modeling, flexible computer-integrated manufacturing, "intelligent" processing equipment, improved materials, environmental technologies (particularly for recycling and reuse of materials), energy management, and biotechnology. We have the road maps that integrate these technologies.

We all should ask, "Is our industry prepared and capable of effectively using successful research results? Are we organized to do so?" We believe our industry is. Productivity improvement is a good way to measure that. Let's look at the productivity improvement of key segments of our industry over time.

Over the past 15 years, our industry has invested continuously in new equipment at the rate of $4 billion per year, thereby producing at higher and higher speeds, and greater and greater levels of productivity. Both our textile and apparel segments have increased productivity at a faster rate (over 3 percent a year) than the average for all U.S. manufacturing (2.5 percent). I believe our industry consortia have driven this achievement.

We have made enormous improvements as we have competed vigorously to survive. Now, where has this occurred? Let's look at yarn manufacturing, where productivity (measured as output per machine hour) has increased more than eightfold in two decades. And fabric formation, where productivity has increase almost sevenfold in the same time period. Clearly our industry is making enormous investments to drive technology.

Unfortunately, the major machinery developments that have brought about these enormous increases in speed have been made, in large part, by about six companies, all foreign. And they are selling the new-generation machines worldwide. We must make breakthroughs here in the United States that are not readily available anywhere else -- and we can.

Let's look at the dyeing and finishing of fabric, the step where we produce colors and product features such as wash-and-wear properties, stain resistance, and anti-static and water-resistant properties. There has been only a 40 percent improvement in process speed in this critical area in the past four decades. What an opportunity. This is a key industry segment; DAM cannot achieve its full potential in our industry without major breakthroughs in this area.

Following are just a few of the specific technology needs in dyeing and finishing manufacturing: new dyeing technology, precise color controls, new chemical application techniques, chemical recovery processes, heat transfer technology, and high-speed fabric stabilization.

No foreign companies dominate this important segment of our industry. Major developments can give us opportunities to leapfrog the competition and create major machinery-building opportunities in the United States. And this is just one specific area of opportunity. We have many, many more, particularly in fabricated products, the most labor-intensive segment of our industry.

Our industry is in real motion with the AMTEX Partnership. We are learning a lot. Projects in progress are focusing on

- DAM architecture (DAMA);
- computer-aided fabric evaluation;
- textile resource conservation (including raw material recovery and reuse, generic technologies, and new manufacturing processes);
- rapid cutting initiative,
- sensors for agile manufacturing, and
- embedded electronic fingerprint.

We have more than 120 companies working as research partners on these initial projects, and we have only begun. I believe AMTEX will prove to be a great study in success for our industry and for America. And we should share the lessons learned as we proceed.

I believe most of the generic technologies that can enhance the competitiveness of *our* industry are equally applicable to many other industries represented here. No generic technology has broader application than DAMA project, the bellwether project of AMTEX. Our industry is far along in implementing DAM, having been on this path for almost eight years.

Our vertical industry already has invested about $4.5 billion of the estimated $6.9 billion needed to implement DAM fully. An enormous amount of data must be handled to use these concepts fully in our industry. Transferring the enormous amount of data from retail to the suppliers is a big issue. The real challenge is to convert that data successfully into a highly effective forecasting and planning system for each level of manufacturing. This is not in place yet, and it is a must. That is the major objective of the DAMA project.

It seems reasonable to assume that there are tremendous opportunities to enhance competitiveness in most industries through real-time transfer of consumer purchases into effective forecasting, planning, ordering, and scheduling systems for the upstream suppliers. We are far down this road. The textile complex seem to be positioned perfectly to ride the information superhighway, using the DAMA to win the race for global competitiveness and American jobs. In the meantime, we are moving ahead at full speed.

In summary, our large industry is a very important contributor to the nation's standard of living. We are a major user of generic manufacturing technologies. We are organized uniquely -- and have been for a long time -- to implement new technology rapidly and effectively. Almost 50 percent of our markets are supplied from offshore, mostly low-labor-cost countries. Each 10 percent of the business we can save or recapture means 124,000 jobs in the United States. Agile manufacturing is a critical factor.

Through NTC and AMTEX, we are searching for opportunities to expand our effects on behalf of the overall competitiveness of our industry and the nation. We are prepared and anxious to work with any government departments and labs or other organizations to advance cooperatively any initiatives that can enhance further our competitiveness, and that of other industries.

We believe the key factor in success is integration through collaboration -- in vertical industries, in government, and in universities. We know such integration is difficult. However, we believe we have learned how to do it. The ideal process is to use Total Quality Management concepts break down the barriers.

In closing, thank you for this exciting event and the opportunity to share with you the story of the U.S. textile complex and the lessons we have learned. We are dedicated to making the next chapter of our industry a great success story of world-class collaboration of government, academia, and the textile complex -- a role model of competitiveness for our great nation.

Food Industry Needs[1]

Adolph S. Clausi
President
Institute of Food Technology

It's no accident that the U.S. food system is the most advanced in the world. It's not luck that makes ours the most reliable, healthy, and abundant food in history. It's research. It's science. It's technology. Food processing requires advanced manufacturing technology and the talents of many scientific disciplines: chemistry, physics, microbiology, molecular biology, mathematics, engineering, and nutrition. And advanced technology is the key to making America even healthier, cleaner, and more competitive.

We are at the threshold of a better understanding of the complex relationships between food and health -- the relationship between heart disease and dietary fat, the interaction between nutrients and the immune system, and the influence of diet on cancer. The food processing industry seeks to enhance the nutritional quality of food, make healthier food choices desirable and available, develop new foods to meet urgent health goals, and make the world's safest food supply even safer. For instance, The Dupont Co.'s microbial typing technology uses genetic analysis to identify bacteria in food definitively and rapidly.

Americans care about the environment. They want cleaner technologies that are protective of natural resources. Food science research has led to new plant technologies that greatly reduce the need for pesticides. We also have developed a laser device for peeling vegetables that significantly reduces resource use and byproduct waste.

It is also no accident that food is America's largest manufacturing industry at $400 billion a year. Research, science, and technology keep it in the forefront. Food is one of the top three industries for value-added products, an engine for economic growth. For instance, Ocean Spray Cranberries, Inc. sold $27 million worth of cranberry products in 1963; today, sales are more than $1 billion. That's a lot of juice from a little berry.

This kind of growth from new technologies and new food products creates American jobs. But our competitive edge is eroding. We are losing industries critical to innovation and design of new processes, and with them jobs and capital. Most food equipment development and

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[1] The first five (indented) paragraphs comprise the script for the video that introduced Mr. Clausi's remarks.

manufacturing has moved overseas. Our competitors in Europe and Asia are better organized than we are to achieve research and development (R&D) priorities. This is a wake-up call for America to become healthier, cleaner, and stronger. We need industry, government, and universities to work together to plant the seeds, nurture the ideas, and harvest the products of the U.S. food system in the 21st century.

With all due respect to Tom Malone and the textile complex, I submit that food is the fabric of America. We say things are "as American as apple pie." Food fuels not only our appetites, but also our economy. Our ability to produce, process, and export commodities and value-added food products at globally competitive costs is fundamental to our stature in the world community. It distinguishes us from almost any other nation in the world, buttresses our national security, and supplies our humanitarian relief efforts.

The U.S. food industry leads the world in its ability to convert raw commodities into finished products and to deliver food to consumers in the safest, most convenient, and highest value-added form possible. As I said earlier, the foundation for this leadership is provided by food science, advanced technology, and research. Other speakers have described some of the exciting prospects for semiconductors and automobiles. We in the food processing industry are here today, alongside these sectors, not because we have the sizzle but because we have the steak. The food processing industry offers equally exciting prospects that can help meet the national goals of making America healthier, safer, cleaner, and more competitive.

Very few people recognize the true size, nature, and economic contribution of our industry, so let me briefly describe it. Food is the nation's largest manufacturing sector. The annual value of shipments by the nation's 16,000 food manufacturers approached $400 billion in 1987 and is even higher today (at $404 billion). Some 1.5 Americans are employed adding value to farm commodities by processing them into foods. In 1991, the industry contributed $145 billion in added value to the U.S. economy. That is comparable to the added value provided by the chemical (including pharmaceuticals) and transportation equipment industries, with $155 billion and $152 billion, respectively.

For the public policy makers present, I note that food processing is vital to the economy of every state. Many food processing jobs are in states with small populations, in rural communities, and in small business. Food processing is a first-tier industry from which many other industries evolve -- industries such as printing, packaging, transportation, and warehousing. Thus, an investment in food jump-starts many other advanced manufacturing sectors. Every job in food processing creates three additional jobs.

America's food technology needs have been articulated by the Institute of Food Technologists in the report *America's Food Research Needs: Into the 21st Century.*[2] This report drew on the expertise of more than 200 individuals and the organizations they represent. The needs of the food industry fall into three categories: health and safety, environment, and global competitiveness. All three areas offer significant opportunities for ground-breaking research, science, and technology.

In brief, this is our road map. In health and safety, the top priority is to improve the health benefits derived from our food supply. To accomplish this, we need to improve understanding of how the nutritional and non-nutritional components of food modulate biological processes and influence the molecular and genetic aspects of health and disease. This field of inquiry will continue to be significant, possibly predominant, in the decades to come and will be a key component of health-related research in the next century. This research will lead to increases in processing effectiveness that will enhance the healthful properties of food and reduce health care costs through preventive medicine. If improved nutrition reduced health care costs by only 10 percent -- which we believe is a realistic goal -- then the savings to the nation could be as high as $14.5 billion.

After all, food is preventive medicine. We envision using new knowledge to create foods designed to meet health promotion goals, as well as the dietary requirements of individuals who are pregnant, aged, or at special risk of disease. We can develop products to help control allergies and other sensitivities as well as genetic and other types of disease. We also must find ways to capture the fun in food without the fat. Entirely new molecules can turn this hope into a reality.

Improving health also means improving food safety. The most critical food safety issue is control of microorganisms, especially those that cause disease. We need technologies that can distinguish pathogenic organisms from harmless or friendly organisms and can detect and measure their presence rapidly, before they create health problems. Promising work is under way in this area.

The Dupont Co. has developed a state-of-the-art genetic analysis technique that makes it possible to identify automatically, within eight hours, the species and strain of bacteria in food or clinical or environmental samples. This process now takes up to two weeks. Thus, the new technology heralds a new era of safety in food processing and in detection of pathogens. It suggests that we also may be able to predict how harmful particular microorganisms are. Rapid pathogen detection and identification has enormous implications for food safety and

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[2] This report was published as a supplement to the March 1993 issue of Food Technology (Vol. 47, No. 3, pp. 1S-40S).

also may enable us to enhance the value of beneficial microorganisms, such as those in cheese, yogurt, and beer.

Our second category of needs is environmental technologies. Not only do Americans want and deserve foods that are healthier and safer, but they also want foods that are cleaner and safer in terms of how they affect the environment. Advances in biotechnology have enabled us to repel pests without pesticides. We can bioengineer crops with resistance to disease, thereby greatly reducing the need for chemicals, and we can modify plant characteristics to reduce the need for energy during processing. Advanced technologies such as the laser peeler actually eliminate product waste.

Environmental concerns are driving the development of cell-free, enzyme-based systems to convert food processing byproducts into useful food and non-food products. For example, biotechnology-derived enzymes can convert byproducts from grain and rice milling, fruit and vegetable processing, shellfish harvesting, and cheese production into products such as vitamin C, ethanol, or other alcohols. These processes not only reduce the waste stream but also yield value-added goods.

Biosensors developed in the space program for atomic reactors are another environmentally friendly technology. The food industry can use biosensors to detect marker substances in foods, monitor antibiotic use, detect food spoilage, and measure the presence of contaminants. These technologies have obvious potential for boosting the engineering and equipment manufacturing segments of our industry. As food processors incorporate environmental technologies and concepts throughout their organizations and relationships with other firms -- a trend some have called industrial ecology -- resources will be conserved and waste reduced.

Our third area of concern is global competitiveness. Currently, food is a bright spot in the U.S. balance of trade. Not only is the rest of the world consuming our grains and farm commodities, but also value-added foods that provide jobs for American workers are expanding our export markets. In the past three years, exports of value-added products for the first time have outstripped the dollar value of exports of raw commodities, and trends are favorable for even further growth in this high-value trade.

As we look toward the 21st century, we must recognize that our food manufacturing base depends on our competitive ability to convert raw materials into a variety of finished, value-added foods. Increasing the U.S. share of the $140 billion world export market for consumer foods from the current 8 percent to 15 percent would generate a 1 to 2 percent increase in the U.S. gross national product and create about 1.5 million new jobs.

But our competitive edge is eroding; most of the equipment used in the food processing industry is made in other countries. Packaging is another sector that is moving overseas. Equipment and packaging are crucial to innovation and product development. We should take a lesson from the automobile industry; the loss of key suppliers to overseas markets was one of the first harbingers of the decline of the U.S. auto industry a decade ago. The U.S. food industry needs to recapture the equipment makers, engineering vigor, and $7.5 billion in capital funds now at work overseas.

One factor in the erosion of U.S. dominance in the food industry has been the formation of public-private alliances overseas. The Germans, the French, the Japanese, and the Koreans have formed alliances of industry, government, and universities to conduct R&D in food science and technology. We propose that such a partnership be established in the United States -- a U.S. Food Experts Alliance for Strategic Technology (USFEAST).

USFEAST would be a collaborative effort of industry, government, and universities, all working together to achieve the scientific and technological breakthroughs needed to take the U.S. food system into the 21st century. The name USFEAST symbolizes the goal of providing Americans and other peoples with healthful, abundant, affordable foods while healing the earth, water, and air and enhancing human health. USFEAST would attack the complex barriers constraining the U.S. food system today. Private and public investments would be used to refocus and leverage existing funds to achieve strategic applications throughout the food system, with far-reaching implications for domestic and international security. USFEAST could achieve breakthroughs in knowledge and technology over the next decade.

Three interdependent, strategic initiatives should be pursued: (1) development of commercially viable processes and foods to promote wellness and reduce disease risk; (2) implementation of environmentally friendly technologies for conserving human and energy resources, reducing pesticide and chemical use, reducing food processing wastes, and improving environmental quality; and (3) application of innovative manufacturing strategies that would enable improvements in productivity and maintain our global competitive edge.

USFEAST has the potential to reach and benefit every American household, measurably improving how we eat and live and assuring America of a strategic position in the world food supply system.

Electronics Industry Needs

Dieter Bergman
Technical Director
Institute for Interconnecting and Packaging Electronic Circuits

I work for a trade association that deals with electronic interconnections. It started out as the Institute of Printed Circuits (IPC) many years ago, and the name was changed later when it became clear that the institute was addressing more than just printed circuit boards. The Institute for Interconnecting and Packaging Electronic Circuits is similar to other trade associations. Such groups conduct seminars, collect marketing data, and do surveys; some also do workshop training and re-certification, and a few do research.

The major emphasis of IPC programs is establishing consensus. We are basically an accredited standards developer, so we write many standards that relate to printed circuit boards and electronics in general, such as for test methods and safety characteristics. Many other groups in the United States and the rest of the world write standards and specifications. In the United States, we in the private sector work under the auspices of the American National Standards Institute. The National Institute of Standards and Technology (NIST) carries out the government standardization activities. Most of the standards in Europe are coordinated through the Committee for European Electrotechnical Standardization, and in Asia most of them are written in Japan.

The standards-setting process relates to the reason IPC is in the road-mapping business. Every organization has to have flexibility, direction, focus, vision, and structure. We start the standards-setting process by identifying a need. We then go through an approval cycle: We have a group that works out the details, which are sent to the companies affected for comment. This process requires a road map, because you need the community -- the map makers -- to be involved. You need to establish a direction, decide on the distance you want to go, and find out the rules of the road.

In 1993, the IPC decided all the members of the supply chain should be involved in our road-mapping activity. The supply chain includes component manufactures, original equipment manufacturers (OEMs), material suppliers, design tool and electronics makers, companies that fabricate or assemble printed circuit boards, and, most importantly, customers. Customers are critical because all too often they decide to buy products overseas. The reason all members of a supply chain have to be involved in road mapping is, simply, they already are exerting some influence. We recognize that the OEM drives the fabricators and the assemblers, and all those companies drive the suppliers. We found we had to deal with three Cs: customers, cooperation, and coordination.

The first step in our road-mapping activity was a survey. Our membership is international, but we work under U.S. rules and we are trying primarily to bolster the U.S. electronics industry. We decided to ask all 1,900 member companies what their needs were for the short term (1993), medium term (1995), and long term (1997). We also sought their innovative ideas and asked questions on certain topics. For example, in fabrication, we asked what kind of conductor they planned to use (i.e., the number of holes, the size of the holes, the number of layers). We were looking for technology trends.

Then the key issue was how to analyze all that data. In 1993, we had over 600 respondents representing every level, from management to quality to process control to engineering design to production. We had a snapshot of the opinions of many people who make things, who produce things, and who buy things. Drawing meaningful results from this information was a very complex process.

This is where the map makers come in. You call for a workshop, get some experts to attend, and lock them in a hotel for three days with the survey data. We had nine teams of experts work on our data at a workshop in 1993. We asked them to determine, for each topic area -- components, equipment, material, design, fabrication -- the current status of the industry and the outlook. We wanted to know where the United States has been successful, and what could be done to ensure that we would be successful in the future.

Five major "show stoppers" were identified at this workshop: (1) limited methodology for integrating new technology into manufacturing, (2) lack of a single set of industry-government economic programs for the supply chain, (3) lack of coordination between design tools and the production process, (4) lack of environmentally friendly materials and processes, and (5) poor customer-supplier relationships. I should add that the United States recently sent a team overseas to talk to Japanese manufacturers. In January, the team reported that the Japanese had been successful because they had the inverse of the five "show stoppers" identified in the IPC workshops. In other words, we probably found the right problems.

The experts at our workshop also came up with 164 distinct recommendations. The IPC decided to examine each one, to establish a priority order and gauge the level of effort required for implementation. Was a national initiative required? Would the recommended action duplicate some little-known activity already completed or under way? Or could the recommendation be carried out as an IPC committee project?

The experts also decided it would be important to repeat the survey in 1994. We did, although we changed the process slightly to concentrate on design, materials, fabrication, and assembly. The new survey was conducted at the beginning of this year, and the road-mapping workshop in March. An executive overview of the 1993 survey has been published, and we are working on the 1994 overview.

As a result of these activities, we recognized that the U.S. electronics industry has to change. We have to change the way we manufacture products, interact with the environment, transfer data from the design phase to the manufacturing floor, service customers, develop new technology, and, most of all, the way we purchase products and work together.

In our road-mapping activities over the past year and a half, it has become very clear that U.S. industry is in a feeding frenzy. As Department of Defense (DOD) budgets have moved away from military hardware, industry is dashing around looking for ways to get some of that money. The IPC is less concerned about getting the money than it is about how to manage the research projects. So we created the Interconnection Technology Research Institute (ITRI). All levels of the supply chain, as well as government and academia, have made a commitment to cooperative research through ITRI, which gives us an opportunity to create a national strategy for printing board and assembly manufacturing.

The mission of ITRI is very simple: to enable revolutionary innovation and solutions for future requirements, and to improve existing technology. We need to borrow a technique from the Japanese, who, instead of always developing new technology, continuously improve the old ones. Our overarching goal is to ensure world-class, U.S.-based manufacturing capability.

We want to foster partnerships among all members of the supply chain and come up with solutions for the needs identified in the road map. So a set of research projects has been developed. The goals of these projects are to develop benign manufacturing processes; reduce the total cost of manufacturing per square foot; develop new manufacturing materials; develop methods to prove our products work and continue to work; and devise methods for transferring new technology to the marketplace.

I worked 24 years for Philips Consumer Electronics, and some of the products I worked on never reached the marketplace. That still happens today. We also have national laboratories that do great work for the DOD, and very little of it has been transferred to the commercial sector. So management of these projects is important, not only to improve the performance of technology but also to ensure technology transfer and to do all the other things that are necessary.

The ITRI is an non-profit, industry-led public-private consortium administered with Federal research and development funds earmarked for precompetitive projects (a funding strategy now allowed under Federal laws). There will be a governing board. The chief executive officer is Marshall Andrews, who formerly was with the Microelectronics and Computer Technology Corporation. The IPC road map is the guide for ITRI projects. The details will be addressed by technical project teams on design, base materials, board fabrication, assembly, and so on. Our whole premise is to form work teams of manufacturers, suppliers, and users so that we can regain the competitive edge we have lost over the last few years.

In summary, the United States must maintain leadership in electronics. It has been said that a country that lacks a good electronics base is not a leader in the world. Japan recognized that reality some time ago, and now the United States has too.

Department of Defense
Manufacturing Technology Programs and Strategies

Anita K. Jones
Director, Defense Research & Engineering
U.S. Department of Defense

Thank you for the opportunity to provide you with an overview of the Department of Defense (DOD) investment in manufacturing technology. The DOD has three objectives in this area: (1) to drive down the costs of producing and owning defense goods, (2) to contribute to national economic security, and (3) to integrate the commercial and defense industrial base. The third objective is new under the Clinton Administration. This objective focuses not only on defense technology, but also on applying these innovations to create new commercial technologies and markets.

The DOD requires an affordable, multi-use manufacturing base. The metrics of success are reduced cost, reduced cycle time from design to production, assured access to the state-of-the-art technologies, and the crafting of new products that contribute to military technological superiority. One message I want to emphasize is that, despite declining defense budgets, we will sustain our investment in manufacturing technology, now roughly $1 billion a year. We will shift our investment focus, however, to emphasize defense-critical manufacturing needs.

The U.S. investment in manufacturing actually is increasing, certainly in industry but also among a number of Federal agencies. For years, the DOD has collaborated on manufacturing projects with the Department of Commerce (DOC), the National Science Foundation, and the National Aeronautics and Space Administration in particular.

The DOD has four major manufacturing programs. One is the scalable flexible manufacturing program in the Advanced Projects Research Agency (ARPA). This program emphasizes electronics, materials, and information systems. One topic of interest is electronic packaging, specifically multichip. In 1990, DOD bought almost the entire U.S. market for defense-critical technologies that offer increased speed and reliability of device interconnects.

Today we control 40 percent of a roughly $50 million market, which we believe is poised to grow significantly. We look forward to dramatically increased commercial participation; we expect to control about 10 percent of a $700 million market at the turn of the century. This is a strategic, sustained investment. It's quite different from ARPA's Technology Reinvestment Project (TRP) or the DOC's Advanced Technology Program, where projects are closer to market and commercial industry assumes greater ownership of risk.

Multichip modules are a good example of a strategic DOD investment that starts when the technology is in the cradle, and DOD continues to support that industrial sector as fabrication and manufacturing capabilities mature. However, once market applications become defined, DOD investment is reduced as industry investment becomes sustained.

The second DOD manufacturing program is a set of projects referred to as Technology for Affordability, also managed by ARPA. The aim here is build portability into a particular class of products. We develop pilot factories and experiment with technology. In one project we are assembling missile seekers for a variety of applications in the tactical missile industry.

The third program is the TRP -- a cost-shared, merit-based program in which awards are made to companies and consortia for specific projects. Roughly half of the 212 awards made so far (for a total of some $300 million) have been in manufacturing. These are late-stage technology manufacturing efforts. For example, in one project we're using computer models to develop molds for injection molding. The injector can make more complex molds, and make them faster, than can be done with other kinds of technology.

The fourth DOD manufacturing effort is the Manufacturing Science and Technology Program, also known as Mantech. This is a long-life program executed across the services and in the Defense Logistics Agency. Here we invest in defense-critical areas, particularly where industry is not investing. An example is advanced tooling for airframe composites, where we established an integrated methodology for automating the tooling design functions; the designs are created in part by expert systems. Another example is a laser-based optical gauge that can inspect automatically for adequate size, contour, and surface defects of welds.

Funds appropriated for this program often are earmarked for specific projects. This is a problem for those of us concerned with fielding the very best possible manufacturing technology program. Fiscal year 1994 has been particularly difficult; we asked for $148 million and were authorized $112 million. Eventually $281 million was appropriated, but some $241 million was earmarked.

We actually had to halt some merit-based industrial contracts that had been awarded by DOD. We anguished over that. However, we continued to work on this problem, project by project, and the comptroller last week released funds sufficient to continue these programs for the remainder of the year. I am very pleased we're able to do that. It is a difficult situation.

The DOD has done a number of things in the past year to improve management and oversight of its manufacturing programs. First, I created a manufacturing panel as part of Project Reliance, the cooperative group that coordinates DOD's science and technology programs. The panel will compare programs to eliminate duplication, chart the course for Mantech, review plans, review center activities, and help with oversight.

Also, at my suggestion, DOD has created the Defense Manufacturing Council, which met for the first time about 2 weeks ago. My objective is to remedy disconnects between science and technology activities and reforms in procurement and acquisition. I wanted a forum where we could deal with these issues.

The third change is that we have established a relationship with a multi-industry Task Force on Affordability, which is chaired by Aris Melissaratos of Westinghouse Electric Corp. The task force has representation from a number of world-class corporations. This group is working with multiple manufacturing associations as well as DOD. I also have asked them to work with our Defense Manufacturing Council, and they are developing action plans for commercial characterization of military parts, one of the issues I'm most interested in, and for constructing road maps for some manufacturing sectors.

So there is a great deal of activity, not only in DOD, but also in industry. But will the changes really be significant? To answer that, let me go back in time. I once lived in Pittsburgh. After World War II, the Japanese rebuilt their steel factories because they had been bombed. The Japanese modernized, while U.S. steel manufactures did not. And as a result, the steel mills in Pittsburgh are now museums, empty industrial shells. That industrial sector did not enhance its infrastructure, did not move with the technology.

Going back even further, in 1851 Queen Victoria presided over a great cultural exposition at the Crystal Palace. They were celebrating mid-19th century British supremacy in industrial practices and technology. At that show were Cyrus McCormick from McCormick Repeater Works and Samuel Colt from the Colt Repeating Arms Company. They had some novel manufacturing concepts such as mass production, interchangeable parts, and division of labor. And they and their colleagues in U.S. industries, particularly manufacturing, became preeminent just a few years after that.

Those are two good examples that illustrate how cataclysmic change can be in the manufacturing arena. I believe the same degree of change is occurring right now. The manufacturing industries are changing at a pace that is very painful but also very empowering.

Let me close by quoting George Bernard Shaw, who said: "The reasonable person adapts himself to the world. The unreasonable one persists in trying to adapt the world to himself. And all progress depends on the unreasonable person."

Thank you again.

Question: A number of defense products require very-high-quality manufacturing. Often these products, such as nuclear bombs, are made in small lots. There doesn't seem to be anything in the defense conversion program to help industries that have produced these small-lot, very-high-quality products.

Answer: The DOD has taken the position that industry has to decide for itself how and where to diversify. Also, a lot of markets require high quality. The electronics industry, for example, has reliability requirements that are at least comparable to what you're talking about. I think such requirements are best driven by the marketplace. The real issue there is how to get out of the business of making an arcane technology. Some kinds of industrial activities will remain defense unique.

Question: You said you wanted greater coordination between Mantech and activities such as acquisition reform. What role do you see Deputy Under Secretary of Defense for Advanced Technology Larry Lynn's department playing in driving or demonstrating DOD science and technology research?

Answer: Larry Lynn handles technology transition and oversees the creation of science and technology programs that have substantial involvement by the operator community. The objective is to get prototype weapons systems that seem realistic into the hands of the fighting force. That way, the military can evaluate the technology and make more educated decisions than we have made in the past. We feel strongly about this program, which is something we did not do in a planned, programmed way in the past.

Department of Energy
Manufacturing Technology Programs and Strategies

Victor H. Reis
Assistant Secretary for Defense Programs
U.S. Department of Energy

Being a total quality guy, I have to tell the truth. The Department of Energy (DOE) does not yet have a mature, department-wide manufacturing strategy. We're still working on one, which I hope and believe will be a significant component of our overall DOE strategy. But I can describe some of the elements and themes of our manufacturing strategy.

The DOE has been a major manufacturer for the past 50 years. We are one of the government agencies that actually makes things. Of course, nuclear weapons were among those things. We're not making them anymore, but we are taking them apart. Nuclear weapons have thousands and thousands of parts, and the process for taking a bomb apart is very much like a manufacturing process. So many advances in manufacturing are helping us dismantle these very complex devices.

Why did DOE get into manufacturing? Among other reasons, the law told us to. The National Energy Policy Act (P.L. 102-486) says DOE should be in the manufacturing business for reasons other than building nuclear warheads, that we should be concerned with efficiency and productivity. We also are supposed to work with the private sector on advanced manufacturing technologies, economic growth, and energy efficiency.

Because DOE budgets are dropping off, particularly in the defense programs, we are looking to be at the forefront of the agile, lean, clean manufacturing movement. Thus, DOE, through its laboratories and remaining production complex, represents a major national scientific and technical asset, which is being applied to a wide variety of industrial problems. Of particular interest to DOE is the whole idea of energy-efficient and pollution-free manufacturing. Both characteristics increase productivity. The environment is a key focus at DOE and this niche will become more and more important.

I want to emphasize the strength of the DOE laboratories. Every year, *R&D Magazine* recognizes the best research and development projects across the country, and in 1993 they gave some 25 of the 100 awards to DOE laboratories. So these laboratories are an enormously powerful engine of technology. The issue is how to use that engine to produce the right applications.

Finally, because we're not in the manufacturing business alone, DOE tries to work with other Federal agencies, including the Department of Commerce, the Department of Defense, the Environmental Protection Agency, and the National Aeronautics and Space Administration. Each agency has its own special expertise and goals. When you add them all up, you get a much more balanced, progressive, and coherent program.

All these elements will go into what I hope is a coherent, integrated, and aligned strategy. I think this conference will provide significant input for us, because, after all, we have to listen to the customer.

Question: When a government laboratory is developing a manufacturing process, at what point does it stop and let industry take over?

Answer: I don't know the answer. I think we're just beginning to learn some of those things. You get into all sorts of issues with regard to intellectual property rights, and it gets very complicated. But I think these problems are beginning to be worked out. These partnerships will require a good deal of good will and patience on both sides. But it's remarkable how attitudes have changed in a relatively short time. In a sense, the hardest part has been, not with industry, but getting the government laboratories to work together.

Question: Will DOE be involved in development of the National Information Infrastructure (NII)?

Answer: One role I think the weapons laboratories will play is related to supercomputers. I think we'll need a new generation of supercomputers to address the grand challenges that will be drivers for the NII. The issue is how to maintain confidence in our weapons stockpile without making or testing anything. The weapons laboratories will work with supercomputer manufacturers on the technology needed to carry out that task. Of course, those computers will be networked and will use software. And once you get into software problems, you have switching problems. So I see the labs working with the computer manufacturers on all these technology problems.

Department of Commerce
Manufacturing Technology Programs and Strategies

Arati Prabhakar
Director
National Institute of Standards and Technology

I will concentrate on Department of Commerce (DOC) programs and strategies, which are an interesting microcosm of what's happening in Federal research and development (R&D). The Federal Government funds 45 percent of all the R&D conducted in the United States. Many different agencies and departments continue to pursue R&D to support their different missions.

The new element in the mix of Federal R&D spending -- one that responds to global economic and technological realities -- is more vigorous support of civilian technology. This is a very deliberate change in strategy. Of course, it remains important to focus on national security and on maintaining our base of scientific knowledge. But with the end of the Cold War and changes in U.S. industrial competitiveness, we also need to focus Federal R&D investments on other areas.

So the overall trend is a much stronger focus on industry's needs, as reflected by this conference. This change also has brought government agencies closer together. Having worked for different parts of the Federal Government for several years, I now see an unparalleled degree of cooperation and collaboration among programs.

The DOC is unique in that it focuses on civilian technology to foster economic growth. This means we have to work with industry. This is not a mission the Federal Government "owns" in the sense that it owns or is responsible for national security. Rather, our job is to contribute to something that is driven by industry. This matters deeply to taxpayers, because the economic growth produced by U.S. industry's success creates job opportunities and raises our standard of living. Moreover, there are technologies that are critical to our long-term economic growth but cannot be developed with private dollars alone.

The DOC technology program receives a tiny portion of Federal R&D dollars, less than 2 percent. We try to focus that small amount precisely where industry sees economic needs and opportunities. That's our strength. But we can do little by ourselves. Everything we do is through partnerships with industry and the broader technical community in government and academia.

Our Technology Administration, headed by Under Secretary for Technology Mary Good, is responsible for a variety of activities. Dr. Good chairs the Civilian Industrial Technology Committee of the National Science and Technology Council, recently established by the White House to coordinate R&D efforts. We have two primary efforts in civilian industrial technology. One focuses on manufacturing infrastructure, and Joseph Bordogna of the National Science Foundation (NSF) chairs that group. The other is the Partnership for a New Generation of Vehicles, described earlier.

The Technology Administration also is responsible for serving as the U.S. secretariat for the Intelligent Manufacturing Systems (IMS) program. This is an international program in which U.S. companies, universities, and laboratories form consortia with their counterparts in 21 other participating nations. The program provides a mechanism for exploring best manufacturing technologies and practices as well as new alliances for global marketing and manufacturing, and perhaps a chance to influence standards setting as well. Andy Wan is the point of contact for the U.S. secretariat, and you can contact him for more information.

The IMS program is an example of a joint effort where industry and other segments of the technology community are doing the work and paying the bill, while DOC establishes the government linkages needed to make an international effort work.

Finally, Graham Mitchell, who heads the Office of Technology Policy in the Technology Administration, is planning a benchmarking effort that will provide detailed and thorough information about U.S. manufacturing capabilities. This project should be useful not only to the government, but also to the larger manufacturing community.

Now I will discuss the National Institute of Standards and Technology (NIST), the part of the Technology Administration that co-funds and conducts industry-driven research and delivers industry-directed services. NIST is in a period of dramatic change; we are addressing new challenges as well as building on our traditional base. Typically, NIST has carried out 0.5 percent or less of Federal R&D, but we're at the beginning of what we hope will be fairly dramatic growth. The President has proposed an increase that would take us to about $1.4 billion total by fiscal year 1997 -- almost four times our current budget.

We're taking that growth very seriously. We think the type of dialogue taking place at this conference is critical to helping us deliver value to industry rather than just building bureaucracy.

NIST is really a portfolio of different programs. Almost everything we do relates to manufacturing. Our story really begins with the job we were given in 1901, when the institute was formed as the National Bureau of Standards. The original mission remains intact: to provide the underpinnings, the infrastructure that companies need to their job -- the technologies every company needs but no company would invest in developing on their own because the returns are nonappropriable, diffusing across groups of companies. Infrastructure technologies include measurement standards, measurement methodologies, data evaluation, and test methods and protocols -- the underpinning technologies that raise the level of play for everyone.

Standards setting is much more technologically challenging and complex today than it was in 1901. NIST laboratories address an extremely broad spectrum of topics and have relationships with every industrial sector. While our job is critical, our greatest successes are things you should take for granted. We hope you use our technologies and capabilities and that they become part of your infrastructure, so the problems they are intended to solve don't keep you up at night.

During this administration, NIST is trying to strengthen that core capability. We have been doing this job for nearly a century, and we have a good methodology for working with industry. We think a lot more about technology transfer and technology partnerships today than we did in the past. In particular, we are trying to strengthen our activities to meet industry needs in key areas of manufacturing, such as process technology, standard reference materials and data, metrology, and the use of information technology. Our efforts range from very quick and practical assistance, similar to hotlines, to longer-range programs.

Back in 1988, when the Congress changed our name to NIST and gave us new jobs on which to work with industry, it was clear that the Congress chose us because of our close connection with industry. We have not only a broad set of interactions across the industrial base, but also a mind-set for listening to industry and working as a partner.

One of our new assignments was to run the Advanced Technology Program (ATP). This program funds industry projects on a cost-shared basis, to stretch the capability of private R&D investments and to encourage the private sector to undertake longer-term or riskier projects that require cooperation among companies or across industry boundaries. The ATP funds projects that are critical to opening up new technology horizons and opportunities but that could not be pursued without Federal dollars.

In its early years, ATP has functioned at the level of a pilot program. In fiscal year 1993, it awarded about $68 million. We have focused on establishing an effective system for working with industry, trying to avoid some of the pitfalls of other civilian technology programs. A great concern is that we'll get disconnected from industry, so we make sure that project ideas come from industry, that the work is done in companies, and that the costs are shared by companies. Those linkages have kept us closely coupled. That element will continue to be crucial as we scale up the program.

The other key element is avoiding earmarked appropriations. So far, thanks to congressional support and a lot of effort by the Administration, the ATP has managed to stay free from political influence. I don't think that threat ever goes away entirely, but we will continue to work hard on keeping it at bay. The whole community will have to continue to advocate a rigorous, merit-based, competitive processes; this will be crucial for the future success of this and other such programs.

In the fall of 1993, responding to plans to increase the ATP budget to about $750 million by 1997, we began to establish a focus so that we could produce dramatic advances in key areas rather than spread this major investment across every project that might come in the door. We will continue to have a general competition open to all areas of technology. But most of the dollars in the ATP budget will be spent in focused program areas, each receiving annual investments of roughly $20 million to $50 million over 5 years.

We've identified one set of focused programs and hope to announce as many as six more in November 1994. This is a continuous process, so I encourage industry to give us input on topics these programs should address. Our goal, as always, is to establish programs comprising collections of individual awards to companies and teams. But now, weaving together a community and taking this systems perspective on technological opportunities, we can create dramatic new opportunities, and the ATP can have a far more dramatic impact than it would by continuing with the "let a thousand flowers bloom" approach in all areas. Focused programs are a very powerful management model, which we've copied in other programs.

We are very careful to coordinate all these projects, ensuring that they complement rather than duplicate other government programs. In fact, when industry proposes ideas that would fit into active programs run by other government agencies, we ship them over there.

Several other presenters at this conference have talked about the Manufacturing Extension Partnership (MEP), another NIST program. Manufacturing extension is the newest recipe for success in Federal R&D programs, although it is not new in many other parts of the world. The notion here is to provide access to information and expertise for the approximately 360,000 small manufacturers (defined as having fewer than 500 employees). While most of these companies excel at carrying out a specific physical or chemical process, many of their costs result from inefficiencies in the rest of their manufacturing activities. The MEP introduces them to new tools, new methodologies, and new industrial engineering practices and helps these small companies implement new technologies and capabilities on the factory floor. This is an activity where very few Federal dollars can have a tremendous impact.

Like the ATP, the MEP started in 1988 with new legislation and has been run as a very modest pilot program. It has taken time to learn how to listen to small manufacturers and figure out what they really need. Today, we have seven active centers. Through them, we have figured out what this business is all about and have begun to deliver increased value to businesses.

The MEP interacts effectively and seamlessly with the Technology Reinvestment Project (TRP) run by the Department of Defense. In our interagency activities, we have been able to leverage the TRP technology deployment funding, much of which is managed through NIST. There are 28 new centers coming on board, funded through TRP and managed through NIST. Our goal is to create a national network of 100 manufacturing extension centers by 1997.

This is not a case of government being the sole provider of bright new ideas for small manufacturers. Rather, we see an enormous number of sources of business and technical expertise across the country. We simply are trying to link manufacturers who are seeking to upgrade their capabilities with the people who can help them accomplish their objectives.

Just a note about evaluating the results of these investments. For most activities in our laboratories and in ATP, you have to wait several years to evaluate the results, and we have established mechanisms to do that. The MEP provides more-immediate gratification, in the sense that if we help a client company improve its manufacturing efficiency, then the economic results become visible fairly quickly. We recently asked client companies to make their own evaluation of the financial benefits they derived from the information or expertise we provided. The total benefit was about $320 million, a sevenfold return on the Federal dollars spent. This was not a thorough study by any means, but I am heartened by that recognition of the value returned.

I also should mention the Malcolm Baldrige National Quality Award Program. This is not a research program but rather an effort to convene the private quality community. The Baldrige program highlights the best examples of quality practices in manufacturing, small businesses, and the service industry. It is very important to hold up examples of how quality practices have driven industry capabilities. But perhaps the bigger impact has come from our judging criteria, which are used by hundreds if not thousands of companies across the country. About a million copies of the criteria have been distributed over the years, and the program has spawned a variety of state, local, and foreign programs built on the same model.

The whole idea of the government giving a quality award to manufacturers would have been a joke a decade ago. But the program has served as a mechanism to pull together the private community and help capture the vague notion of quality in specific criteria that are really useful. This program has been very effective in the long run.

To sum up, the main theme of NIST activities is that we cannot just sit out here alone in Gaithersburg and accomplish our mission. We have to establish links with industry and universities. We have the opportunity now to build our capabilities to fulfill national goals. We need your input and we look forward to continuing to work with you.

Question: My university colleagues and I are fascinated by the ATP, but we can't figure out how we enter into the structure of program. With whom do we negotiate?

Answer: The ATP is designed explicitly to work with industry. The awards can be made only to for-profit companies, or to joint ventures that include two or more for-profit companies. Many other Federal R&D programs, such as those run by NSF and the National Institutes of Health, are designed to work with universities. So, if you look at the entire $70 billion Federal R&D investment, the ATP probably is not the easiest place for universities to get involved.

Having said that, in many cases the best way to carry out an ATP project is for the company or companies involved to link to the broader technology community, including universities. Universities and other not-for-profit organizations and laboratories can serve as subcontractors or as team members in joint ventures. Many of the 89 ATP projects undertaken so far involve interactions with universities and national labs. So you should get involved with a company that wants to get involved with ATP. That's a tactical answer.

From a strategic standpoint, we've accelerated dialogue with other agencies, such as NSF, about joining forces in strategic planning. So there may be opportunities in some areas where we can connect closely with the university investments made by NSF in a related area. To accomplish technological feats of the sort we are attempting, you have to move the entire technology community, so these linkages will be crucial.

Question: I want to hear more about NIST benchmarking studies. I have a small company, and we have an automated rapid prototyping system that makes functional prototypes out of metals. We want a technology assessment and endorsement so we can approach big companies, such as General Motors Corp. (GM), The Ford Motor Co., and Chrysler Corp., to seek funding to develop and commercialize the technology. We submitted a proposal to a Small Business Innovation Research (SBIR) program and, 6 months later, without any other interaction, we received three evaluations. One said there was no market for these types of systems, the second said quite the opposite, and the third basically said the proposal was unreadable.

When you take the average of the three, I guess that makes us an average company. To make a long story short, we were not awarded funding. I still stand behind the technology, but it would be nice to not have to waste 6 months and then find out NIST is doing benchmarking studies for companies like GM, Ford, and Chrysler to point out promising technologies, and that NIST also is dealing with small companies like mine to help us assess whether we outperform benchmark technology.

Answer: With respect to your story, I would not look to the government as a source of wisdom on markets. In fact, we in government look to private industry as a source of wisdom on markets. In ATP proposal evaluations, we've sought out experts in the private sector to help assess business plans. I can't tell you what happened with your SBIR proposal.

With respect to benchmarking, perhaps I gave you far too glorious an impression of our efforts in that area. We are not trying to identify the most promising technologies from the market point of view. Rather, we are assessing the manufacturing base in terms of its capabilities and international competitiveness. It is mostly a matter of gathering information, much of which has been collected by one industry association or another. The results might let your downstream customers know that you exist, but it will not be a technical evaluation of the market worth of your product.

Question: I am a Ph.D. student at Massachusetts Institute of Technology (MIT). You should be aware that, by funding universities, you're funding middle management -- the tenured faculty. I feel lucky to have one of the 10 Department of Energy fellowships in integrated manufacturing. But most students can make more money on Wall Street than in manufacturing. I know of five students at MIT who are going into manufacturing, and if you are serious and committed about trying to foster a new generation of Americans who are going to make a difference, you might think of some program to fund student work in manufacturing.

Answer: I will pass that comment along to Joe Bordogna at NSF, who knows a lot more about universities than I do.

Question: Critical issues must be addressed when universities work with industry, especially intellectual property issues. The ATP prohibits a university from owning intellectual property. I have been told that the Congress is working on new legislation to change that rule. Could you elaborate on that?

Answer: Originally, if a university participated in an ATP activity, then all intellectual property belonged to the university. But people complained, and the rule was changed so that only for-profit companies could own intellectual property in any joint activity. This was an overcorrection, in my view. In fact, neither of these artificial situations make sense to me. So we have been urging a change to remove the government from intellectual property negotiations. The government maintains no intellectual property rights in ATP projects, except the march-in rights, should the technology fail to be commercialized.

So I hope this legislative change will be passed. Then the participants in any joint activity would assign intellectual property rights among themselves as part of their other negotiations. I think it is important to not make these decisions by law.

National Science Foundation
Manufacturing Technology Programs and Strategies

Joseph Bordogna
Assistant Director for Engineering
National Science Foundation

Let me first field the question posed to Arati Prabhakar about funding young people. I am happy to announce that soon the National Science Foundation (NSF) will launch a new program, CAREER, which gathers together all we've learned in the 40-year history of NSF about investment in young faculty. Faculty members in their first 4 years will be able to submit proposals outlining their integrated research, teaching, and education innovation vision for their professorial careers and how it all fits into the context of national needs. In this way, we hope to establish a competitive, merit-reviewed award process for the development of new faculty as the academic leaders of the future.

Now I will describe how NSF spends its $200 million in annual funding in manufacturing -- quite a bit less than the Department of Defense, which spends $1 billion. The NSF has a strategy for coordinating the spending of these dollars among all its directorates. To mention several topics in particular, social, behavioral, and economic sciences are becoming more important, because management of the manufacturing enterprise is of great research interest at NSF. The cognitive revolution is also of increasing interest: We have to build intelligence into our machines to help us handle the explosion of information.

NSF projects in manufacturing come out of the merit review process, based primarily on unsolicited ideas but also selected in the context of national needs identified in partnership with industry and academe. I also want to note that NSF funds integrated research teams as well as single investigators.

As the context for NSF investment in manufacturing research and education activities, I want to address the process for bridging the gap from discovery to applications that can lead to wealth creation and jobs. In the past, this process generally has been considered to be linear, because technological change has been slow. But technology changes so fast now that the process, which is clearly nonlinear, must be integrated and brought up to date. Jack Gibbons, for example, spoke about feedback loops in this regard. There is a trend toward concurrent integration of the whole enterprise, not just concurrent engineering with design and manufacturing done together. NSF support catalyzes linkages to help bridge the nonlinear gap from discovery to applications, not just piece work on individual concepts. Partnerships are very, very important in this regard.

The NSF research and education activities that have been under way for a long time provide a firm base for our new move toward increased interagency cooperation and increased leveraging of and synergy among academic, industry, and government research and development activities. I will describe some of these longstanding efforts.

The Engineering Research Center program is about 10 years old. We have 18 centers and will open about four or five more this year. The original plan was to go to 25. Some 500 companies are involved. Engineering education has changed and become more holistic because of the interaction that takes place through these centers.

The Science and Technology Center (STC) program is about 5 years old. Its mission is to bring together scientists and engineers on a campus so that discoveries may be translated more readily into applications. There is no requirement for industrial linkages but increasingly, on their own initiative, STC leaders are beginning to cooperate with industry. At present, there are 25 STCs in operation.

There are also more than 50 Industry/University Cooperative Research Centers (IUCRC). This program is 20 years old. These centers are organized by industry and academe to take advantage of university expertise in a particular field. The centers mostly address industry's generic needs, but any industry member can set up a joint project with a university partner on a special topic.

We formed a variation of the IUCRC program with the states several years ago. We now support 10 state IUCRCs and plan to double that number in the next couple of years. The idea is to take advantage of state technology transfer initiatives and local economic development initiatives. Industry pays a third, NSF pays a third, and the states pay a third, for a total of about $900,000 for each center.

In education, we are in the third year of the Engineering Education Coalition (EEC) program. This program was intended to effect a paradigm shift in engineering curricula -- to make undergraduate baccalaureate programs more integrative by establishing student teams and addressing open-ended dilemmas, design, and manufacturing in the freshman year. The coalitions are groups of engineering schools that band together, write proposals, and compete in a merit-based review process. We have 60 schools involved. Each coalition must be eclectic, representing a range of types of schools.

A very interesting EEC project is under way in Detroit that involves both technician training and manufacturing engineering education. We find this coalition intriguing because it is aimed at producing a skilled work force at the technician level while educating engineers in the same group.

A relatively new program supports a partnership-building effort to leverage NSF funds for addressing critical manufacturing issues. We call it Grant Opportunities for Academic Liaison with Industry (GOALI). This program links academic and industrial experts one-on-one or in small groups and has three facets. One is manufacturing internships for engineering faculty, who are given research sabbaticals on the production floor. Response from initial participants has been uniformly positive.

The second facet is the Combined Research-Industrial Scholarship Projects (CRISP) program, in which faculty members receive grants for 3 years, of which 2 to 6 months are spent in industry. This is a research grant in the normal sense but the investigator has an intellectual partner in industry and spends some time in industry, along with his or her doctoral student, in the first 18 months.

The third facet is the Industry-University Cooperative Research Projects (IUCRP) program. This programs funds professors who have ideas for marketable devices or processes and have a connection with industry.

The NSF also funds a program to bring research discoveries into the curriculum more rapidly than has been typical in the past. The Combined Research/Curriculum Development (CRCD) program builds on and funds the work of research faculty to get their discoveries into the curriculum immediately.

The NSF also is one of the six agencies involved in the Technology Reinvestment Project (TRP), a $500 million program integrating technology development, deployment, and manufacturing education. The agencies review and select the awards as a team; we have made 57 awards worth about $50 million in manufacturing education and training.

An eclectic array of interrelated projects is funded through the TRP. We want all engineers to learn how to make things, so we award grants for teaching manufacturing across all curricula. Grants also are awarded for development of practice-oriented master's degrees, so that these programs are not just stepping stones to the Ph.D. but rather integrated programs to prepare students for industry. We also fund efforts to work with defense industry engineers, to help them change their design practices to meet commercial needs.

As other agencies do, NSF supports the new Small Business Technology Transfer pilot program and the older Small Business Innovation Research (SBIR) program, which fund industry projects. About 20 percent of SBIR awards go to manufacturing enterprises. We are encouraging more manufacturing businesses to apply for these awards.

The Agile Manufacturing Initiative (AMI), a joint effort of NSF and the Advanced Research Projects Agency, has three components. One is the Industry Forum for Agile Manufacturing. The second component is a set of three Agile Manufacturing Research Institutes (AMRIs) focusing on industry sector-specific needs in electronics, aerospace, and machine tools. We intend to fund additional AMRIs in other industry sectors during the next several years. The third component involves prototyping, demonstrations, and test bedding.

The NSF just announced the Rapid Prototyping Initiative, which addresses virtual prototyping (modeling, simulation, model validation, design tools, design techniques), physical prototyping (machine design, process design, computer-aided design and computer-aided manufacturing integration), and the integration of virtual and physical prototyping. We will make 6 to 10 awards, $100,000 to $600,000 each per year, for up to 3 years. We're very excited about this new endeavor, especially because it, like the AMI, responds directly to the interagency manufacturing infrastructure strategy of the National Science and Technology Council.

Another new NSF program supports research on quality issues. We rarely think of the private sector transferring money directly to NSF for support of research, but a partnership has been announced involving NSF, the Leadership Steering Committee of the Total Quality Forum, and the American Society for Quality Control. The objective is to support research to develop or improve concepts, tools, and methods for improved management of the transformation to quality organizations. The challenge is to determine the process underlying the continuous transformation of a quality company. Most of the money for this $9 million program will come from the private sector. That in itself is a new dimension of commitment to a government-industry-university partnership.

Finally, we are funding research in Management of Technological Innovation (MOTI), focusing on the complex process of bringing technology to the marketplace by making things we can sell in a competitive atmosphere. This work is done by engineering and business school teams with industrial partners. In this first year, we focused on soliciting proposals in environmentally conscious manufacturing, in order to limit what we believe to be great pent-up demand for funds to pursue research in the general MOTI field. The MOTI research effort is important because innovative technology cannot fulfill its potential unless industry improves its capability to manage assessment, validity, and market needs, as well as environmental quality and adoption of new materials, processes, and systems. Companies need to integrate technology with business strategies that strengthen competitiveness and productivity.

Question: I sat on an NSF evaluation panel last year. We were given 28 proposals and told there was only enough money to fund two of them, which is very disconcerting when the proposals are very good. I'm concerned that NSF is undercapitalized.

Answer: I think these decisions will get more difficult. This is a zero-sum game, as you have heard before in this conference. We have to make hard decisions to put the money in areas that seem most related to national needs as defined by the Administration and the community.

There is controversy about how to do this. One approach is to focus on high-risk projects that might fail but also might lead to significant paradigm shifts.

We don't do a good enough job focusing proposals at the front end. We did a pretty good job on the AMRIs, where we had 15 to 20 proposals and made three awards. In the TRP, we had 2,800 proposals and made 212 awards. We are trying to narrow down the number of proposals. You'll see more of this. We'll probably have a system whereby we ask for brief concept papers, have them reviewed by a panel, and then invite just twice the number of the proposals that we can fund.

I should add that, even though the NSF budget has been increasing at twice the rate of inflation in the last few years, we continue to receive many more excellent proposals than we can fund.

Question: Stanford University has a new Ph.D. program funded by the Sloan Foundation to produce researchers who will become professors of manufacturing. What do you think of that idea?

Answer: That's a great experiment; we need an eclectic mix of experiments. If it works, then maybe we should invest broadly in such programs. Obviously, the Stanford people have told us they need money for it.

Question: I have received a few first-time SBIR grants from NSF, and I've noticed something about the evaluation process, not only from my experience, but also from comments of other people. Evaluators definitely are thinking more about marketability today than they did before. But I find they really don't know much about marketability, so don't think they should use it as a criterion. I have been an evaluator, so I have been on both sides of the fence.

Answer: I think we all agree with you. We're into a new mode and we don't necessarily know how to do it very well. We have a lot of work to do in that respect.

MATCHING INDUSTRY NEEDS TO GOVERNMENT PROGRAMS

Overview of Panel Objectives

Thomas Murrin
Dean, School of Business and Administration
Duquesne University

Let me briefly make three general comments about my reactions to being here and to this conference -- and then a few brief additional comments related to what we need from you and how you can help make this a truly valuable undertaking.

First, it is a delight to be here! The National Institute of Standards and Technology (NIST) has been committed from day one to working closely with and helping American industry. So a culture exists here that is genuine in that regard -- and NIST has an incredible array of capable, committed, and compatible people. I hope you all become familiar with NIST, if you are not already. As you see, it's quite a serene, attractive environment, almost campus-like. If the trend toward privatization ever takes hold, we'd like to privatize NIST into a university some day, and I'd apply for a job as the president.

My second point is that, in listening to and pondering the presentations, it has been great to see the extraordinary cooperation already well under way among key people in government, industry, academia, and labor. Many of the cooperative consortia that have been described are well along in producing wonderful results. Others are exciting due to their promise. Perhaps only five years ago, some things industry is doing now that are applauded and supported by the government would have landed some folks in deep trouble with at least one Washington, D.C.-based agency, the Department of Justice. So, I don't know whether our laws or our attitudes have changed all that much -- but whatever, I think this is a much healthier and promising situation and it's a delight.

The thing that strikes me particularly about the presentations and mood of this conference -- and to some extent the mood in Washington and our nation -- is that we seem to be at least approaching consensus on how our top priority of global competitiveness relates to economic growth, and how that in turn translates into jobs, jobs, jobs, and better jobs. I guess we're reacting in large measure to our national economic problems, but, whatever the stimuli, I think it's extraordinarily appropriate and beneficial.

I won't tell any war stories, but I assure you that as recently as a few years ago, there was nothing approaching consensus on these issues in Washington, D.C. If you were a visiting martian in earlier years -- observing our legislation and regulations and the like -- I think you would conclude that we were out to cripple ourselves in terms of global competitiveness and were quite indifferent about economic growth. I guess for a lot of reasons we didn't have to worry too much about jobs, jobs, and jobs. That has changed, and I'm delighted about that.

So those are very upbeat and positive comments. Let me just make a third comment that is cautionary. As I talk with people at this conference and elsewhere, I don't find anyone claiming they have everything under control. In fact, I find people quite challenged and somewhat bewildered if they're honest about the incredible changes taking place around the world -- changes of all kinds, but certainly those relating to business.

Recently, I had the opportunity to visit Tianjin, China. I couldn't spell Tianjin before I prepared for the trip and I'm a business school dean. About 9 million people live in Tianjin. But what's more notable is that Tianjin now has several world-class manufacturing plants that are as good as or better than any others in the world. More startling is the combination of work ethic and God-given mental acumen the Chinese people have. All this translates into one of the most formidable competitive challenges -- or, depending on how we approach it, teaming opportunities -- that I've ever seen in traveling around the world for many decades.

Those of us who have been challenged by the Japanese in recent years have, at least in my case, great respect for them. I also visited Japan on this recent trip. I think they're getting ready to rebound, or, more appropriately, re-attack. So please don't be too comforted by what you read in the newspapers about Japanese problems. But if you think our generation has been challenged by the Japanese, then I assert that our children and their generation will be challenged by the Chinese and their neighbors to an extent that will surpass what we've experienced heretofore.

It may sound silly to note that the Chinese can tell jokes and laugh at them, and their English is pretty good. These may seem like trivial characteristics, but in my experience they are very important attributes that distinguish the Chinese from some of their Asian neighbors.

I recently received two books written in the spirit of caution. One is *Quality Wars*[1], written by Jeremy Main, the former editor and magnificent writer at Fortune, now associated with the Juran Institute. Speaking of quality, I think most if not all of you share with me the conviction that Curt Reimann and his small but splendid organization here at NIST have done a magnificent job advancing the Malcolm Baldrige National Quality Award process in the last several years.

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[1] Main, J. 1994. Quality Wars: The Triumphs and Defeats of American Business, A Juran Institute Report. New York: The Free Press.

Quality Wars is a captivating story about a lot of the victories of the last 13 years. But it also reveals a lot about the countless failures and frustrations. The book talks about uncertainty concerning what will happen when quality concepts and procedures are applied -- as hopefully they will be -- in government, health care, academia, and other sectors. The jury is out. Indeed, Jeremy suggests that in some respects, for most of American business, the jury is still out with regard to Total Quality Management. So I hope I have whetted your appetite for reading and pondering this book. We haven't yet solved fully the quality challenge or exploited that opportunity.

I make this point because throughout this conference we have heard repeatedly that quality is a given, a necessity. I think it's a necessity, but in my judgment we have not yet achieved widespread world-class quality performance. We have more to do.

The other book is *Sea Change*[2], written by Jim Abegglin. If you're not familiar with the Pacific Rim, this book would really spoil your day. Jim has spent most of his life in Japan, ever since he waded ashore as a Marine in World War II. He holds a doctorate from the University of Chicago in macro-economics and is very, very bright. He is probably as knowledgeable about Japan and that part of the world as any American is.

The thesis of the book is that much of the industrial and business power center of the world is leaving the United States and moving to eastern Asia. Fortunately or unfortunately, Jim has data, statistics, and I think unassailable insights to support that assertion. If you're not familiar with what's happening in this regard, then I urge you to learn about it. At least read the book. And if you are familiar with this issue, then you ought to ponder the implications, as I have suggested in my comments about China.

This is a rare opportunity to share these few simple views with all the brain power and resources represented in this room. If we could ever get our act together like a world-class team and get clicking, then we could re-establish ourselves in the industrial sectors where we aren't quite there. We're working on that.

Now, a few comments about how the previous presentations relate to what we plan to do now. So far, this conference has been a wonderful experience for me. I sense that maybe all of you have been delighted as well. Following are my perceptions of some of the highlights.

Jack Gibbons -- speaking on behalf of the President, the White House, the Administration, and hopefully the Congress -- said some very appropriate things to a group like this. Toward the end he said that manufacturing is "the foundation of our economy." I think Jack really

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[2] Abegglin, J.C. 1994. Sea Change: Pacific Asia as the New World Industrial Center. New York: The Free Press.

believes that, and I think a lot of people in the Administration and in Washington now believe that. I think it is a truism. That is a wonderful commitment to the importance of this undertaking.

There were also eight presentations by industry leaders, virtually all representing not only themselves and their own organizations but also broad-based consortia of various kinds. They were spectacular. I think I'm fairly knowledgeable about many of these issues, and I learned a lot sitting here.

I never thought much before about the food industry, frankly, although if you look closely at me, you can see I'm an over-consumer of food. (My wife will attest to this.) But I thought Adolph Clausi's information was very enlightening. He didn't make any reference to the relative importance of potato chips versus computer chips (I was delighted by that) but he did highlight the importance of potatoes and other food to our economy, health, and environment in a way I hadn't quite thought of before.

I was struck also by one presentation that seemed to attract more attention than any other: Tom Malone's description of the realities of the textile complex, which comprises about 12 percent of the jobs in the United States. This is the largest single segment of U.S. employment and a major producer of value-added products. He talked about the prospect of this incredible new consortium bringing together -- again -- government, industry, academia, and labor. If we can pull this off, and somehow we must, then we really will have a paradigm to follow in the future. So any of you at Federal agencies who have an opportunity to endorse and support this exciting albeit challenging undertaking, I urge you to do so.

There were also brilliant presentations by leaders from the Department of Defense, the Department of Energy, the Department of Commerce, and the National Science Foundation.

The task now is to figure out how to match up the industry programs to the government efforts. No easy task, particularly with a room full of folks who have disparate views. We will have nine presentations from leaders in various fields and then get reactions and recommendations.

I urge you to think about the following opportunities and challenges. What needs underlie many of the situations in which U.S. industries find themselves? What is common to the industrial sectors we have heard about? What are the critical cross-industry needs? It probably would be impossible to establish national priorities here, as we could spend a week trying to battle that out. But this is part of our task -- not picking winners and losers per se, but trying to arrive, in some Solomon-like fashion, at a set of national priorities. Participants in this conference probably have as much insight about how this should be done as do any segments of the citizenry.

Matching industry needs to government programs is easier said than done. Probably the greatest value of this conference so far has been the opportunity to learn about what's going on in different segments of industry and government that we normally wouldn't know about. It can be tedious to observe all this and take notes, but there's probably no other way to identify gaps or opportunities. Are we missing something really important? Are we apt to be blindsided by developments by competitors that we aren't anticipating? Finally, we need your suggestions on new strategies.

That's a tough set of tasks, and I doubt we will do this perfectly. But please think about these issues. This is a one-of-a-kind opportunity!

Automotive Industry Viewpoint

Donald Campbell
Coordinator
General Motors Corp.

I will to try to build a bridge between what Tim Adams said about the automobile industry and the various presentations on government research programs.

First, I want to commend Arati Prabhakar of the National Institute of Standards and Technology (NIST) for the new pathfinding efforts reflected in all the recent conferences. It seems like I have been a monthly visitor to this auditorium since late last summer, with all the conferences on industry needs and working group sessions to structure programs. I trace this back a couple of years to the Office of Science and Technology Policy (OSTP) crosscut initiatives, especially in advanced materials and manufacturing, in which industry participated. Finally, after two or three years of percolating, many government programs appear to be responding to the needs identified by industry.

I also notice that the Advanced Research Projects Administration (ARPA) is focusing some of the Technology Reinvestment Project projects on specific industry needs. I go back a couple of years to the work of General Motors Corp. (GM), our industrial partners, and various national laboratories through the U.S. Council for Automotive Research (U.S. CAR). Now ARPA is soliciting proposals from the auto industry to work with the labs.

Tim Adams talked about the Partnership for a New Generation of Vehicles (PNGV), which is still being defined. He also talked about our research and development (R&D) goals in manufacturing. The near-term research is based on the recognition that the internal combustion, spark-ignited, gasoline-fired engine is going to be around for at least 20 more years. The average life of a vehicle produced today is more than 10 years, and obviously we cannot make instantaneous changes in production. We also need to recognize that those vehicles produce a lot of emissions, which we need to reduce in order to meet new Federal and California emission standards. We're pursuing development of nitrous oxide catalysts, which would enable development of more fuel efficient, "lean burn" engines.

Over the long term, we want to develop a vehicle that has three times the fuel efficiency of today's car but is comparable in size, performance, utility, and cost while meeting or exceeding safety and emissions requirements. We'll probably have to reduce the weight by one third, or 1,200 pounds, and that means new materials. Those materials exist but the auto industry cannot afford them. A car is a $5-per-pound commodity, whereas an aircraft is a

$5,000-per-pound commodity. We have to find a way to reduce the cost of those lightweight but strong materials.

The PNGV is looking at 14 technologies, three of which have a major impact on manufacturing. Advanced lightweight materials is obviously critical. We're looking at glass fiber, carbon fiber, polymer composites, metal-matrix composites, ceramics, engineering plastics, aluminum, titanium, magnesium, and alloys. We also have to be concerned about technologies for joining dissimilar materials.

The second technology relevant to manufacturing is advanced analysis and design methods, including simulations, fluid dynamics, structural mechanics, and virtual prototyping. Third, we are looking at advanced manufacturing techniques, such as agile manufacturing, high-speed data communication and data management, rapid prototyping, virtual manufacturing, and supercomputing.

To achieve our ultimate goal of three times today's fuel efficiency, we'll probably have to abandon the gasoline-powered piston engine in favor of either a fuel cell or a gas turbine, or perhaps a lightweight, super-efficient diesel. Energy storage devices will be required. The high-speed flywheel shows a lot of promise. We also need much more efficient heating, ventilating, and air condition systems, perhaps through recovery of exhaust energy. In an all-electric vehicle, for example, we could not afford to use one-third of the battery power just to heat the cabin.

To accomplish all this, 11 research consortia are active under the umbrella of U.S. CAR. Most of the consortia focus on manufacturing technology. CADCAM is obviously a manufacturing consortium. The Low Emission Paint Consortium focuses on a new coating technology -- powder paint that is sprayed on dry, electrostatically bonded, and then heated to fuse it. The Vehicle Recycling Partnership is looking at promoting intelligent manufacturing, so that more of a vehicle is recyclable. Today, perhaps 95 percent of the steel is recovered, as well as most of the other metals, but most of the composites and plastics go into landfills. And the Advanced Battery Consortium is examining future power supplies for an all-electric vehicle.

The government is involved in many of these efforts. Research on and development of advanced batteries is under way at the Department of Energy (DOE), a several-hundred-million-dollar project with a 50-50 government-industry cost share. Another DOE contract is for a Hybrid Electric Propulsion System. The Ford Motor Co. and GM have contracts in the hundred-million-dollar range, again sharing 50 percent or more of the cost. Chrysler Corp. has not yet received a contract, and I'm not sure what their status is. I assume they will submit a proposal for such a development effort.

Advanced materials R&D also is going on, mostly in the form of Cooperative Research and Development Agreements with DOE labs. Research to reduce emissions also is under way with DOE labs. And the Supercomputing Consortium is working with some national labs to develop software that will enable industry to employ concurrent design, engineering, and manufacturing to shorten product development cycles.

Finally, let's look at some topics for potential cross-industry partnerships. Currently, the sheet steel we use to stamp out most auto body parts is about 50 cents a pound. Lightweight aluminum alloys are $2 to $3 a pound. Perhaps when we start producing 15 million aluminum vehicles a year, using many millions of tons of material, those prices will come down. But there are other ways to reduce costs as well.

Partnerships also could look at developing hybrid electric vehicles. Diesel-electric locomotive and high-speed rail vehicles are all hybrid electric, and maybe some of those technologies can be transferred to automobiles.

Meanwhile, the PNGV Technical Coordinating Group is continuing to develop a road map, which hopefully will be completed by the end of the summer.

Labor Viewpoint

Howard Samuel
Senior Fellow
Council on Competitiveness

Let me begin by congratulating the Department of Commerce and the National Institute of Standards and Technology (NIST) for sponsoring this conference. This conference is good news, and it's even better news that a place has been reserved on the program for labor's viewpoint. In past years, a forum of this type probably would not have been sponsored by any government agency. And if one had slipped through, there surely would not have been much interest in the viewpoint of the American worker.

The reluctance of prior administrations to become involved in advancing technology and manufacturing has been rather astonishing, especially in view of what's been happening in the rest of the world. Our most effective competitors long ago developed a strategy of partnerships between the public and private sectors. As a result, Japan, Germany, and a number of less-developed countries have narrowed the gap between their economies and ours.

The U.S. Government began providing support to agriculture almost 150 years ago, and the result has been the development of a world-class agricultural industry. More recently, the government played an important role in the creation of a dominant aerospace industry. Despite these and other initiatives, there remains a consensus that the marketplace must be the final arbiter, that government never should pick winners and losers. On the other hand, we seem to be approaching agreement that government has a role beyond benign neglect, that occasional sorties into particular industrial sectors can be useful supplements to macroeconomic initiatives. This conference, I believe, symbolizes the ratification of our growing awareness of government's responsibility -- hence my congratulations.

As we move toward this new awareness, technology and manufacturing should take center stage. Not so many years ago, as we began to lose manufacturing sectors to foreign competition, beginning with such industries as textiles and apparel, it was suggested that we instead base our manufacturing future on high-tech industries, such as consumer electronics. Then, when we lost radios and television to the Far East, it was suggested that we make our living on financial services, such as banking, and high-tech service industries, such as engineering. That was puzzling to some of us, because about that time we discovered that only one U.S. bank made the list of the world's 10 largest. And countries such as Korea began to capture our international engineering business.

I hope we have grown out of these theories and recognized that manufacturing matters and that the development of technology is central to our prosperity in the global economy.

Unfortunately, technology development is neither cheap nor easy. It is no longer the preserve of solitary inventors experimenting in their home laboratories. Companies large and small must commit major resources to research and development, and occasionally the technological goal is so large and complex that government resources are needed to achieve it.

Enter NIST, the Advanced Technology Program, the national laboratories, Cooperative Research and Development Agreements, the Manufacturing Extension Partnership, and the Technology Reinvestment Project. When I was president of the AFL-CIO Industrial Union Department, we supported initiatives such as these, out of a conviction that an active partnership between government and the private sector was imperative to ensure economic progress, full employment, and a rising standard of living. We still believe that, and I assume we always will.

But technology alone is not a panacea. Technology must be part of an holistic approach to manufacturing that embraces such principles as meeting the customer's specific needs, flexibility, a commitment to continuous improvement in quality, a cooperative relationship with suppliers -- coupled with the elevation of worker skills and the involvement of workers in the decision-making process.

When it comes to these last two elements, I regretfully suggest we are barely off the ground. Flexibility and quality would appear to require a highly skilled work force, capable of making decisions on the spot. But too many manufacturers still regard technology in the narrow sense, as the whole solution to their problems, and they adopt technologies aimed at speeding up or displacing workers. Too many manufacturers remain wedded to the theories of Frederick Taylor, the manufacturing guru of the early 20th century, matching interchangeable parts with interchangeable workers and reserving brain work for supervisors and management. If we are to win the international competition, then we must abandon the mass production assembly lines of the past and instead adopt the new principles of lean or high-performance manufacturing.

A skilled work force, capable of mastering the new technologies and guiding the process of continuous improvement, is a central feature in the workplace of the future. NIST is aware of this and is committed to helping American manufacturers achieve this goal. The Administration is offering support through the Goals 2000 Act and its provision for a skills standards program, as well as the School-to-Work Opportunities Act. The skills standards program will provide us for the first time with a means of testing outputs as well as inputs in our many public and private training programs. The School-to-Work Opportunities Act will encourage the linking of academic education and on-the-job training in order to provide a meaningful transition into the work force for non-college-bound high school graduates.

The labor movement also has an important role to play in improving our manufacturing effectiveness. I can assure you that the Luddite spirit has disappeared; no American union resists technology improvement today. They are not afraid of technology. Unions are committed to cooperating with the employers and managers who want to tap the creativity and experience of their workers. There are ample examples of such cooperation in almost every industry, including communications, steel, electronics, auto, apparel and textiles, rubber, glass, and others.

Unions can point to research showing that the presence of support from an institution, such as a trade union, is essential in sustaining ongoing cooperation between management and workers who are striving to wring maximum benefit out of new technology and new manufacturing processes. The evidence from abroad is equally convincing: Labor unions in Germany and Japan promote continuing consensus and improvement. American unions are not afraid of technology; they fear and reject only those managers who have not yet learned the true role of technology or the real lessons of international competitiveness. Thus, American workers and trade unions are among those who look most eagerly to NIST to provide leadership in the effort to make business and labor the masters of technology.

Cooperative Technology Development

J. Clifford Schoep
President
National Center for Advanced Technology

I was asked to discuss matching industry needs to government programs. I believe that is the wrong question. The real challenge today is the reverse -- matching government programs to industry needs. I will expand on that idea in a moment.

First, let's look at government's role in technology. A year ago, Joe Bordogna of the National Science Foundation (NSF) addressed the Industry Advisory Board of the American Society of Mechanical Engineers. He identified three roles for government in technology: (1) invest in long-term basic research, (2) participate with the private sector, and (3) disseminate results. All these activities imply cooperation between government and industry, and all have or can have a strong element of manufacturing technology.

The first government role Joe identified was investment in long-term basic research. We usually associate this role with support of universities and the relatively small amount of basic research conducted in private industry. But recent changes in emphasis at NSF have created new opportunities for industry-government cooperation in this area. Earlier you heard about the "long view" perspective that NSF has taken. Advanced manufacturing technologies are an important element of the multidisciplinary research emphasis.

Industry must take the lead in identifying long-term manufacturing technology needs that can be addressed in the NSF programs. And the partnership must continue through close association with the academic world to capture the fruits of that research and provide an occasional mid-course correction or sanity check.

The second role that Joe identified is participation with the private sector. This role has at least two aspects. The first is to create and maintain an environment supportive of the free-enterprise system. This aspect includes things such as tax law and monetary policy, patent and intellectual property laws, environmental policy, export controls, and so on. I'll leave discussion of that aspect to others who may understand it better than I do.

I want to focus on the second aspect -- the reversal of roles that has occurred in government-industry cooperation in funded programs. For the past half-century, cooperative government-industry technology development has taken place in the context of major production programs. The Department of Defense (DOD) and the National Aeronautics and Space Administration funded the vast majority of those programs. Requirements were determined by the government in response to real or perceived threats. Often in consultation with industry, future products were conceived, and technology paths laid out. Research and development (R&D) budgets were developed and allocated to service laboratories, weapons laboratories, or industry, to accomplish the needed tasks en route to the ultimate product. Industry participated and invested its own earnings in anticipation of recovering those investments in the production program.

Now the environment has changed dramatically. The end of the Cold War and attempts to reduce the Federal budget deficit virtually have eliminated those future production programs. Companies are eliminating layers of overhead, reducing R&D expenditures, and focusing on the technology they are best at -- their core competencies. Investments that do not demonstrate a near-term payoff virtually are doomed, with financial hurdle rates the determining factor in new products.

Government-industry cooperation is even more important in this new environment than it was before, but the parameters have changed. In many ways the roles are reversed. There are no big government new-start production programs, and those parts of industry that are waiting for the government to tell them what's coming have a long wait. Government is no longer the customer of industry. Industry is now the customer of government.

I suggest that the question I was asked to address be reworded. We should not be asking, "How can we match industry needs to government programs?" The question should be, "How can the government match programs to industry needs?"

Even for the few major defense programs that are on the horizon, the commercial industrial base is being called upon to fill an expanding role in providing an affordable defense. This will require close government and industry cooperation very early in the planning process. Effective use of commercial products and practices in defense programs needs to be planned up front, not the subject of mid-course changes, if the true benefits are to be realized.

The DOD is addressing seriously this issue of integrating the commercial industrial base into defense products. An Industry Affordability Task Force has been formed, which serves as a window to industry for the Defense Manufacturing Council. The National Center for Advanced Technologies (NCAT) is proud to have been the forerunner of this activity through our support of the affordability thrust of the Defense Research & Engineering Science and Technology Program. We supported the formation of this task force and its working task teams and NCAT is serving as the secretariat to the task force. You will hear more about DOD manufacturing technology activities from Michael McGrath.

There is growing recognition that government's role is one of creating a supportive environment for industry. This always may have been true for the Department of Commerce (DOC), but its efforts were overshadowed by the "government as customer" image in other departments. Is has been my observation that over the past year DOC has stepped up to the challenge and is working with industry in a number of new and innovative ways. Active support of U.S. industry in global commerce, reduction of export controls, opening of new markets through the North American Free Trade Agreement and the General Agreement on Tariffs and Trade are just some of the recent actions.

The Advanced Technology Program (ATP) certainly emphasizes manufacturing technology, as do elements of the Technology Reinvestment Project. The National Institute of Standards and Technology should be proud of the success of the ATP; the dramatic increases in funding for the program bear witness to that success.

The third role for government is dissemination of the results. This conference bears witness to the increased emphasis placed on this role. Support of manufacturing centers, such as the agile manufacturing centers, the National Center for Manufacturing Sciences, and the Lean Aircraft Initiative, is a vital element of the diffusion of lessons learned to a broad audience. The technology deployment segment of the ATP, the Manufacturing Extension Partnership, and, of course, the Malcolm Baldrige National Quality Award Program, are intended to further the dissemination of improved manufacturing technology to widely dispersed segments of the economy.

In summary, I believe that both industry and government are experiencing a new recognition of the need and opportunities for cooperative development of manufacturing technology. Of course, both industry and government are having difficulty breaking out of the old paradigms, but the successes are outweighing the failures. And, as Alexander Hamilton said more than 200 years ago, it's about time.

> The expediency of encouraging manufacturers in the United States, which was not long since deemed very questionable, appears at this time to be pretty generally admitted. (Alexander Hamilton, December 5, 1791.)

National Center for Manufacturing Sciences Viewpoint

Jack Swindle
Senior Vice President
Texas Instruments

I will build on what John DeCaire said and discuss the National Center for Manufacturing Sciences (NCMS) programs supported jointly by industry and government.

The NCMS is industry driven, and its Technology Review Board is made up of technologists from our member companies who set the manufacturing agenda. We have programs in six areas. I'll provide examples of programs that illustrate our priorities, then explain what you can expect in the future.

In the area of manufacturing processes for materials, NCMS focuses on continuous quality improvement, process improvement, design and manufacturing flexibility, and rapid product realization. The programs are centered on manufacturing of materials and process selection, predictive process controls, advanced processing technologies, and quick prototyping.

In production of equipment and systems, we focus on production systems and data-driven, multipurpose equipment. We look at methodologies, equipment, technology enablers, and tuning. The programs are centered on reliability and maintainability, metrology and measurement, machine tool accuracy, advance machining technology, flexible assembly, primary product shape systems, new technology for forming equipment and handling, and manipulation systems.

The third and most rapidly growing area is environmentally conscious manufacturing (ECM). In order of priority, we focus on prevention first, then minimization, treatment, remediation, and monitoring. Our programs will be centered on life-cycle design, sensors for ECM processors, reduced lead in manufacturing, packaging initiatives, environmental practices, and many other topics. I should add that the U.S. Air Force, particularly, has been very active in working with us to establish these programs.

The fourth and newest area is electronics. The roots of NCMS go back to the machine tool industry, and we're now broadening our focus into electronics. Our flagship programs are in printed wiring boards (PWBs) and rapid response manufacturing. The Advanced Technology Program (ATP) addresses both of these topics. The ATP project in PWBs is only half finished and already is making significant improvements in PWB processing, equipment, and materials. The rapid response manufacturing project is intended to develop ways to bring products to market faster than is possible now.

The fifth area is computer-integrated operations. This area focuses on business systems, design systems, production support systems, and process and equipment control systems. The programs will be built around autonomous agent technology, platform enablers, factory controls, and sensor support subsystems.

The sixth and all-encompassing area is management practices, or what NCMS refers to as "The Big M", enterprise management. This area encompasses design, distribution, engineering, human resources, manufacturing, marketing, purchasing, sales and service, partnering, supply chain management, quality, and everything else that has to do with "The Big M."

The key point is that NCMS is industry driven. Members set the priorities, and the requisite work is done is our member factories. The other point is that our mission is to make U.S. manufacturing competitive throughout the world. I just spent 3 weeks in Asia and came back especially anxious to get on with NCMS programs. The world is catching up with us fast, and the competition is fiercer than ever. The NCMS will not invent the new antigravity machine, but NCMS will develop the manufacturing processes to make that machine.

Finally, to help match government funds to industry needs, I suggest that a steering team be established involving industry, government, and academia, to establish priorities on an annual basis and then let the National Institute of Standards and Technology manage the implementation.

International Perspective

Robert J. Hermann
Senior Vice President
United Technologies

I am from a large, multinational, multiproduct corporation, so some of my perspective comes from that platform. But I am here to provide one person's international perspective, with a bit of nationalistic, patriotic fervor.

International perspective is so important. We work in an economy that is global in scope, and we must recognize that as we strive to be a good nation, a competitive nation, a nation that provides a good standard of living for our people. Our industrial base is distributed across the globe, increasingly so. True, other nations are gaining on us, but this is inevitable and essential if our political objective is to provide for human rights for all people. Furthermore, for our own well-being, other countries must prosper so they can produce and consume, because our economies are interconnected, as are our industrial bases.

The United States represents only 5 percent of the world's population. We cannot prosper either as a company or a country with only a U.S. industrial base. We must find the right way to achieve prosperity. We must be good at managing global enterprises, not just at manufacturing parts and pieces at home.

This means, among other things, that we must be able to work across cultures, in all aspects of the enterprise. We must look to other parts of the world to acquire capital, understand how they govern enterprises, and learn about their social mores and industrial practices. We must develop and use the latent human capability that exists across the globe. All of these activities will require education and training.

I believe the government's role should be to make the United States a very good place to work, make good products, and do business. Such an environment would enable business leaders to create and sustain producing enterprises in our country, attract capital investment, create jobs of the best kind, and ensure a robust economic future. The people of the world should want to establish activities here, create wealth here, and be internationally competitive from here.

A lot of tools are available to the government, beyond programs and subsidies for selected industrial sectors. There is not enough collectible tax money to move the whole ship in a different direction through subsidies. Direct investment in the Advanced Technology Program, the Technology Reinvestment Project, and dual-use technology will help quite a lot, but this is only part of the solution. So the government must change the environment, the rules of doing business. Technologies are an important aspect of this.

Technology can be defined in different ways. I argue that we keep it in our people, and that the skills and technical expertise of our people are a critical part of the U.S. technology infrastructure.

To maintain that infrastructure, we probably also need to invest in strategic science relevant to national objectives. It seems to me that the public and private sectors need to invest in science and technology, both to derive products and to create the human talent that goes with it. It is then important to retain that talent within our borders, so it adds to the wealth and well-being of our country.

We have an accounting process to keep track of tangible assets or capital, but we have not the vaguest idea of how to measure human capital. We know that the first-class nation and the first-class corporation will be dominated by excellence in quality people and their processes. But we need to get the accounting community to work on measuring these assets.

One element of a good living and working environment is a superior political system, which I believe we have. This gives us some advantages: a superior social, technical, and industrial infrastructure; a superior university system and a well-educated work force; access to capital and entrepreneurial skills; and a set of user-friendly governments at the municipal, state, and Federal levels. Of course there are problems. I sometimes work with the Department of Defense on acquisition reform; their procurement practices definitely are not user friendly. I also believe we may have a superior university system but not a superior overall educational system.

But we really need to recognize our comparative advantages. First of all, we will be the only major superpower. We are expected to lead in the world, to provide moral, ethical, and political leadership. That implies having a certain amount of military force to back up our leadership.

Second, the United States has a large, coherent internal market today, but it will not remain dominant. In the long run, our 250 million citizens will not dominate the 1.2 billion in China, a population that is increasing at a rather rapid rate. Third, we have to create a superior capital marketplace. This is a difficult task, but one of the jewels of our country is the way in which we can liquify not only capital but also human assets.

Fourth, one of our great virtues is that we have a multicultural society, one of the few in the world. We are a multicultural society learning to work together in a stable, desirable political environment. That is a tremendously valuable attribute that we should recognize and exploit.

Finally, we have the experience, the philosophy, and the political and human base to be the integrating part of this world. We have the capability to integrate programs, cultures, and processes; we have systems competence, and we think globally in a way that few other societies do. These are our major assets.

There are also some roles we should not play, with our 5 percent of the world's population. We're not going to be a low-cost labor supplier. We have no hope of being a follower nation. And we have no hope of being the best at *everything*.

The United States should not be too much of a demagogue about creating domestic jobs now. Also, I want to emphasize that we must be concerned with not only our jobs now, but also the jobs of our children and grandchildren later. Because we have an important role to play as an integrator in the world economy, this role will be the basis for a substantial chunk of relatively high-salaried jobs in the business of producing things in a global marketplace. We need to remember the importance of foreign ownership and participation to our ability to fulfill our role. Remember, as competing companies housed in the United States, we need some reciprocity from other nations.

Furthermore, to enlarge the marketplace, to tap the 4 billion people who are not participating in the world's wealth creation capability today, we need to learn to deal with people, instruments, and processes at all levels of sophistication. We will not establish high-tech manufacturing capabilities in what we would call primitive areas.

Finally, we cannot rely on current concepts of intellectual property. What is intellectual property in today's environment? How do you know when you have some? How do you know when it moves? Particularly in a world of the Internet and electronic mail, it is not clear where sovereignty comes in and how you control this type of property.

I want to plug two international efforts I am involved in. One is the Intelligent Manufacturing Systems (IMS) program, an initiative launched by Japan about 5 years ago. It has evolved through a demonstration phase. I think the United States should take a leadership role in this framework for international cooperation. I believe it suits our purposes better than it suits the Japanese or the Europeans. I encourage you to explore IMS as a basis for U.S. government-industry cooperation and international private-sector cooperation.

The second area is international standards setting. The standards-setting system is good but not ideally poised for the future, which will have a much more distributed industrial and technological base than exists today. So I encourage you all to reexamine whether we are helping this country represent itself well, both internally and externally, in the standardization process.

Finally, I think the Clinton Administration has recognized that competitiveness is a national problem. The government is acting in a way that is consistent with the framework of ideas I presented. I believe that globalization is the most important single issue for most producing enterprises. We have to deal with the multicultural globalization of the economy and industry. We can't do everything best, so we have to make some choices.

National Laboratories' Viewpoint

Heinz Schmitt
Vice President
Sandia National Laboratories

The national laboratories are facing highly significant changes. These labs represent a significant investment on the part of this country, and by virtue of that investment they have significant core competencies, outstanding facilities, and experience with manufacturing and the related technology. We also recognize that these capabilities and experiences will be useful only if we match them to industry needs.

I want to discuss the product realization process, because we need to think in terms of taking innovation from the concept stage through prototyping, production, and disposal. It is in viewing manufacturing in this way that we find opportunities to leverage the competencies and experiences of the national labs. So we want to move toward an agile product realization process and think about virtual enterprises, virtual prototyping, agile personnel, energy efficiency, environmental responsibility, quality, and reliability.

We need to think about production and disposal up front, during the conceptualization phase. And we need to think about realizing marketable goods from small and medium-sized as well as large enterprises. The output ought to be jobs, market share, and economic well-being. All this implies that we must have an information-driven product realization process. This means accumulating an information base much richer than ever developed before on integrated products and processes, business practices, modeling and simulation, material characterizations, and "intelligent" processes.

In discussing the national labs, we also need to include the production agencies in the Department of Energy (DOE) that participate in the product realization process. Teams of production agencies and labs produce integrated systems, everything from plastic parts to interconnects to major structures to mechanical and electronic assemblages. In the Kansas City production agency, for instance, we have 3 million square feet of floor space and 168 processors. All of this can be leveraged and transformed from a national security asset into a capability to develop prototype technology for making commercial products.

In the area of environmentally conscious manufacturing, for example, our product realization team reduced the need for solvents through an integrated evolution of not only production processes, but also product design. This eliminated the need for some solvents and increased the efficiency of the manufacturing process. The achievement was possible because DOE, Sandia National Laboratories, and AlliedSignal Inc.-Kansas City signed an agreement very early stating that this was a collective objective, that we weren't just looking at the functional characteristics of a product but also at an environmental opportunity and responsibility.

The labs' expertise in reliability and quality also can be leveraged for the benefit of commercial industries. These characteristics are critical from a weapon security and safety standpoint, to be sure, but they also are important in radars for an "intelligent" vehicle highway system, in computerized automobiles, and in manufacturing equipment. In fact, this is an area where we're finding many opportunities for Cooperative Research and Development Agreements (CRADAs). We have six CRADAs in quality and reliability that are funded fully by industry.

There is also tremendous re-configuration and downsizing going on in DOE. But this is an opportunity, because DOE has made a commitment to transforming its product realization capability into an agile enterprise. It is our intention to take the characteristics of agility and deploy them and make prototypes in this transformation. Therefore, the agility demonstrations actually will produce products, and most of the products will be deployed and produced in industry. The DOE always has depended on industry to a large extent to make its products; in the new strategy, roughly 50 percent of those products will come from industry.

With that summary of why DOE and the national labs can be valuable national assets in manufacturing, the question is, how do we exploit some of these capabilities? Across all the labs, there tend to be three categories of opportunities: deploying technology, research and development partnerships, and spinning off technology into new companies.

You will see, at least at Sandia, changes at many facilities, such as the Integrated Manufacturing Technology Laboratory in California and the Advanced Manufacturing Technology Laboratory in New Mexico. In attempting to match our programs to industry needs, we understand that our facilities must be more accessible to industry and other agencies than they have been in the past. You'll find that these facilities now are outside the secure areas, allow visitors, and are ready to work with you.

There has been a significant increase in DOE-industry cooperation in the past year. Sandia is involved in 160 CRADAs worth roughly $500 million. The distribution of projects depends on who tallies the data, but I believe over 22 percent are in manufacturing, focusing on automobiles, textiles, electronics, and many other areas.

Similarly, I think the spirit of cooperation across government agencies is increasing, although I believe there should be even more teaming. For example, DOE has a partnership with the Department of Defense to provide technology for the microelectronics and flat-panel display industry. All proposals are industry led. A laboratory partner is required, but there is no dictate on the distribution of funding, nor is there a mandate for how the money will be distributed among Los Alamos, Lawrence Livermore, and Sandia national laboratories.

Industry has to provide road maps. There are two types. Industrial sector-specific road maps represent an important national step in the right direction, and this conference has shown me that they require a lot more work than I had thought. But we also need a road map for the technologies needed to make all the industrial sectors interoperable. For instance, it's important for textile industry executives to interact agilely with their counterparts in the automobile industry.

Essentially, industry needs to define and prioritize its technological needs. Government then should help you meet those needs. This set of needs and solutions must be those that enable the United States to be economically competitive.

It also would be useful to have a national manufacturing agenda, which in my view we do not have. We have national centers and programs, but no national program. We need a national coalition. So this is an argument for integration of existing efforts. A lot of money is being invested in a wide assortment of programs in manufacturing technology. With a national agenda, these could be orchestrated and integrated so that the impact would be greater than the sum of the individual parts. Government agencies have identical visions for agile enterprises. We should integrate and leverage our programs to achieve our goals more effectively and quickly. My anxiety level is quite high, and time is wasting.

So what's next? We need to establish national priorities and strategies and pursue them. First, we need to complete the industry-specific road maps. Then we need to identify the crosscutting needs, take an inventory of present and planned advanced manufacturing technology programs, and define an integrated national program that addresses not only technology, but also infrastructure. New manufacturing processes will not be very useful if we don't have a work force that can function in that environment. People are our greatest asset.

Defense Logistics Viewpoint

Lorna Estep
Technical Director, Information Technology Initiatives
Naval Supply Systems Command

I will discuss the logistics infrastructure within the Department of Defense (DOD), and the technology and business needs we see emerging as we downsize, or "rightsize". Let me start with two key points. First, everything within the DOD logistics system depends on a cross-industry structure. We support weapons systems not only through the aerospace industry, shipbuilding, and the automobile industry, but also by depending on the electronics, computer, clothing, and fuel industries. So we need to look at mechanisms, business processes, and technologies that cross all industries, and look for commonalities.

Second, our logistics process depends heavily on small businesses. So, as we look at new technologies and the resulting changes in our processes, we are very concerned about bringing not just our prime common industries together, but also our third- and fourth-tier business structures.

Time is critical in industry's manufacturing strategies -- time to market, design-to-manufacture time, time to the customer, and so on. Time is also critical to the logistics infrastructure and therefore may be a shared strategy. In the logistics process, time is an issue because we need to support deployed operating forces. But we're also interested in the relationship of time to our pipeline costs. In the U.S. Navy, one day of inventory in a logistics pipeline is worth $11 million, and it takes an average of more than 300 days to complete repairs and get spare parts. That makes roughly $4 billion of inventory in our pipeline. So we incur substantial costs in supporting that pipeline for that length of time. Therefore, rapid response makes a big difference in our logistics infrastructure.

Unlike the private sector, we're not interested in market share and profits. But cost and efficiency are still big issues for us, in terms of both acquisition and logistics support. Our main goal is to support DOD operating forces. We now find ourselves in the position of making trade-offs between acquiring new technology and supporting the operating forces and our logistics infrastructure. We're trying to make balanced decisions about how many operating forces we need, the nature and cost of our logistics infrastructure, and the types of technologies we can buy to give the operating forces the tools they need. That logistics infrastructure will have to become more efficient in the next 10 years.

We're focusing on cycle time and cycle costs, not only for the manufacturing process, but also for weapons repair and overhaul. In that quest, because DOD depends on industry to manufacture parts and systems, we need to form partnerships with industry. We've heard a lot about cooperation on technology development, but we also need cooperation in the business process environment.

The first thing we need to do collectively is to break down technology and business barriers. We've talked about technology sharing. We also need dual-use processes, not only on the production floor but also in business, in terms of how we communicate with and relate to each other.

We also need to exploit existing assets. The DOD has significant national capital assets, including a tremendous infrastructure of commercial enterprises. We need to take advantage of our tremendous investment in the small business community, machine tool industries, and manufacturing processes. Our technologies need to accommodate the use of those existing capital assets, because we can't afford to replace them wholesale.

Finally, we need to remember that cooperation depends on trust. Much of infrastructure and past history does not support the development of mutual trust between industry and DOD. So we are looking at ways to change the logistics and procurement infrastructure to foster development of a more trusting relationship.

Now I will discuss technologies, what I call integration technologies. In our 300-day pipeline, less than 10 percent of that time actually is spent on the production floor. Over 100 days are related to procurement lead times in the acquisition process. The remaining 150 days are consumed by internal processes, including engineering, business, and procurement of raw material. We're trying to integrate the procurement and other internal processes so we can spend more time on the shop floor making products, and get them to the operating forces as quickly as possible.

If we could reduce the length of the pipeline by even 50 percent, then we would save some $2 billion. That savings would help us make optimal trade-off decisions as we downsize.

The DOD also has some initiatives aimed at establishing partnerships with the small business community and integrating our new data and business processes into production. The Computer-aided Acquisition and Logistics Support initiative, the Flexible Computer Integrated Manufacturing program, and the National Initiative for Product Data Exchange are examples.

Government-industry cooperation does not come naturally to DOD. In fact, there are numerous barriers. But I think the pendulum is swinging toward cooperation. I like to say the stars and the moon are finally aligned, and we're beginning to make the crossover in business activities that will help realize some of the technologies we've been working on for the last 15 years.

Defense Manufacturing Science and Technology Viewpoint

Michael F. McGrath
Executive Director for Manufacturing
Advanced Research Projects Agency
U.S. Department of Defense

I would like to discuss how, from the defense science and technology viewpoint, we look at industry needs, and how government programs can be aligned with industry needs.

First, the Defense Science and Technology (S&T) program has to meet defense needs. We have a customer in the military forces, so our S&T program is put together with priorities based on military needs. In years past, that strategy has driven us to emphasize performance and technological superiority. Those characteristics are still very important, but other key considerations have emerged.

One of these concerns is affordability. Our procurement budget is about 40 percent of what it was at its peak during the Cold War. We also are concerned about having a robust, responsive industrial base that we can count on. We can't afford a separate defense industrial base, so we must look to an integrated civil and military industrial base.

These concerns lead us to a strategy that emphasizes investments in process technology as well as product technology, in areas where we can reduce weapon system costs. We'll pursue these opportunities, wherever possible, with the objective of dual-use manufacturing. In some cases, military and commercial needs are similar, and we can capitalize on that.

There are still areas where military needs are ahead of commercial market development, and in those areas we need to make defense-specific investments. Over time, there may be spin-off opportunities where commercial markets can develop. Multichip modules are an example of such an area, as Anita Jones mentioned earlier. We're still the dominant customer in the marketplace but we see that, someday, we'll be just one customer among many.

We also recognize that technology alone will not solve our affordability problems, so there is a strong emphasis on integrating technology programs with other initiatives, to change the way we do business. We can't do this without continued dialogue with industry, so industry is involved in our planning process.

With industry, we view manufacturing in "The Big M" sense, encompassing all the functions of the manufacturing enterprise. We want to achieve in the defense business what world-class companies have done over the past 10 years with their improvements in cost, cycle time, and quality. To pull that off, we have to become a world-class customer, interfacing with our suppliers the way world-class companies interface with their suppliers. We have to make a lot of changes in our business practices. Our acquisition reform initiatives are an important part of the overall strategy.

We also need our supplier base to become world class. That means industry has to make some changes. Through agile and flexible manufacturing, cost has to be decoupled from lot size. We need to expand Department of Defense (DOD) access to high-volume commercial production lines that can make small lots for us. We have some examples of this today but need to expand the envelope of flexibility to make dual-use manufacturing the norm.

The DOD also is investing in enabling technology. As the procurement budget has declined, we've tried to keep the S&T budget roughly constant, so that we have the resources to invest for the future. An important part of our strategy is to use technology to reduce costs and cycle time and improve quality.

Costs are hard to manage because so much is in overhead. But we can reduce overhead costs through agile manufacturing, information integration, and electronic commerce, both within and among companies. Costs also can be reduced on the factory floor through process innovation, flexible manufacturing equipment, "intelligent" closed-loop process control, and integrated product and process development. We have structured, integrated pilot programs using combinations of these technologies, to evaluate the combined effects of acquisition reform and our S&T investments.

The DOD is spending about $1 billion this year on science and technology related to engineering and manufacturing. The Advanced Research Projects Agency (ARPA) has a large program in manufacturing technology, focused primarily on electronics. We participate in big projects, such as SEMATECH and one on flat-panel displays, and numerous smaller efforts. These projects tend to be high in dual-use potential but also cutting edge. Decisions on whether these programs ought to be cost shared with industry or funded totally by ARPA are driven by assessments of the risk involved and market conditions.

ARPA's manufacturing technology programs include several pilot factories established under DOD's Technology for Affordability initiative, where we're installing the next generation of factory systems to de-couple cost from quantity. These programs focus on components and subsystems of importance to DOD. One key component area is infrared focal plane arrays used in sensors and seekers for "smart" weapons. There is not a large commercial market for these components, at least for cryogenically cooled arrays, so this is an example of a defense-driven program. Other programs, such as those addressing signal processors and fiber-optic gyros, have high potential for dual-use manufacturing.

At the subsystem/system level, we plan to have a pilot factory for next-generation capabilities in missile manufacturing. Materials processing is another important investment area. We work closely with the Department of Energy and the National Institute of Standards and Technology (NIST) on many of these technology themes.

ARPA also is involved in other manufacturing technology programs:

o About half of the first year's Technology Reinvestment Project (TRP) awards were associated with manufacturing technology. The TRP is funded at about $600 million a year, so that 50 percent is a big source of resources for dual-use technology development.

o The Computer-aided Acquisition and Logistics Support (CALS) Shared Resource Centers recently were transferred from the U.S. Air Force to ARPA. Industry refers to CALS as "Commerce at Light Speed." We're working with NIST and its Manufacturing Extension Partnership to turn these CALS centers into national assets that can help manufacturers, particularly small and mid-sized manufacturers, get on the information highway and do profitable things.

o The Agile Manufacturing Initiative is a collaborative effort by ARPA and the National Science Foundation. We made a number of awards last year, and we are about to solicit proposals for pilot programs in agile manufacturing this year.

Finally, we need to continue our dialogue with industry at several levels. At the strategic level, we've formed a relationship with a multi-industry Task Force on Affordability. The executive group of this task force is chaired by Aris Melissaratos, vice president of technology and quality at Westinghouse Electric Corp. They rely on the National Center for Advanced Technology to be their secretariat and they have chartered a number of working groups that are working with DOD, Mantech committees, ARPA groups, and other agencies on manufacturing technology, acquisition reform, and industrial base issues. Yesterday was the first meeting between the chairman of our new Defense Manufacturing Council and the industry task force. We want industry to be involved in shaping the defense investment agenda in the future.

Defense Conversion

Dorothy Robyn
Special Assistant to the President
National Economic Council

Did you know that the place we are meeting today, the National Institute of Standards and Technology (NIST), has the fastest growing budget of any Federal agency? The overall Federal budget is in a hard freeze, but the NIST budget is growing by double digits. When Leon Panetta, the head of the Office of Management and Budget, briefed members of the Congress on the President's fiscal year (FY) 1995 budget proposal, the most frequently asked question was "What is NIST?"

I want to discuss one aspect of defense conversion. There are really two broad challenges that define the Administration's approach to defense reinvestment and conversion. The first -- and the one the press generally writes about -- is economic adjustment, helping the men and women in firms and communities who depended on defense work to adjust to downsizing in the defense budget. The President refers to this as "not leaving the men and women who won the Cold War out in the cold." That is enormously important, but I want to discuss the second challenge.

This other fundamental challenge is to meet future military needs with a declining defense budget in a world that still challenges our security and our interests. We plan to do that by integrating the now-separate commercial and military industrial sectors.

It has become increasingly clear in recent years that, to maintain its technological advantage, the Department of Defense (DOD) must bring down the barriers it has erected between defense and commercial firms. Those barriers are the result of an enormously cumbersome, sclerotic, unworkable procurement system, which has driven away many commercial firms altogether. And firms that do business with DOD often "wall off" their defense production from their commercial lines. As a result, over the last 20 years DOD has become increasingly reliant on an isolated defense industrial base. That strategy is no longer appropriate, for a couple of reasons. The most obvious is, as Deputy Secretary of Defense John Deutch says, DOD no longer can afford the luxury of having its own private industry.

The DOD is paying $10 for integrated circuits, when equivalents are available commercially for $1. The $9 difference is due largely to overhead resulting from an enormous number of government-unique requirements. The Defense Science Board estimates that DOD can save tens of billions of dollars a year by integrating substantial amounts of the commercial and military industrial sectors. That's the most obvious reason for commercial-military integration, but I don't think it is the most important one.

The most important reason is that, increasingly, DOD cannot get access to the critical technology it needs. Leading-edge technologies in electronics, telecommunications, and software increasingly emerge first in the commercial rather than the defense sector -- a reversal of the traditional pattern. That is not to say that DOD is not supporting leading-edge technology. It certainly is. But the rate at which innovation actually moves into volume production often trails well behind that of commercial industry. And given our procurement system, DOD cannot be assured of access to that critical technology.

Let me give you an example, which the President used when he kicked off our procurement reform initiative last fall. At the beginning of the Gulf War, the U.S. Army wanted to buy 6,000 commercial radio receivers from Motorola, Inc. But Motorola wouldn't sell the commercial radio receivers to the Army, because Motorola's commercial division did not follow cost accounting standards and a long list of other defense-unique requirements. Now, the Army says we could have worked out this problem in a month or so, but we didn't have a month. So we had the Japanese buy the 6,000 commercial radio receivers, and they donated them to the war effort, crediting that expense against their contribution to the war. That kind of back-door procedure is simply not acceptable.

There is also a third reason why we can no longer rely on an isolated defense industrial base. As that industrial base declines in size, it is losing technological leadership and failing to attract sufficient capital. It no longer is large enough to support surge capabilities. In the words of Louis Branscomb, formerly IBM Corp.'s chief scientist, the defense industry is becoming "ghetto-ized."

In sum, to reduce the cost of defense technology, get access to critical technology, and broaden the defense industrial base, DOD has to bring down the barriers between the defense and commercial sectors. Simply stated, the goal is to erase the distinctions between the two sectors wherever possible.

Three pillars support this dual-use vision. The most important is procurement reform, which is proceeding on two levels. One is statutory reform of legislative obstacles to buying commercial products. Significant legislation was voted out of committee yesterday, to the Senate floor. The legislation does not go far enough but it is a significant move in the right direction. On another level, DOD is proceeding internally to eliminate what Secretary of Defense William Perry calls "self-inflicted wounds," or administrative impediments to commercial-military integration. This is the most important problem.

The second pillar is increased support, particularly through the Advanced Research Projects Administration (ARPA), of dual-use research and development (R&D). Gary Denman, the head of ARPA, characterized DOD's new approach when he said recently: "If a I put a stake in the ground and commercial industry doesn't gather around that stake, then I'm going to move the stake." That's very different from the attitudes of past years. About three-quarters of ARPA's R&D budget now could be considered dual use. The Technology Reinvestment Project (TRP) is the most visible but by no means the only dual-use program.

The third pillar is international cooperation. Technology knows no national boundaries, and to get access to the very best technology for our weapon systems, we have to work with companies in Japan and Germany. Bill Perry is pursuing this issue vigorously. When he was director of Defense Research and Engineering (DDR&E) in the 1970s, he went to Japan; no DDR&E went there again until Anita Jones visited last fall. This Administration is very interested in both dual-use and international technology. In fact, there is a person who oversees this activity: Ken Flamm, the deputy assistant secretary of defense for dual-use and international technology. We see those two pieces as fitting closely together.

Let me turn to the TRP, the most visible part of what the Administration is doing to bring about commercial-military integration. The mission of the TRP is "to stimulate the transition to a growing integrated national industrial capability, which provides the most advanced, affordable military systems and simultaneously the most competitive commercial products."

Let me also clarify what the TRP is *not*, because there has been some misunderstanding about the meaning of "defense conversion." The TRP is not meant to be disaster relief for beleaguered defense companies. It is not meant to convert large prime contractors from making tanks to making toasters, nor is it meant to stimulate growth among small companies in sectors unrelated to the industrial base on which DOD can draw. The TRP is designed to stimulate the integration of the commercial and military sectors so that DOD can get technology that is affordable because it is simultaneously appealing to the commercial sector.

There are three avenues of attack through the TRP. The first is technology development programs, typically carried out by consortia designed to develop new dual-use product and process technologies. The second avenue is technology deployment -- getting technology into small and medium-sized firms, the backbone of our industrial base. To reach these firms, we are taking advantage of the very good existing programs at state and regional levels. The third avenue is manufacturing education and training programs designed to raise manufacturing to a level on a par with other engineering and scientific disciplines. Joe Bordogna of the National Science Foundation has done a tremendous job putting that program together.

All TRP programs must be awarded on a competitive basis. In addition, industry must provide at least 50 percent of the funds for each project. We actually did better than that in the last round. This willingness to provide funds is the only way we have of knowing whether industry thinks a technology is commercially viable. We're good at judging whether a technology can meet defense needs, but we can't judge the commercial potential.

We identify focus areas and also encourage industry to submit proposals in other categories; these latter proposals did extremely well in the first round. We were inundated with proposals in the first year. We offered roughly $500 million in matching Federal funds and received about 3,000 proposals requesting about $9 billion. So, the program was oversubscribed by about 17 to 1 overall, and individual focus areas were oversubscribed by 30 or 40 to 1.

ARPA and the other five agencies involved went through an elaborate evaluation process to identify 212 projects, for which we announced matching awards of $605 million. We ended up using the entire $500 million in FY 1993 funds and then an additional $140 million in FY 1994 funds, in order to make awards to all the programs that were highly recommended by evaluators. So even though we had to reject many very good proposals, we were able to make awards to all of the highly recommended proposals.

Now let me describe what we see as measures of success. First of all, the response from industry was very strong and enthusiastic. The degree to which the program was oversubscribed and the quality of the proposals were positive signs, as was the amount of matching funds offered. In addition, teams of firms often were willing to put up cash rather than other resources. That put teams unable to offer cash at a disadvantage.

Another sign of success was the meaningful and unique nature of the collaborations. The technology development teams were integrated both horizontally and vertically and represented partnerships between defense and commercial firms -- and that is exactly what the six agencies that implemented the TRP were trying to bring about.

There was also relatively good small business participation, albeit not as much as we would like. One or more small firms were involved in 60 percent of the partnerships. State and local governments also were stimulated by this process. The TRP was the first program to provide significant amounts of money for state manufacturing extension and technology commercialization programs, and a number of states, such as California, set up their own TRP-like programs to supplement the Federal program.

Finally, there was extraordinary collaboration among the six Federal agencies. That is a rare but growing practice.

We also are trying to make substantial improvements in a number of areas. I will mention two. First, we want to reduce the number of unsuccessful proposals. We got 3,000 proposals and only made 212 awards, so there were some 2,800 unhappy teams. One strategy is to identify technology focus areas. We also are holding more outreach workshops than we did last year -- one in each of the seven technology focus areas in the recent solicitation. Finally, we plan to encourage applicants to submit to ARPA a White Paper, a five-page description of what they intend to propose. Then the other five agencies will give the applicants feedback, which should improve their decision making about whether to bid.

Second, we also must improve the capability of small firms to compete. So small firms now may use Small Business Innovation and Research grants as part of their cost share. In addition, small firms will have three to four months following the announcement of an award to come up with their share of the matching funds.

We announced the next competition in April. The focus areas are high-density data storage systems, object technology for rapid software development and delivery, interoperability test beds for the National Information Infrastructure, high-definition systems manufacturing, low-cost electronic packaging, uncooled infrared sensors, and environmental sensors. We're doing a series of workshops now. More information on the workshops is available through ARPA's toll-free dual-use telephone number (1-800-DUAL-USE). We will announce the first competition next week. About $180 million is available in this round, of which about $25 million will go to manufacturing extension centers so they can carry out technology deployment.

In late summer, we'll announce a second, more general competition that will include technology development, regional technology alliances, manufacturing education and training, and also small business innovation and research. That round probably will be worth about $500 million. We will exhaust our FY 1994 funding and begin to draw on our FY 1995 funding.

Let me close by saying what a pleasure it is to be on a program along with other people from the Administration, talking about manufacturing. Manufacturing was a bad word in the last administration, because it was considered too close to market for the Federal Government to get involved in. Manufacturing is now legitimate again, and it's wonderful to see this kind of response to it.

Panel Discussion

Thomas Murrin: Thank you very much, Dorothy, that's not only captivating but very courageous and candid.

I want to share with you one of the reasons why some of the things you've been hearing are so exciting and promising. A few years ago a Defense Manufacturing Board was established. It was a very poor man's and poor woman's version of the Defense Science Board. It literally had one staff person and a very modest budget, but we were asked to get into manufacturing activities.

One of the things we did, and did really comprehensively, was to study the difference between commercial integrated circuits (ICs) and Department of Defense (DOD)-procured ICs. One of the highlights was to have the entire group and some government figures visit Motorola, Inc. in Phoenix, where in virtually contiguous but separate areas, DOD ICs were being produced and commercial ICs were being produced. The relevant procurement regulations, and how to do it, that the DOD people had prescribed actually lay out on two large tables. It took two large tables. I got in deep trouble as the chair for doing that.

Later, a few of us went to the very highest offices in the Pentagon to espouse a concept we called "world-class customer." And that caused a great deal of trauma. But it is fascinating to hear Mike McGrath talk now about world class.

I just want to share one final incident with you, because it might move some of you folks to dig this out. After one year we were told to write a report and put in some recommendations. Apparently we didn't follow all the protocols and bureaucracy of the Pentagon because, literally the morning the report was to be released (I was to release it), it was seized. The report literally was seized, never to be seen again. I know of at least one underground copy of that report, in case anybody is interested in duplicating it. Believe me, it's nothing but common sense, just what we are espousing now. I share this with you because it is such a powerful insight into how this wonderful change in attitude is taking place and, I think, is going to benefit all of us.

We have some time now to question, comment on, or discuss what we've been listening to today. I don't want to constrain your comments; all I'm going to try to be is a facilitator. Let's just look for a moment at some ideas Heinz Schmitt left with us, because he's one of our key government executives who had to leave. I think you sensed Heinz's sense of urgency, which is what I would like to share with you. We can talk about these things ad nauseam, we could have conferences coming out the kazoo, but the world is turning and the realities we've been talking about are very real. We have incredible resources -- how do we really get our act together and do something of great national benefit?

Shirley Willett, Stylometrics, Inc.: I want to bring up the issue of improving engineering design, which is poor in all industries. I want to bring out three points. The first concerns crossing disciplines. What I mean by that is, we've got to involve aesthetics, science, and technology at the "points of design" in engineering design.

Second, we've got to make it cross-industry. As a winner of a Small Business Innovation Research (SBIR) grant in the apparel industry, and being involved in conference papers for the National Science Foundation (NSF), I was introduced to other industries. I was almost shocked to learn of the common denominators among aerospace, automobiles, mechanical engineering, architecture, and apparel. When I say apparel, I mean the actual geometric structures within engineering design.

The third point is that I have been working with Howard Moncarz here at the National Institute of Standards and Technology to develop and strengthen apparel engineering design. This term is not even used in the apparel industry yet. I think we in the apparel industry need some help from other industries. My point is, I know about product realization, and you all are discussing things I need to know about such as rapid prototyping, product life cycle, and product data exchange standards in terms of engineering design.

Audience Comment: I'm from the University of Texas at Austin. I've been studying machine technology for about 35 years and lecturing and doing research in the field. I've also been looking at the history of technology over about 150 years, in some depth. Tom Malone's presentation was the highlight of this conference for me. He showed that the textile industry has to invest $4 billion a year in factory-floor technology.

I suggest that there can be just as much excitement about factory floor technology (e.g., wire-by-wire technology, "intelligent" systems) as there is "above the floor." There is an enormous gap in this country when it comes to machine technology. In 1950, about 90 percent of our machines were U.S. made. Today, this figure is approaching 10 percent in virtually every category, whether it has to do with paper, shoes, food, textiles, or microelectronics.

Why can't we address this problem? The machine tool industry is important, but it's only a slice of the problem. Patching machinery, paneling machinery, and so on are equally important.

Steve Robinson, Rock Island Arsenal, U.S. Army: I'm very much interested in technical data exchange. The arsenal is a traditional ironworks, for which the Standard for the Exchange of Product Model Data (STEP) is very important. But the presentations have touched on industries for which STEP may *not* be all that important. My impression of electronics manufacturing is that it's two dimensional, with wiring diagrams in schematics and printed circuit layouts. While there is a lot of enthusiasm for STEP, I don't see an integrated market demand in terms of lowest-common-denominator, industry-wide needs for a more coherent strategy for technical, engineering, and manufacturing data exchange.

Milton Chang, president, New Focus: I've been involved in starting 12 high-tech companies. New Focus is a small company, with 30 people, in the laser-optics field. I would like to present a small company perspective.

Small companies need special consideration from funding agencies, for the following reasons. We're an engine for renewal, because we are the future. We're flexible and agile, lean and mean, and street smart. No other country has the infrastructure to spawn new high-tech companies, not Japan, not Europe. This is an opportunity we should exploit.

Another reason is that, for small companies, small funding is equivalent to big funding, because we can use a small award as validation to get more funding from venture capital firms. Also, in a sense, at this meeting we are approaching productivity and competitiveness as technical people rather than as businessmen. big companies already have financial resources, and there are other ways, apart from direct subsidies, to encourage management to invest these resources (such as with tax incentives).

Finally, I think we can learn from the track record of venture capitalists that there are very few blockbuster successes, and the overall return is very low. With consortia, there are administrative costs and many cooks to spoil the soup. My point is, give special funding consideration to small companies, much more than what the SBIR program allows.

Mike Kelly, Georgia Institute of Technology: I'm a former breakfast partner of Dorothy Robyn at the National Academy of Sciences. I want to support earlier comments about the importance of equipment for manufacturing. I recently participated in a study of Japanese technology for electronic packaging. Every company we visited, without exception, controlled all of their own design and building of equipment. It was the single factor identified as making them more competitive, not only with one another, but also globally.

In light of the government's increased emphasis on investing in manufacturing, how can we get more people with industrial experience, particularly in manufacturing, working within the Administration, so that the people who control the funding can begin to emphasize equipment and the systems integration associated with "The Big M"?

Dorothy Robyn: I think we're probably moving in the opposite direction. I know the Advanced Research Projects Agency (ARPA) used to have a much more rapid turnover in program managers than they do now. Managers typically come from industry, but the problem is the restraints on what ARPA program managers can do after they leave the agency. I think there is a tradeoff between trying to avoid conflict of interest and discouraging industry people from coming into the government.

Mike McGrath: I agree with Mike Kelly. I think this is a real need in government, certainly at DOD, and I expect it's the case in other agencies as well. It's something we probably ought to come back to.

Tom Murrin: Let me comment as a citizen. I think Mike's comments are right on, as always. But the question really gets back to us as citizens. In my judgment, we have to raise hell with the Congress to change the mindless process that talented, patriotic people have to go through to apply for government work. Usually it costs you a fortune, you often break up your family, and you end up in a milieu that is not fun and games. Washington is the strangest place I've been in, and I've been in 42 countries. Someone asked me how long I was with the Department of Commerce. Officially, I was here 18 months, but actually I was here 24 months and the balance of the time was spent going through forms.

Dick Enswald, Westinghouse Electric Corp.: I spent most of my life in the commercial sector before coming to Westinghouse and have been one of those guys that grew up in manufacturing. In fact, I'm on all the manufacturing committees of the various industry associations -- you never know which hat I'm wearing.

We hear all these things about dual use and one industrial base, which most of us have been looking for and seeing evolve. The one issue that always gets me is that, in the commercial world, we conduct a significant amount of our research and development (R&D) in government language 6.1, 6.2, 6.3, 6.4, with manufacturing an integral part of the team. We keep dealing with Mantech and we're dealing with $100 million, now up to $300-plus million, whatever it might be.

If you look at the amount of money we really spend on R&D and had it done by manufacturing people, whether it be federal labs or someplace else ... Why can't we get a percentage of Federal R&D funds to address the first part of the manufacturing process, so you can design for dual use and design for manufacturing and production? This would reduce greatly the number of problems arising on the factory floor. Even in the machine tool industry, you have to design what the machines are capable of, and you have alternative design approaches. How can we change the Federal approach to complement the dual-use thrust?

Mike McGrath: Noel Longuemare, principal deputy under secretary of defense (acquisition and technology) ran a Defense Science Board summer study a couple of years ago that reached exactly that conclusion -- that the real leverage is up front in design. You have to design for manufacturing. That's now a criterion for the forerunners of tomorrow's weapons systems. So we have made a real commitment, and I've seen a real shift in the science and technology community as program managers start to come to grips with this issue and start to ask manufacturing people, "What do I do? I need to worry about affordability in a way I never did before -- what do I do?"

The problem, however, is that we have relatively few new starts in DOD. It will take a while for the new approach to permeate the department, if we do it one new start at a time. That's one reason why we're trying so hard to launch pilot programs, so that we can create more role models and success stories and have this approach permeate the culture.

George Hazelrigg, NSF: I'd like to talk about education. We heard today that the U.S. university system is viewed as the top or one of the top university systems in the world. I think that's a globally held view. But I want to comment on the K-12 system, because much of the manufacturing work force comes out of that system.

I spent the last year teaching in and traveling around Asia. The U.S. K-12 system is vastly inferior to many of the systems in Asia and we're losing quickly whatever edge we have. For example, English is taught widely in Asia. It is taught to everyone in Korea. Yet the United States does not emphasize the teaching of English. These things are really mind boggling to me -- the way we're losing out.

In manufacturing, we have several options. One is to throw our hands up in the air and say, "We're going to lose." Another option is to design manufacturing equipment for stupid people. The third option is to try to improve our educational system. Probably some combination of those strategies is appropriate. But I'd like to hear comments from the panel on education.

Tom Murrin: In the interests of time, I will simply agree with you. We share your views. And if you can take a similar trip to Europe, you'll feel even worse, I think.

Howard Samuel: You're quite right, our K-12 system generally is regarded as inferior to many others. But you have to realize that the educational system does not exist in isolation. If the educational system, particularly K-12, is to be improved, then we have to start before kindergarten, with early childhood and prenatal programs that take into account problems caused by, for example, social changes. These changes include the rise in immigration and the breakdown of the family.

The Administration is trying to attack this problem. The School to Work Opportunities Act, just passed last week, offers some improvement in moving youngsters who are not going to college from the school climate to the workplace. But this is a very complicated problem and cannot be attacked in isolation.

Bill Smith, Georgia Institute of Technology: I too was once a member of the no-name group that met on Constitution Avenue. I have two comments. One is directed at Tom

Murrin. A topic worthy of some debate at the national level is the role that various participants will play in making us globally competitive. There is no agreement, for example, on the role the national laboratories should play, or that academic institutions or industry should play. I think we need a common dictionary, a common understanding -- at least some consensus so we can move forward from that base.

My second comment is directed at my dear friend Dorothy Robyn. You are doing an outstanding and exceptional job, but we can't stay on this course forever under the rubric of defense conversion. Someday we'll have to make a decision about whether to continue this kind of government involvement because we have seen a real change in the national security posture, or whether we are going to convert it -- institutionalize it -- so there will be some predictability and the private sector will have some assurance of where government is going. I suggest that as you make policy, you think about where we're going with all of this, and where we want to be in 1998, 2000, or 2002.

Heinz Schmitt: I want to comment on defining the role of the participants. I think that's an absolutely crucial step in what I proposed earlier. And I think you ought to avoid defining iron-clad roles for agencies, laboratories, and industry. I think roles depend on the situation, the technologies, the process, and the needs, so we shouldn't go for black-and-white definitions. We also need to avoid defining roles when we don't know the characteristics of the people doing the work. The capabilities of many people who are part of the necessary integration are not known by those defining the roles. I think we need to understand each other a bit better before we make those decisions.

That said, I think the national laboratories can add value to the transformation we're discussing by providing enabling technologies and a link between universities and industry and applications. There was talk earlier about where the dividing line is. I suggest there is no line -- it depends on the situation. We shouldn't try for a line. We ought to try for some common sense participation and work toward a process that makes sense for the situation we're talking about.

Gene Allen, MacNeal-Schwendler Corp.: I work with a company that provides computer-aided engineering tools. I'd like to comment on a recommended strategy. This panel has focused almost unanimously on the idea that the government is going in this direction, and we're going to work with industry and we're going to make it happen. Let's assume that it happens, it works. In the year 2020, manufacturing follows the agricultural paradigm, where 1 percent of the population produces all the goods everybody needs. We have customized mass production; if you want something, you just design it on your computer screen, and it's delivered to you the next day. That might be a little far-fetched, but if you take the technology to its natural extension, that's where we're going to go. If we're not there in 2020, then maybe it's 2050.

What I want you to consider is lifestyle, how the average person lives. Because all of a sudden, productivity will be so great that people won't have to work 40 hours a week. How do you maintain a middle class, not only in the United States but also worldwide, to ensure that you have an economically stable population?

Bob Hermann mentioned that the United States has a leadership responsibility. So rather than national goals, maybe there should be international goals. But what incentives should the government put in place to ensure a stable middle class, and a stable economic system that is viable? I encourage the group to look at that issue.

Denyse DuBrucq, E3TV Limited Liability Co.: I want to say that the national movement of late under the Clinton Administration, with the grants for industrial expansion, while they may not have awarded funds to every applicant, they certainly have stimulated companies to organize for national advancement -- and that's beyond cash involvement.

I learned many things at this conference, but the most significant thing is that all these government activities -- STEP, manufacturing associations, the agile manufacturing initiative -- have been "snowballing" over the years. When we finish forming my company, a pilot project sponsored by a group of large corporations, we will take advantage of these things without having to instruct our people in each of the gargantuan piles of information that have been put together so properly. I am most grateful for the conference.

Ron Selvidge, SDM Consultants: I am a management consultant. I think we need to walk away from this conference having accomplished something. After listening to all the presentations, I feel there is a consensus that there needs to be a single entity -- maybe it's an agency, maybe it's not even established yet -- to take the lead in coordinating all these activities in manufacturing technology. Such an entity would set priorities for the nation, define the agenda, and coordinate the programs.

Thomas Murrin: Thank you very much. We will follow up on that as best we can. Let me take the last minute to thank you all for your attention and participation. It's been a great honor for me to participate. I'd like to thank Arati Prabhakar, Mike Wozny, John Meyer, Matt Heyman, and the others for their terrific arrangements and each of our presenters for their contributions.

I would like to close by recalling that old adage about whether a tree falling in the forest makes a sound. The answer is, only if it is heard. Applying that to the present situation, these conferences only amount to anything if you take intellectual ownership of them and act with a sense of urgency in a world-class way. I hope you all will do that.

KEYNOTE ADDRESS:
Government Directions in Advanced Manufacturing

Mary L. Good
Under Secretary for Technology
U.S. Department of Commerce

We really appreciate the large contingent from industry and the academic community who have come to this meeting to share their insight and views on advanced manufacturing technology. This exchange of information among so many people who think manufacturing matters provides a tremendous learning environment. I just want to reiterate that we from the government are here to listen. We want to hear you, try to understand where you're coming from, share with you some of our programs, and discuss our directions and get your feedback.

I want to integrate all the comments that have been made by speakers from the various industries and government agencies. My aim is to provide some coherent perspective on and understanding of how we can push our programs forward to make a big difference in the U.S. economy.

Before the election, President Clinton commented that manufacturing remains the foundation of the U.S. economy. For those of us concerned that we increasingly are viewed as a service economy, that was a heartening comment. This is not an issue of numbers of jobs, but rather of quality of jobs and of an infrastructure that combines manufacturing with service organizations. It is important to remember that, in many ways, the service industry is served by the U.S. manufacturing community, which supports 90 percent of the industrial research and development (R&D) conducted in this country.

As many speakers have said, we have to deal with the powerful forces that are recasting the competitive environment for U.S.-based companies. These forces have far-reaching consequences and pose major challenges for the manufacturing sector. These forces include rapid technological change, the birth of the information age, globalization of the world's markets, and the press of global competition. New manufacturing and management innovations are helping U.S. firms meet these challenges. Companies are becoming more nimble and more flexible, and they are improving quality and reducing costs. Indeed, many U.S. manufacturing companies literally are reinventing themselves in a process as profound and dynamic as the shift from craft-based to mass production.

I was in Chicago yesterday, at the International Forum on Manufacturing, where about half the attendees were U.S. vice presidents of manufacturing and about half foreign vice presidents. They all are moving very quickly along the lines I just mentioned. However, when you dig a little bit deeper, you find only a thin layer of top companies moving in this direction. Beneath that veneer, the situation is less promising. So we need not only to discuss what those world-class companies are doing, but also to diffuse those activities throughout the manufacturing sector.

A theme underlying much of the discussion here is that information has emerged as the lifeblood of modern manufacturing. Advanced technologies are essential for the effective and efficient management and use of technology and information. But manufacturing technologies pose a lot of challenges for many firms. New technology is a big commitment, for one thing. It is complex and costly. Furthermore, it may take years to assimilate it -- to learn to use it productively and gain a significant return on the investment. In a country with a relatively little patience for waiting for such returns, these are issues we need to tackle.

Another issue is that major changes in the organization of production may be required, and new management and labor skills clearly will be needed. I want to stress that the management needs are as significant in many ways as the skill-base needs. In many cases, firms lack the skills needed to be successful in the 21st century; they also may lack the requisite diversity in the work force, the advanced technologies, and the ability to harmonize the work force skills and the technology.

We also need to address the supply side of the manufacturing industry. Some technologies require multidisciplinary R&D efforts that may exceed the capabilities of individual firms or even an entire industry. Often, our fragmented industry structure works against the development and deployment of highly integrated systems that require components from many different resources.

Combining all these issues, we are confronted with an array of financial, technical, managerial, and organizational challenges that must be overcome if we're to exploit fully the economic growth potential inherent in advanced manufacturing technologies.

In this environment, industry must be willing to take some risks, to invest wisely, to develop technical capabilities, and to require new management and labor skills. The supply side of the industry may have to explore alliances in order to obtain the financial resources and the scope of skills needed to advance technologies in any useful way. Meanwhile, the academic community can provide manufacturing managers and the work force with knowledge and skills and also provide technical assistance, especially to small and medium-sized firms.

Regarding the debate over government's role in development of advanced manufacturing technology, I think we have not yet articulated fully in the civilian sector the role of the government. We have yet to articulate it in a way that has the same resonance as do the government's arguments for intervening to improve technologies for the mission agencies in defense, health, and space. We have not articulated our role in manufacturing in a way that resonates with the public, and we need to try to do that.

We understand that investing in the development and application of new commercial technologies is primarily the job of private enterprise. But the issue is how public policies can provide an environment that encourages private innovation. Speakers mentioned low interest rates, tax incentives for R&D, liberalized export controls, and improved conditions for trade. The Clinton Administration has recognized these issues and is making some progress, particularly in liberalizing export controls, improving the conditions for trade, and looking at other incentives for R&D. Public investment also can complement private investment to maximize the social return on R&D as well as provide a world-class playing field where private companies can compete.

Some ask why the government should be involved at all in manufacturing. But we know that individual companies can under-invest in certain new technologies for many reasons, including the high technical risks and the long time frames involved. New technologies create benefits for the overall economy but individual firms cannot recoup their investments if they pursue development alone. Moreover, the integration of new process technologies into modern manufacturing systems often involves advances in knowhow, organizational structure, and standards that no one company can pursue alone.

Companies also under-invest in infrastructure, so this is another area where public investment can raise the productivity of private firms across the board. In a knowledge-based world economy, information and communications infrastructure takes on new importance, as do enabling technologies such as standards, software protocols, measurement, and testing. In all these cases, public actions can make up for under-investment by the private sector.

Furthermore, contrary to some of the rhetoric, broad-based public support of the private sector has a long and rich tradition in this market-driven U.S. economy. Look at transportation, agriculture, and standards, weights, and measures. These are all areas where the public sector has had major impacts on markets and on the civilian economy.

One issue for us is to define more clearly an argument concerning where public resources can make a major difference. At the same time, we must reassure people that we will continue to support basic science and the vital Federal agency missions, particularly in defense, health, energy, and space. But in a vastly changed world economy, I think the Federal Government also must implement new strategies to develop and deploy advanced technologies in partnerships with industry, and to help build a technology infrastructure that will support a competitive 21st-century civilian economy.

All that was the background for President Clinton and Vice President Gore's ambitious technology strategy, which outlines the framework for the Federal Government's role in helping private firms develop and profit from innovations. New let me provide an overview of the ongoing government programs that have been described at this conference.

We have a number of manufacturing initiatives. They are of two types: development of manufacturing technologies, and deployment of technology into companies that cannot do this for themselves. Technology development spans numerous programs, including the Technology Reinvestment Project (TRP), the Advanced Technology Program (ATP), and the National Science Foundation (NSF) fundamental programs, particularly in the Engineering Directorate. We also heard about the Department of Energy (DOE) programs, not only in technology development, but also in deployment, where DOE is sharing its manufacturing facilities with industry. There are similar programs in the National Aeronautics and Space Administration and the Department of Defense (DOD).

Our technology deployment programs are fewer in number than the technology development efforts, but the TRP and the Manufacturing Extension Partnership, which are managed together, form the basis for the manufacturing technology and outreach centers. We hope to have 100 such centers by 1997. The integration of that program through the coordinated efforts of DOD and the Department of Commerce is almost unprecedented in the Federal Government. That effort functions as if it were a single program, and there is no overlap. The result has been much better use of the limited dollars than would have been possible with two separate programs run by two agencies.

Deployment is important because there are approximately 360,000 U.S. manufacturers with fewer than 500 employees. Those businesses represent 95 percent of U.S. manufacturing firms and account for over 75 percent of new manufacturing jobs. They also have major effects in their communities. But these companies find it difficult to take advantage of new technologies that will enable them to modernize and be competitive in terms of quality and cost. And many of these firms are suppliers for big companies, which means quality must be the same on both sides. So smaller firms must be able to accomplish the same things as do large firms in terms of quality, cost reduction, and timely development of products.

We are pleased with our progress in deployment so far, and it will be interesting to observe the overall effect in a year or two.

The rest of my comments are in response to the comment that we need a national vision and a national policy. The question is how to organize all these programs and provide a national vision, a set of goals, and a timetable. The best mechanism we have in place to do that is the new National Science and Technology Council (NSTC), which President Clinton appointed at the secretary level, and the NSTC committees that handle most of the R&D and technology issues. The Committee on Civilian Industrial Technology has taken on the role of coordinating civilian technology initiatives.

We are fairly well organized, but it is very difficult to organize R&D programs on a government-wide basis. The first thing we did was to address areas where there are possibilities for making a major impact. So we have initiatives in development of automotive technologies and manufacturing technologies for electronics. Other focus areas are under review.

In the automotive area, we have an agreement with the "Big Three" auto makers to develop, in 10 years, a family vehicle with all the amenities of today's cars but three times the fuel efficiency. We also are identifying ways to develop new ideas that arise outside the program objective. So, in addition to pursuing a specific objective we are trying to collect innovative ideas from throughout the automobile industry.

The electronics initiative is focused on manufacturing. Several comments were made about how, in the electronics area, the issue is how to manufacture in a way that is flexible, so less capital will be needed to make more products, or at least products can be made cost effectively. We know how to make electronics, but we don't have the manufacturing structure in place to make them at a competitive price.

We also are looking very carefully at the construction and building industry, which is quite good but relies on technology that is inferior to that used in Europe and the Far East. With a small amount of leverage from the government, we might be able to make quite a difference in this area. Furthermore, the industry has recognized the problem and therefore is receptive to our efforts.

In addition, we are considering how best to promote environmental technologies -- both the "green" technologies of the future, which have to do with green manufacturing, and the technologies of today, which have to do with monitoring current manufacturing facilities in a more effective and less costly way than is now possible. We still are working out turf issues in this area. When six or seven agencies are involved in an area, it is not always easy to resolve organizational issues. But we're working hard to decide how to tackle that problem, because environmental technologies are a significant factor in improving manufacturing.

We also want to focus government programs to improve the manufacturing infrastructure, to improve controls and provide the foundation for agile manufacturing. Some of these issues have been discussed at this conference.

The remaining focus area is materials, an arena in which in the United States probably is far ahead of most of the world. On the other hand, our use of those materials in products has not been exemplary. We hope to break that paradigm by shifting our attention to materials in specific industries. For example, for the automotive initiative to succeed, we must develop lightweight materials, because vehicle weight must be reduced. We have identified the lightweight materials, but they cost too much. So, we're focusing our materials initiatives to reduce these costs, to try and get to the point where some of the advanced materials we've invented over the last 40 years can be used effectively in cars.

To outline the manufacturing vision for the future, we need to agree on some goals. These must involve more than just technology. We also must address education and training, because the work force may not be equipped adequately, and the manufacturing infrastructure, which has to allow us to transfer technology information throughout the industrial sector. So the National Information Infrastructure becomes very, very important, not only in terms of its technology, but also in terms of its design, location, and uses.

In other words, we must look beyond R&D to an integrated technology infrastructure base. This requires subjugating agency needs to national needs. This is difficult, because all the agencies have their own goals and objectives. But we need to integrate government manufacturing programs to keep them all moving in the same direction with the same set of goals.

We must have very good industry input, so we can understand industry needs and directions. In my view, we also must have much better public input. We must articulate the needs to the public and get their input, so they will be willing to support initiatives of this type.

Having been in this office now for about 9 months, I have observed that communicating with industry is by far our easiest task. It is not difficult to get industry's views; industry is very willing to provide input and in some cases can be very critical, as it should be. The bigger challenges are the infrastructure issues within the government and how we go about making the case to the public.

Question: How can we get the providers of capital more in sync with the needs, so that they will provide capital for small manufacturing firms?

Answer: This is an interesting dilemma in the United States. We have the front end of technology development covered, and we sort of have the back end covered; the problem in venture capital today is the middle part of the process, which sometimes is very difficult to get through. We have a rather good R&D infrastructure; we can develop technologies. The issue then becomes how can I get that technology into a prototype that will attract the interest of a venture capital firm? If you have a really good idea, then you can get venture capital. But small entrepreneurs have a very difficult time finding enough capital to take this intermediate step.

This issue was brought out in the debate on the Senate bill on competitiveness. Senator Jay Rockefeller (D-West Virginia) has some ideas about how to do that. Some TRP and ATP projects can get relatively close to a prototype that might attract venture capital. We need to look at how we can provide incentives to get capital coverage of that intermediate gap.

Question: Is industrial policy still a dirty word? Can we have it without talking about it? If we equate industrial policy to picking winners and losers, of course that's contrary to our culture. The market should decide that. However, in the past, NSF always accepted unsolicited proposals, and now more and more the government is asking people to respond to focused programs. So can we equate industrial policy to being focused?

Answer: We still have to debate that question and articulate it better. Semantics can get you into trouble. If you mention industrial policy, everyone always worries that we'll decide to bail out of dying industries -- their industries. My view is that government moves very slowly, and there's not a lot you can do to change that. So we should look for opportunities to make a difference 5 years from now, to change the paradigm. That's what is meant by strategic issues. If you want to call that industrial policy, be my guest, but I don't.

We need to look for places where the government can provide some leverage, where funding is difficult for industry to afford. Industry is moving along very well, spending a lot of money in manufacturing. I'm really very optimistic. At the same time, we have to think about who will develop emerging technologies that will be needed 5 years from now. We need to look at the systems, identify the holes, and figure out where the government can make a major difference. We need to make choices, because resources are limited. We can throw 5 percent at each hole and accomplish nothing or look for major opportunities. Maybe half the projects will fail, but if the other half hit, then the money will have been extraordinarily well spent.

DISCUSSION OF RECOMMENDED ACTIONS

Overview of Panel Objectives

Cynthia Arnold-McKenna
AAAS Fellow
Office of Science and Technology Policy

When I came to Washington about 2 years ago, I had to resort to "covert" activity to get into the Office of Science and Technology Policy (OSTP). Under the strict interpretation of the Federal Advisory Committee Act, no industrial scientist could work in OSTP, even though industrial advice was very much needed. So Dr. Allan Bromley, then director of OSTP, and Ralph Gomory of the Sloan Foundation decided to set up a fellowship managed by the American Association for the Advancement of Science, so industrial people could work in OSTP on temporary assignments.

We have come a long way, because here we have a forum with an open dialogue involving industry, government, and universities, where issues of interest to industry are right here on the table.

So where do we go from here? We have listened to industry representatives talk about how they put their road maps together. These are interesting and complex processes and represent a great accomplishment in and of themselves. We also heard government participants talk about the programs at some of the major Federal agencies. Now we must start trying to mesh our interests together to establish a national policy. Mary Good indicated the role of the National Science and Technology Council in doing that. But today we will hear from panelists offering their perspectives on how industry, government, and universities can work better together.

I appreciate the nature of this challenge, due not only to my background at OSTP, but also to the perspective gained in my current position at General Electric Co. (GE). I recently joined GE in a "business interface" capacity. GE established this position to ensure that GE's research and development (R&D) activities are coordinated and timely and that the results get back into the businesses -- the plastics business, in my case. I have a counterpart in every other major GE business, including lighting, appliances, and power generation systems. The business interface folks talk to each other and share practices, coordinating across business lines.

So our activities at GE are a sort of microcosm of what is happening at this conference. It's hard to find common ground. When I talk to my business interface counterpart at NBC (a division of GE), he thinks a high-technology operation is getting a contract with Jay Leno. So we're coming at this from different perspectives.

But there is a lot of common ground, and our objective here is to find it and leverage it. We want recommendations on how all these organizations can work together more effectively, and what steps should be taken to develop and execute a national agenda for advanced manufacturing. Some of the challenges were identified at the earlier panel discussion: determining the cross-industry needs, establishing national priorities for advanced manufacturing technology, and matching government programs to industry needs. In this session, we need to identify the R&D gaps and recommend strategies to address them.

Competitiveness Viewpoint

Erich Bloch
Distinguished Fellow
Council on Competitiveness

When I came into the room, one of my friends asked, "How is competitiveness?" And my answer was very simple: "Not good, otherwise I would be out of a job." You hear too much these days about how we have regained our previous status in technology and how our problems are solved. I think this is far from the truth. I hope we're not falling back into old habits but instead are continuing on the path to change.

I hope I can leave you with three thoughts, which I will summarize right now. The first one is, our economic and policy environment -- and with it research and development (R&D), manufacturing, and marketing -- is changing in a very fundamental way. These are major changes, really paradigm shifts.

The second thought is that there is no silver bullet, no single action that will make everything all right. We need to experiment. We're not starting with a clean sheet of paper; history cannot be denied, but much has been learned in the past few years, and let's not ignore that.

My third thought is that putting strategies in place means more than just starting programs. A four-pronged effort is needed in which we define the problem, design a strategy for solutions, put a program in place for carrying out the strategy, and then measure the results. We're pretty good, as a country, at starting programs and writing reports on strategies and things like that. I suggest that we're very deficient in defining the problem and measuring results.

The first issue is our economic and policy environment, past and future. Containment has been a basic principle around which we organized not only our Federal activities, but also many of our private sector and academic activities. That is changing. Today our national policies are based on economic competition and global markets.

Research priorities also are changing, from defense technologies to civilian technologies. And our timetable is changing from a longer-term focus to shorter-term goals and objectives. Instead of science and basic research, we're now focusing on science and technology, particularly in the current Administration. Today you hear about strategic R&D, to the discomfort of some people. But I applaud that particular change.

Our innovation model is changing. In both industry and government, things used to move in a sequential way, from basic research to applied, from design to manufacturing to marketing. Now these activities are all overlapping, they are occurring concurrently, and they are influencing each other in a significant way. Also, our R&D program used to be single-agency driven and project oriented. Today, we have at least the beginnings of an interagency-driven process and a programmatic orientation.

Meanwhile, our government laboratories are changing in a dramatic way, from an agency or mission focus to a national goals focus. This is a difficult transition but one with potentially great benefits. There is also a change in the practice of R&D, from individual researchers to teams, centers, and consortia. They all have a role to play in the spectrum of activities.

My second major thought is, there is no silver bullet. There are many avenues, approaches, strategies, and programs. Of course, they all should have some common elements. They should be cooperative efforts, and the participants should share in expenses and results. I don't think current activities are measuring up to the needs. It is difficult for industry to go it alone. Government programs speak to national needs and objectives, either directly or as parts of a bigger program. We've seen many examples at this conference. But to be successful, government, the private sector, and academia will have to collaborate more effectively than they do now.

The grandfather of all cooperative efforts is in semiconductors, first with the Semiconductor Research Corporation (SRC) and now with SEMATECH. It's interesting to note the reasons behind both efforts. The SRC was established as an answer to Japanese competition. SEMATECH was established because of the non-availability of important components for the national defense. So one activity was tied to a threat to industry and the other to a threat to a national imperative. We need a credible driving force. For 15 years, the semiconductor industry has been at the forefront of joined R&D, strategizing, road mapping, and marrying technology and trade. This is the one industry that has been able to carry out technology programs and link them to trade policies and objectives.

There are newer examples: the "clean car" initiative, the American Textile Partnership, and today's announcement in *The New York Times* of the government's pursuit of a flat-panel display industry. Mary Good was asked if industrial policy is still a bad word. My answer is yes, it's still a bad word, but at least you don't get fired for using it.

My third point concerns the need for a four-pronged effort. First we need to define the problem. Too often, there is only a hazy understanding of what the effort is all about. Defining the problem is especially important in multiparty undertakings. However, you don't need to adhere rigidly to problem statements, once they are developed; new insights and new results may suggest that an effort should be modified or discontinued.

The second step is to design a strategy for solutions. I want to emphasize the requirement for identifying and benchmarking the competition in this step, both before and after the program. I don't think we're doing enough of that, in either industry or government.

The third step concerns putting a program in place. Part of any program is a set of qualitative and quantitative measurements. One needs to be clear on how to judge success, not only by schedules, but also by measurable output. I think this is a problem with many programs. SEMATECH, of which I think very highly, didn't define its goals clearly and early. Therefore, views are divided as to whether it is a success or a failure.

Last, but not least, a "sunset" provision has to be part of any program. We have a cultural problem: we can start programs but never end them. Just this morning, I rode down New Hampshire Avenue and saw a brownstone mansion with a neatly polished brass plaque that read "Association of Colonial Dames." That's an example of an organization that cannot turn itself off.

All of this requires a rethinking of problems and issues we thought we understood at one time. It certainly requires a rethinking of the relationship between industry and government and between academia and industry, on an international scale. We need to experiment to find out what works, and we need to have patience and consistency. The world was not made in 7 days, but we're capable of destroying it in less time than that. At a minimum, we need to be realistic about what we can achieve, and we need to measure the results.

National Labs Perspective

Jeffrey Bostock
Vice President
Martin Marietta Energy Systems

It's encouraging to see so many people dedicated to improving economic competitiveness and national security through manufacturing. There truly is a revolution underway in manufacturing. I am sure you are all as frustrated as I am at the report that the United States is evolving into a service economy. We all know that is not true. According to the National Association of Manufacturing, almost three-quarters of all U.S. research and development (R&D) is carried out in manufacturing firms, and U.S manufacturing exports doubled between 1986 and 1991. A dollar increase in manufacturing output generates $2.30 in output in the rest of the economy, compared to $1.60 for the service economy.

I will describe the Department of Energy (DOE) draft criteria for selecting major R&D programs, some examples of existing programs, and finally a few specific recommendations for improving our ability to identify and deploy technology.

This should not be thought of as a process of picking winners and losers. As Katherine Gillman of the Office of Science and Technology Policy said recently, why would anyone want to pick losers? We are all recipients of these major R&D programs, either directly or indirectly, assuming the programs are selected correctly, because the resulting technologies will fuel the economic engine. Of course, that assumes the fuel will get to the engine, and that's a question of deployment.

It's important to emphasize deployment. Often the R&D is excellent but the results languish, for a whole litany of reasons. We have to learn how to disseminate product and process technology across industries. Bridging the gap between ideas and products is vital if we are to be successful.

The DOE's draft criteria for choosing major partnerships are consistent with the comments Mary Good just made. First, there must be high-level, dedicated industry and laboratory leadership with a clear vision. As followers in the re-engineering and total quality movement know, senior leadership involvement increases the probability of success; multiple leaders with a common vision almost guarantee it!

The second criterion is a focus on long-term, high-risk programs. This means programs that require government involvement, because otherwise the investment will not be made, at least not in a timely fashion. Either the project risk is too high or the marginal rate of return too low for industry to handle alone. Government resources can be used to mitigate the risk; after all, taxpayers already have paid for this.

Third, we look at the potential for major economic impact. The focus on dual-benefit applications that improve both economic and national security is essential in today's world, and certainly at DOE, where we have limited R&D dollars. Many agencies have defined critical materials -- product technologies that are seriously affected by imports. It is clear that we can add high-quality jobs in critical industry segments if we focus resources around a strong leadership commitment from industry.

Finally, technology road maps are essential. Road maps for electronics, textiles, automobiles, and the food industry have been discussed at length at this conference. We must find ways to expedite the road-mapping process so we can use our limited resources effectively. The Semiconductor Industry Association (SIA) road map is the model. Road mapping must be industry led, with broad participation from the affected sector. A good road map is an articulation of the leadership's vision and how to get there.

There are a number of examples of existing national programs that are good lessons. The SIA effort, the Partnership for a New Generation of Vehicles (PNGV), the flat-panel display initiative, the American Textile Partnership, and the National Machine Tool Partnerships are all good examples. Many of the lessons learned with semiconductors are being incorporated into the PNGV.

Now for a few recommendations, or thoughts. First, we must learn to work together more as a team. Collaboration is a very effective approach to achieving quality results fast with limited dollars. We must be able to form strategic alliances quickly. We should exchange personnel as much as possible. Many organizations should consider sending fewer people to Washington, DC and more to trade associations and independent organizations working to support and respond to industry needs. On the other hand, industry should send people to the national labs and the manufacturing user centers.

Second, we need a well-defined commercialization plan for technology. Rapid deployment of ideas is essential; we must expedite the movement of technology into products and processes and then use the successes as benchmarks. The example of the four-minute mile still holds true today: It's easier to perform very difficult tasks when you have a successful model to use as a benchmark.

Third, success should be measured by more than process metrics, by numbers of cooperative agreements, for example, or the amount of repeat business with a particular company. We also should measure global market growth and specific benefits to the private sector. The

Manufacturing Extension Partnership and the Oak Ridge Center for Manufacturing Technology are examples of programs where private-sector benefits clearly are measured.

Finally, let's be sure to balance our efforts and our policies among three components: R&D, deployment of technology to the approximately 360,000 small and medium-sized manufacturers, and education.

Electronics Industry Perspective

Herm Reininga
Vice President, Operations
Collins Avionics and Communications Division
Rockwell International

Many of you can remember when the Department of Defense (DOD) considered $100 million a lot to spend on manufacturing. We were pushed off to the side. To have DOD spend $1 billion on manufacturing is really exciting. We're seeing many changes in our environment, throughout the world and especially in the DOD electronics industry.

With the uncertainties we face in electronics, it's difficult to focus on the future. We see that our volumes are decreasing and the government electronics market is downsizing. The total market for electronics is increasing, from $650 billion in 1992 to a projected $1.2 trillion in 2002, but the defense portion is dropping from 20 percent to 7 percent. Meanwhile, technology continues to advance at an ever-increasing rate.

We have made some progress through the programs that have been discussed at this conference. The focused industry/DOD workshops have been successful, the surveys have been successful, and we have numerous centers of excellence now. The joint associations and services projects are showing some real success. There is an old saying out West that you should "scout before you send out the wagons." I think we've scouted a lot, and it's about time for us to get on with some real streamlining activities.

Both the commercial electronics industry and DOD require state-of-the-art electronics. Design activities for manufacturability have to start up front. Manufacturability, producibility, and supportability are determined during basic design activities. We need to understand the rules. Engineering has to start producing designs for manufacturing, and manufacturing has to start telling engineering about the characterizations of their processes so they can design accordingly. We need, for example, improved characterization of materials used in components, and we need to give engineering the results without stifling their creativity. We don't do this well today. We keep telling engineering, "Design something I can use, but I'm not going tell you what you've got to work with."

The forces affecting the electronic industry are about the same as those at work throughout the manufacturing sector. We look at infrastructure, affordability, automation, and technology. With respect to infrastructure, there is a lot of discussion about small, focused, self-sustaining business teams, sometimes referred to as high-commitment teams, high-performance work systems, or self-directed teams. If we continue to rely on our old paradigms and our old way of doing business, then it will be like trying to put lipstick on a pig. You may get it on, but you may not want to kiss it. It is important to use all employees to their fullest.

Companies are trying to form coalitions. On one hand, we are competitors fighting to get some business. On the other, we're collaborating on one program and trying to move from a competitive to a collaborative environment. Also, world-class companies need world-class workers. I think we have world-class universities in the United States, but our K-12 and technical schools have *not* done a world-class job of keeping their students up to date. The government needs to help in this area by establishing curricula for our technical schools and even high-school students.

I recently visited England, and in reviewing the Magna Charta I couldn't help but think that the feudal system of that time resembles how I treat my suppliers today. I don't let them live, but I sure don't want them to die. So I really have to examine that issue and start getting our suppliers integrated into our process. They must be part of our design team, part of our process characterization. We need to work toward becoming a virtual enterprise.

With respect to affordability, this is the only thing that will save your bacon today. Technology is a way to develop and exploit affordability. The lean electronics approach is a way to make a difference. The agile activities look a little further out, and they give us a basis for expanding our current processes. The dual-use studies of the last couple of years have been pathfinder projects; each one give us a direction to follow. This is not an exact science, but it gives us a direction.

Overhead costs are really driving our activities. We're going into a period where we'll design a lot and produce a little, so we'll need help from our accountants. We haven't talked about them much, but we need their help to understand our costs and identify wastes so they can be eliminated. The new technology that enables us to communicate with one another will allow us to have a much flatter infrastructure than we've had in the past. Streamlining will be essential.

Automation depends on process technology we're just starting to understand. Now we can get equipment that tells us what to do, measures the operation of components, and determines whether they worked. This gives us opportunities to improve our process continuously as we go.

But we haven't given the engineers everything they need for designing. We've given them lists of parts, but we also need to give them the characteristics of those parts. We have the ability to do that but have not done it. We also need open systems -- seamless interoperability of our computer-aided design and engineering and our information systems. We need continuous, pioneering improvement.

The electronics industry changes engineering technology every 2 or 3 years, so we really have to pay attention to our emerging technologies and characterize the critical requirements. That doesn't mean we have to develop process technology down to the lowest level for an emerging product, but we at least need to characterize the critical characteristics. Concurrence is needed.

Simulation will be the key. I've been a proponent of simulation for a number of years, because it is a way we can understand our process and develop strategies to focus on various areas of the life cycle of our product. We have said that getting government, industry, and academia to work together is probably like herding cats -- I don't know if you can do it, but we need to figure out how, and do it.

I want to touch briefly on several other areas. The industry task force of the Defense Manufacturing Council is working on a number of projects. The council supports all DOD agencies and services, industry associations, and industry. It would be wonderful to have an interagency review of key technology projects to eliminate the duplication. I think the program looks better on paper than it is in reality. But there are a lot of areas where industry and DOD could work well together as a team.

I think the Industrial Modernization Incentive Program (IMIP) was excellent in some respects. It also had a lot of faults and I had no qualms about it being canceled. But that type of incentive still is required by industry. The Defense Manufacturing Council could be the vehicle for speeding development of IMIP technology and matching the Federal funding available for 1995. I also think working groups need to be established in industry, academia, and government to develop the technology list. The tools are available, but coordination is required in the process area to develop them into a national activity.

Finally, we need to expand automation and eliminate waste in the electronics industry. The DOD has acted as a catalyst for new technologies to ensure affordability and producibility. Academia also must change and help apply technology to reduce infrastructure costs. The Advanced Technology Program, the Technology Reinvestment Project, and Mantech all provide incentives for experts in different areas to really work together. If a forum can be developed for a common, coordinated, and waste-free approach in the manufacturing technology area, then revolutionary ideas will be a reality rather than merely science fiction.

Small Business Viewpoint

Daniel Koenig
Vice President for Manufacturing
Steinway and Sons

I have the unenviable task of summarizing the viewpoint of 95 percent of U.S. manufacturing businesses in 15 minutes -- and to do it in some coherent fashion, and to come up with recommendations on how to help that sector partake in industry-government partnerships developing new technology. I will give it a try.

I spent a good deal of my career with General Electric Co. (GE), a very large company, before moving over to Steinway and Sons. Also, for the past 4 years I have served on the Board of Directors for the Industrial Technology Assistance Corporation (ITAC), a not-for-profit group of manufacturing businesses in the New York City area. Steinway is the largest employer in that group, with 250 workers. Most members of that group have 25 to 50 workers.

The typical small manufacturer is an entrepreneur who is interested in making an honest living, providing jobs for other people in the community, and trying to raise a family and be a good citizen. They don't get involved much in the theoretical aspects of manufacturing. In fact, they don't really get involved in anything much beyond what's necessary to stay in business.

There are different types of small businesses. The most familiar type is the spinoff from a large corporation, where some very bright technical people decided they could build a better ashtray and went out and did it, because their employer had no interest in the project. These people bring very high levels of technical competence to the marketplace. But that's probably an aberration rather than the norm for small businesses.

Small firms are mostly oblivious to government technology development. Small businesses also are very independent; they are not joiners. We have 17,000 small businesses in the City of New York, and our total membership in ITAC is something like 368. So we have not even begun to solve the problem of getting small business to be world class.

Is it necessary for small businesses to be world class, or is it sufficient for them to just be productive enough to stay in business? From the macroeconomic viewpoint, we would say, yes, they have to be world class if we in the United States are going to be leaders in business and industry in the future, because small businesses make up the vast majority of industry in our country.

But most small companies are "status quo" users of technology. They take little initiative, mainly because they can't afford it. Their resources are scarce and they have cash flow problems. They worry about meeting payroll and paying the bills, because they don't have the credit reputation, staying power, or influence of, say, GE. Most small businesses, therefore, look strictly at how they can create profits in the short term, giving little thought to long-term capabilities or needs. They typically are not tapped into information networks, unless it is related to their business and they see it as a means of creating wealth in the short term.

While there are some very bright, capable people in small business, we have to recognize that this veneer is very thin. It's usually one or two persons deep, and they are engaged 150 percent in running their businesses and providing their products. They don't have much time to think about the nuances of improving technology in their company. So they are pragmatists. They believe in the good old-fashioned American philosophy of pragmatism.

Small business can't afford to pioneer technologies, unless that is their business. They are too busy trying to make a profit. There is no depth of talent available to permit the small business owner to say, "I'll assign Joe to do this, and I'll pay him for the next year and a half even though he's not making money for me."

Small businesses usually are more successful with tried-and-true technology. To give you an example, lots of small machine shops use computer numerically controlled machine tools, and they use them very successfully. But how many really think about computer-integrated manufacturing? Most don't even know what it means. And unless they see it as a way of making a buck tomorrow, they are not interested -- they can't be interested, they can't afford it. This may be myopic, but unfortunately it is how they think.

If we're going to create a dialogue between small businesses and the government on the topic of technology needs, the government must find a way to become more customer oriented. We see that already in the Manufacturing Extension Partnership (MEP). We also need to show that there is a direct cause-and-effect relationship between implementation of new technology and profitability -- that the status quo isn't good enough. There aren't too many successful buggy whip makers left in this world. But that was a big industry back in 1875, and those people probably didn't think much about the future, either.

How do we get small businesses away from the daily grind, to do a little a forward thinking? Small businesses are not very good at creating strategic plans and business plans, understanding processes and value, and understanding what technologies are complementary to theirs and what the marketplace is doing. That's why so many small businesses fail. We need to find ways to get small businesses to do the types of things we take for granted in large corporations. Otherwise, few small businesses will grow into big businesses, and a lot of good ideas may never gel.

How do we get small business into the dialogue involving government, academia, and big businesses concerning where our technology thrusts should be. I think the only practical way to do that is through the MEP and its affiliates -- the ITACs of the world. We have to find ways to provide small companies with the capabilities of larger companies. We have to improve their planning, implementation skills, and identification-of-opportunity skills.

Someone said earlier that, perhaps, in the next century, 1 percent of the population will provide all U.S. manufacturing products, and the rest of us will be wealthy enough to play golf and go fishing every day. Well, if that's true then a lot of small businesses will have to become very, very successful, because it won't happen with big corporations, which do not have the most dynamic and entrepreneurial spirit.

We should use the model of the American farmer and the agricultural extension agent. We need government initiatives, and I think MEP is one, to fund nonprofit organizations to help businesses in New York, Chicago, and anywhere else. These nonprofits should serve as the technical equivalents of the agricultural extension agent, to help small businesses develop these skills and emulate what big businesses can do.

Perhaps the technologies most needed by small business are the software and programming capabilities to make it easy to do strategic and business planning and to implement production control and simulation technologies. Small businesses need to be able to do these things without great consternation, and without losing money while preoccupied in developing new technology.

We also need to create awareness of the potential benefits of technology. We need to help small businesses see that there has to be government-industry partnership if the United States is to have a growing economy and a good standard of living -- and that they have to participate in this partnership.

Interagency Perspective

Joseph Bordogna
Assistant Director for Engineering
National Science Foundation

The program says we should "find ways of improving how industry and government jointly identify specific technologies that should receive future emphasis." To revise that statement a little, perhaps we ought to identify the technology that supports national programs that we jointly define in areas of need.

Someone in the audience suggested that a high-level entity in the government should coordinate agency activities and oversee a national interagency effort, with industry an intimate member of the team. Well, there is such an entity. Actually, there have been two Federal groups. The old one was the Federal Coordinating Council on Science, Engineering, and Technology (FCCSET), the interagency coalition from the previous Administration. The FCCSET identified programs that are continuing, one of which is in manufacturing. The new group is the National Science and Technology Council (NSTC), which is similar to FCCSET but more action oriented, more industry sector-specific oriented.

The basic precept of NSTC regarding industry-government interaction is that government should respond to industry needs. Also, someone suggested that we invert our original approach so that government programs are designed to match industry needs and industry is a party to program conceptualization, all within an envelope of national need. That is how we do it, although this can be an arduously slow process. And all this is energized by government acting as a catalyst for investment of public funds in high-risk partnerships. Others have explained where the government funds go.

So government should do four things: respond to industry needs, make sure industry is involved up front with conceptualization, pursue projects in keeping with national needs (we can't do it ad hoc because of agency mission interests), and catalyze the process to make sure public investment is made in the high-risk end. I will discuss the interagency efforts and the issue of getting industry involved up front.

There is a Federal law, the Federal Advisory Committee Act, that says industry can't be involved up front. I was asked to chair the FCCSET Advanced Manufacturing Technology Working Group when I first came to the National Science Foundation (NSF) a couple of years ago, and, being naive then about government protocol but having worked in industry, I was chairing the first couple of meetings with 20 great people around the table. These are government people who are smart, well versed in what's going on, and know a lot about what industry needs. Two questions went through my mind that I was afraid to ask. One was, how many people around this table ever actually made anything? It turned out some had, so that made me comfortable. The other question was, why isn't industry represented at the table? I didn't know about the Federal law at that point. But I finally spoke up and the problem was explained to me.

So we began looking for ways to get industry people involved. Cynthia Arnold-McKenna is one of them. Then we went looking for someone else and found Stan Settles, who had a 30-year career in manufacturing. We hired him at NSF and detailed him over to the Office of Science and Technology Policy (OSTP) to work on the manufacturing initiative. Then we went out and talked to some industry people. We connected with Jack Simon of General Motors, who brought a variety of industry organizations together to work with us in developing the plan for advanced manufacturing technology. We had good industry interaction; we had a couple of meetings with 50 people and also workshops. But industry still was not involved at the front end.

What is happening now with industry involvement is really different, perhaps the ultimate experiment -- to create a joint government-industry committee to pursue implementation of a common project. The NSTC Partnership for a New Generation of Vehicles (PNGV) is an example of the new approach. Some may argue about whether improving cars is a national need, but there certainly is a need to experiment with PNGV-like committees. Industry input is obtained at the front end with that group, and project conceptualization is truly a joint effort. To me, this is a hard experiment that's fresh and mind boggling, a true partnership.

The PNGV team includes seven agencies -- those involved in the Technology Reinvestment Project (TRP) plus the Environmental Protection Agency. The TRP group has worked together closely for a long time, so there is a lot of trust already developed for the PNGV task. The three major car companies are involved, plus connections to supplier chains, so small business is in there too. Thus, there is a richness in the vehicle group, with seven agencies, major companies, and the supplier chain.

The PNGV started out as a "clean car" project, to make a car that is less polluting than are today's models. Supercar was another name for it, for those worried about energy efficiency. Still others liked the name AmeriCar, because they wanted to see American cars make a comeback. Eventually it turned into a Partnership for a New Generation of Vehicles, which is a much broader concept. The car will be safer, better, cleaner, and more energy efficient -- all those things.

There is also an NSTC electronics initiative. Now, there aren't three major companies in electronics as there are in the automobile industry. Thus, we see that each industry sector needs a different approach; for example, getting the electronics industry "team" involved at the front end is a bit more complicated than it is with the auto industry. With the electronics committee, a lot of companies come in and out of the meetings. It isn't clear yet exactly how to get that up-front input.

Another theme running through all these meetings, more so than with FCCSET, is simultaneous movement toward creating wealth while protecting the environment. The environmental technologies committee is an example. We want to get into environmental technologies because we need them in order to be cleaner in manufacturing, in cars, and so on. The overarching goal is a cleaner environment, but if you develop these technologies well then you also can create wealth by integrating them into the industrial enterprise. The government perhaps can act in synergy with the environmental technologies industry and help foster wealth creation, not only domestically, but also abroad, because the technologies can be exported.

The NSTC Committee on Environment and Natural Resources (CENR) held a forum focusing on environmental issues and needs. The CENR had reached a certain point in building a draft strategy where it was decided to invite selected groups of people -- big companies, small companies, technology experts, academics, and environmentalists -- to spend several days talking to each other. This is another way of getting industrial practitioners involved in conceptualizing government programs.

Finally, we have the manufacturing infrastructure committee, which has working groups active in five areas that define the elements of next-generation manufacturing systems: manufacturing systems, engineering tools for design and manufacturing, manufacturing processes and equipment, manufacturing education and training, and manufacturing technology deployment. To obtain industry input up front, the committee is getting the private sector involved with the five working groups as they develop White Papers to establish technology opportunities and link them with industrial need.

To summarize, the government mixes with industry in different ways. There is no one way to do this. The selection of the approach is driven partly by the nature of the industry sector involved. We've never done this before, and there are both soft and hard experiments going on that we must examine carefully and learn from.

In closing, I want to discuss the idea of a virtual agency. The TRP is a great example of a virtual agency. That program was invented by five agencies because the Congress mandated some action in this area. There were nine different mandated programs, which eventually were folded into three: manufacturing technology development, deployment, and manufacturing engineering education. The individuals developing the TRP got together at least one full day a week, sometimes two, to put it together quickly.

The initial response was that each agency should take a piece of the $500 million and pursue projects in their respective areas of expertise. That might have happened, were it not for the leadership of the head of the Advanced Research Projects Agency (ARPA), who recommended an integrated program. His idea was, here is our chance to really do some defense conversion, and to have the program defined by the marketplace through merit-reviewed competitive proposals.

That was an intense experience in which no Federal official actually worked for or was paid by the TRP. We all went back to our agencies to get our salaries. There was no permanent TRP staff; we used our regular agency staffs. The idea of a virtual entity is to bring groups together to attack a problem or an opportunity and, when it's done, you go back to where you came from.

Now, there were driving forces. The President wanted this project launched; this Administration thought it was important. That leadership motivated everyone to do the TRP work -- not the promise of a piece of the $500 million for your agency. And trust developed over time, because the experience was so intense.

It was extraordinary to have a virtual agency with a $500 million budget, the goodwill of ARPA (whose money it was, in essence), and an interagency group that reached a consensus about how it would be invested. But it worked out that way. The announcement was written, the solicitation written, the proposals received, and the proposals reviewed. There were 300 reviewers, all of whom carried out their task at the end of August, peak vacation time around here. My perspective was that, at every step along the way, everyone said a virtual agency couldn't function, but it happened, and now there is precedent for having a budget for a group of agencies in a virtual sense.

Office of Science and Technology Policy Viewpoint

Katherine Gillman
Special Assistant for Defense Conversion
Office of Science and Technology Policy

The Office of Science and Technology Policy (OSTP) coordinates technology and science policies both across the Federal Government and with industry, universities, and research institutions outside the government. We're working hard to put all these parts together into a whole that is greater than the sum of the parts. The President has given OSTP's National Science and Technology Council (NSTC) the charge to coordinate all research and development (R&D) and other science and technology activities throughout the Federal Government.

Unlike its predecessor (the Federal Coordinating Council for Science, Engineering and Technology), the NSTC has the President as chairman. Jack Gibbons, the President's science advisor, is the operational head. The NSTC has real authority; we give strategic guidance to the agencies on their science and technology investments and work with the Office of Management and Budget (OMB) to set budget priorities in R&D. Giving budget guidance makes our job practical and real. We don't get down to the line items in the budget; that's the work of OMB. But we do work with OMB to say to agencies, "These are priorities you should attend to as you plan your detailed budgets."

There are nine committees of the NSTC, and they will be advised formally by a group of distinguished citizens from industry, universities, and so on, the President's Council of Advisors on Science and Technology (PCAST). That council will be announced soon. That is a very high-level, formal advisory council to the President.

That is only the beginning of our interaction with industry and others outside the government. Every one of the nine NSTC committees interacts with industry on at least an informal basis. We don't yet have formal advisory groups for all of these committees, but we interact all the time; industry is very ready to give us advice on where our priorities ought to be.

I am most familiar with Committee on Civilian Industrial Technology. That's the committee most closely related to manufacturing, although some other committees have manufacturing activities. For example, the transportation committee has an aeronautics subcommittee concerned with aircraft manufacturing.

We approach manufacturing in two ways. One is through sector-specific projects. Certain manufacturing technologies are not broadly applicable but are very specific to a particular cluster of industries. For example, the technologies needed for wafer fabrication in semiconductors are different from those needed for welding on a ship. With the help of formal and informal input from industries, we have chosen or are developing three high-priority initiatives: the Partnership for a New Generation of Vehicles, the national electronics manufacturing initiative, and a new initiative in technologies for building and construction.

None of these activities is meant to go on forever; they have milestones, schedules, and deliverables, and they are intended to end after they accomplish their goals. Then I'm sure we'll have other priorities to pursue.

In the electronics manufacturing initiative, members of our interagency team have told the manufacturers of systems, telecommunications equipment, computers, workstations, and so on: "We are interested in working with you, if you're interested in working with us on the manufacturing process technologies and component technologies you will need to make products that will have access to the National Information Infrastructure." Here we are building an electronic superhighway. Do we want the vehicles that run on that highway to be built someplace else or in the United States? We believe there is a national interest in making them in the United States, and industry agrees.

We are trying to develop a set of priorities for manufacturing process technologies in electronics, and that means working with the equipment and material suppliers for electronics systems makers. We're working with the industry to identify the priorities for a government-industry partnership. These are the projects that single firms are unlikely to pursue alone, because the potential benefits, while substantial, would be spread widely rather than captured by the individual firm making the investment.

There are projects like this in the automobile industry, too, and certainly in building and construction, where there is hardly any R&D because single firms are unlikely to pursue it. This is a very dispersed industry. For a single project, a temporary team is formed combining various professions: architects, engineers, builders, suppliers, and so forth. When the project is over, the team splits up. It is very difficult to get R&D going on new technologies in such a fluid, disaggregated industry. This is exactly the type of situation where government leadership and partnership can make a difference.

The other way the NSTC addresses manufacturing is through projects focusing on more generic technologies. The subcommittee that Joe Bordogna chairs is looking at developing standards and interfaces for electronic communication within and among manufacturing companies. In addition, we want to develop "intelligent" controllers, sensors, and actuators. And we also are focusing on rapid prototyping (both virtual and real) and many aspects of agile manufacturing, as well as the important areas of manufacturing extension services and manufacturing engineering education and training. These technology areas have very broad applicability to many kinds of industries. Infrastructure-related technologies are also the types of things that lend themselves to government-industry partnerships.

There are all kinds of other projects going on as well. This government really is committed to listening to industry and making things happen. The Semiconductor Industry Association (SIA) road map is a model, and there are at least two new initiatives in this Administration that are direct results of listening to the SIA talk about their priorities. One is the new metrology center for microelectronics, recently established at the National Institute of Standards and Technology. Some $10 million has been requested for the center, and the budget is expected to grow to $25 million.

The second initiative to come out of the SIA interaction is the Department of Energy (DOE) modeling and simulation center for semiconductors. That's a $100 million program over 5 years, with half to come from the government and half from the industry. The Semiconductor Research Corporation is working on a Cooperative Research and Development Agreement with DOE, which has committed to its half of the $50 million government share over 5 years. That will be a very productive use of the exceptional capabilities of the national laboratories for modeling and simulation.

Another very intense interagency effort that has been responsive to industry needs is the Flat-Panel Display Consortium, which has been working under the sponsorship of the Advanced Research and Projects Agency. Under this initiative the government will offer R&D partnerships to companies committed to commercial production of flat-panel displays, thus assuring that the R&D finds practical application. If this initiative helps build a U.S. industry, then the Department of Defense will be assured of a reliable, affordable supply of flat-panel displays to meet its needs.

I think you'll find an openness in this Administration. One of the semiconductor industry associations met here in March, and Vice President Albert Gore Jr. came to tell them that this is a new era, that we're listening to industry, and we want to work together with industry. The *San Jose Mercury News*, which is almost the trade publication of the SIA, reported that this attitude really is new, saying the industry never used to be able to get in the door and now the government is welcoming it with open arms.

Yet it is also true that the government research agenda is not being dictated by industry. There are things the government should do that are very important to industry and to the future but may not be on industry's road map now. It is the responsibility of government to look further ahead, to look for paradigm changes, for breakthroughs, for revolutionary changes in technology that are not supported adequately by industry. These things may not be on an industry road map, which may focus on the nearer term.

Still, there are many rich possibilities for cooperation on the road maps that industries are developing. I don't think we have to worry about running out of opportunities for cooperation and for aligning industry needs with opportunities for the government.

National Science and Engineering Perspective

Tom Mahoney
Director, Manufacturing Sciences Board
National Research Council

I have a few concerns about what has been said at this conference. My first point is that government-industry collaboration is politically correct, and most of the programs that have been described are of this nature. But just because there is collaboration doesn't mean success is guaranteed. Erich Bloch emphasized that we need metrics, goals, and objectives -- a basis for judging whether something works or doesn't. I think it needs to be politically acceptable for as many of these programs as is relevant to fail, and we need to be prepared to try something different if they do fail. It's not clear to me that those metrics are in place, or that there is any sense of learning from experience as we go along. We're in a start-up mode, and this is the time to think about metrics.

Secondly, the point has been made about setting program priorities, which is where industry collaboration comes in. My concern relates to the need to get government assistance to as many companies as possible, and that implies a need to focus on generic kinds of technologies. So the traditional role of the National Institute of Standards and Technology (NIST) -- working with the community to develop standards, testing methods, and metrology -- needs to continue, because that role affects just about everyone.

Another generic area is process equipment. We heard that the food and textile industries use foreign process equipment. So, as we put money into research and development (R&D) and develop technologies that would be incorporated into process equipment, but there are no U.S. companies that make such equipment, what will we do with the technology? Will we invite foreign process equipment makers into the operation? Will we establish new process equipment companies?

To further emphasize that point, we heard that the National Center for Manufacturing Sciences (NCMS) was created in part out of concern for the U.S. machine tool industry, but the NCMS then drifted away from machine tools. And in fact, the U.S. machine tool industry probably has gotten weaker over the past decade. At some point, we need to face up to that problem, as we did with semiconductors, where SEMATECH was formed partly in response to the plight of the semiconductor process equipment industry.

My third point relates to skills and people. Several speakers have commented on K-12 education and discussed the need for (and some experiments in) changing engineering education. But for the most part, "people issues" have not been raised at this conference. There are many, many problems in education and training and in developing the requisite manufacturing skills, both at the shop-floor and the engineering levels. We still have a problem in that manufacturing is not a particularly attractive field to engineers. It doesn't attract the best and brightest.

Many of the needs are very basic. I know a man in Chicago who owns a small machine shop with about 50 employees. Within that 50-person work force there are eight ethnic groups and eight different languages; the largest group is 18 workers who speak Vietnamese. My friend and his partner were trying to implement some of the principles of lean production and empowered workers, but having eight different languages on the shop floor made that process very difficult. In the end, they used a State of Illinois program to help bring English-language training to the work force. My friend has made some progress, but he still has a long way to go. That's the level of the problems requiring attention in the typical manufacturing work force.

Fourth, we haven't heard much at this conference about lean manufacturing, the term for the Toyota production system used by the Massachusetts Institute of Technology (MIT) team in the book *The Machine that Changed the World.*[1] We have heard a lot about agility and agile manufacturing, which tends to be more of an information system-driven paradigm. As you know, lean production involves continuous improvement and an empowered work force -- the building of a learning organization that includes not only the single-customer enterprise, but also customer-supplier relationships. In some cases, these relationships are based on major corporations dumping major money into technology. I don't believe that technology is a panacea; you can't use technology to leapfrog ahead of what you might achieve through lean production principles. But if you have applied lean production principles, then technology will be much more effective.

The point is, I haven't resolved in my own mind whether the government should play a role in spreading the tenets of lean production over other kinds of technology deployment. My general sense is that the government probably can help in this area, because there are cost-free ways to implement statistical process control, mistake proofing, and other things the MIT team writes about. Small companies can learn these things fairly easily; no investment is required and the results are evident quickly.

This leads to my fifth point about building an infrastructure for industrial assistance and deployment. This can't be a passing fad. Once we start building industrial assistance centers, or manufacturing technology centers, we have to keep them going. These centers are unlikely

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[1] Womack, J.P. 1990. The Machine that Changed the World: Based on the MIT 5-million-dollar 5-year study on the future of the Automobile. New York: Rawson Associates. 323 p.

to become self-sufficient based on the revenue they can generate from customer companies. So there needs to be a commitment from both government and industry that the resources will stay in place, assuming the effectiveness of these programs is established and documented.

The Manufacturing Studies Board recently carried out a project for NIST that reviewed the Manufacturing Technology Centers (MTCs). The review committee talked to small and medium-sized manufacturers to get some sense of whether the MTCs and similar programs were providing the needed services. In general, the answer was yes. The committee did make some recommendations concerning the need to allow MTCs and other such programs some flexibility, so they could respond to the changing needs of the local industrial community. These programs are not amenable to a cookie-cutter approach, and we need to keep that in mind.

I also want to raise a question. To what extent is there a mismatch between the technology and R&D capabilities and interests in government and academic labs, and the real technology and R&D needs of industry? The reason I ask is, the government labs are very high technology, and academics like to do cutting-edge research. But industry often needs mundane types of technologies and improvements. The issue of legacy systems has been mentioned. There is a lot of technology out there, and there is no clear strategy for making the transition to the next best thing.

How do you capture a factory's mundane, basic data in a digital form so as to take advantage of the information systems that agile manufacturing requires? Who will do the research to help us understand basic shop-floor processes so that we know what types of technology to apply? If we don't understand the process, then we don't know, for example, where to install sensors to improve process control. I fear that too little of that type of basic research is going on.

My last point echoes earlier comments about small companies. There is a general euphoria about the government getting involved in manufacturing R&D, but we are relying on a "field of dreams" approach: That is, if government builds the program, then companies will come. This approach may not work for the hundreds of thousands of companies beneath the thin veneer of industry leaders that are applying lean production principles and advanced manufacturing technologies. The companies underneath don't know about the government R&D and technology deployment programs or what improvements are needed on the shop floor. Their interaction with government comes in the form of taxes, regulation, and poorly provided services. What needs to be done to pull those companies into the process? I don't have the answer.

Panel Discussion

Cynthia Arnold-McKenna: I think we all agree on our future direction, and we've heard a lot about how we're trying to get there. This panel is charged with making recommendations for improving the way industry, government, and universities jointly identify specific technologies that should receive future emphasis. Again, we're talking about specific technologies.

Tom Mahoney did a good job of laying out a lot of issues and concerns we have to deal with. He mentioned areas such as metrics and performance evaluation; how do we establish these criteria? And what should we do about process equipment industries, a large part of which seems to have moved overseas; the skills and training of our people; and the match or mismatch between the government labs and industry research and development (R&D) capabilities? And, if you want to get beyond technology, there are questions of export control, tax policy, and education and training. So there are a lot of issues floating out there as we think about how to move forward.

I'd like us to think about identifying cross-industry needs, deciding which technologies to focus on, establishing national priorities, and matching government programs to industry needs. I think we have a consensus that we need to identify the R&D gaps and recommend new strategies. I'd like to open up the floor for discussion of what's working, what we could do more of, what we could do better, what we could do differently, and what we should not do again.

YuBao Chen, University of Michigan, Dearborn: I was pleased to hear the last speaker address the problem of education. We have world-class universities in the United States but we do not yet have world-class manufacturing education programs in universities. I hope we make an effort to match educational programs to industry needs and government programs.

we're doing something in this area at the University of Michigan, Dearborn. For the last 2 years, we have been trying to create new programs. We have a lot of engineering programs in manufacturing. Just a few weeks ago, this proposal was passed unanimously by the faculty governing body. But the response from the university administration was, "The program is great, but we have zero budget for it."

I want to call upon industry and the government to take a more aggressive, positive position in improving manufacturing education, especially in higher education.

Kitty Gillman: I would like to make one observation about that, which is that the Technology Reinvestment Project (TRP) does have money for manufacturing/engineering education and training that has gone to some very creative projects. I agree that we need much more emphasis on that. There are some really creative projects, some involving teaching graduate students computer modeling and simulation. Another award went to Project Focus Hope in Detroit, which teaches people to be technicians and puts a lot of emphasis on recruiting minorities and women. So education is not neglected entirely in government programs. It's really very important.

Secretary of Labor Robert Reich and Secretary of Education Richard Riley are extremely interested in setting up school-to-work transition programs, which would include manufacturing education. The effort hasn't paid off yet, but they are very interested in doing that kind of thing.

Joe Bordogna: I am going to make a comment that will cause you great discomfort, I'm afraid. And that is, in developing this new program for which you have a passion, the strategy has to address what existing programs will be shut down or changed. So if manufacturing education is very important to the faculty, and it's going to make Dearborn great, and it's a service to the public -- not just government or industry -- then you are going to have to say, "This is what we have to spend our money on." And I think it would be great if we start to develop new programs for which we're going to ask the government for additional money. I think the government would respond very well. Kitty Gillman mentioned one way this can be done: Do something exciting and new that addresses national priorities.

Dan Koenig: I think you have to start earlier than the doctoral program in manufacturing. You have to start back in the K-12 system. We definitely need to do something about math and science education in the United States to make ourselves more viable.

Dave Alman, Oregon State University: I'm president and chief designer for a small original equipment manufacturer. What you sell is what you manufacture is what you design. I fail to find the letter "D" for design in the word "manufacture." People keep talking about "The Big M" but I haven't heard much emphasis on it; instead, I hear a lot about the shop floor. On the other hand, we have to move more of the decisions up front, into the design process. Yet we really don't understand the design process very well, and we don't know how to manage it very well. A lot of what we do in this country is borrowed from Europe and Japan. We don't do much research in this area.

I'd like someone to address that issue. Also, there is a sociological aspect to designing. We haven't heard much about that at this conference, either, and I don't see much research aimed in that direction.

Daniel Koenig: Because my job involves both manufacturing and engineering, I think we have to conclude that manufacturing *is* "The Big M" and includes the process of creating the design as well as well as creating the process for making the product. It's a team process of developing a product, which doesn't just come out of the air. It has to be designed, and that design has to be compatible with the manufacturing capabilities of a particular company. And there has to be interaction back and forth between design and manufacturing in order to "boot strap" that company to world-class prominence, so to speak. It has to be a concurrent process.

Erich Bloch: I have great problems with the assertion that we don't understand the design process. I don't think that's true. Maybe research on the design process hasn't been documented as much you would have liked, but it's been going on for 500 years now, and it will go on forever. That's not the point. But I hope we don't continue to divide up things as we did in the past -- here's research, here's development, here's design, here's manufacturing, and here are the walls in between. If we do that, then I'm afraid we won't win this race. I hope we can look at this whole process, from beginning to end, as a system. After all, some of us are supposed to be engineers and we should know something about systems.

Joe Bordogna: Let me tell you what we're doing, and you can either criticize it or help us do it. The National Science Foundation (NSF) is supposed to leverage change in engineering education. We've heard all of this and we bought into it. We have a new division called Design, Manufacturing, and Industrial Innovation. Let me explain that name.

We all agree there has to be concurrence. But as you have heard from everyone here, I think that concurrence has to begin at the point of discovery and continue through the entire system process. That's the "industrial innovation" part of the name. The "design" and "manufacturing" make people understand that they're all connected. Industrial innovation is probably the most important element, because that means the idea comes and you make an enterprise out of it.

Earlier, we explained the new programs that support those elements. The transformation to total quality organizations, management of technological innovation -- these are all part of making this whole thing work. The one thing we're *not* doing is saying that design is *more* important than manufacturing. It's the integration of the two that's critical. So, our whole effort to change education, all the grants -- we use the TRP to help with that -- is exactly what you're rightfully saying needs to be done.

Shirley Willett, Stylometrics, Inc.: I want to throw out some ideas, responses to what I've heard here. The first thing that impressed me was when Mary Good mentioned bringing the public into this effort. That means a great deal to me. Also, Dan Koenig talked about bringing small business into the process. Some answers may come from what Joe Bordogna mentioned about virtual organizations, and what Cynthia Arnold-McKenna mentioned about the National Information Infrastructure and the electronic superhighway.

Bringing the public into the process means a great deal to me. I'm in the apparel industry, working on making the consumer the designer. That means she'll be sitting at one end of the electronic superhighway, and we'll be designing clothes based on her input. That's bringing the public in. I would like to see more activities of this nature -- more industries bringing the consumer in, asking what products they want and how they want them made.

With respect to small business, I'm setting up a directory and an electronic engineering design complex to do the designing and marketing for a group of small apparel contractors. This will become a virtual organization in terms of its structure. I think this idea could be useful for small businesses in many ways.

One last point about the problems involved in dealing with many languages on the factory floor. An answer I've found, through one of my grants from NSF, is multimedia systems for the workers on the factory floor. Pictures can take the place of words and overcome language differences. This kind of thing can come through the electronic superhighway. We need more of this on the factory floor, where the workers themselves can be involved in the electronic superhighway.

Bob Reeg, National Society of Professional Engineers: I want to follow up on the comment about public input. I haven't seen many members of the Congress or their staff here, so I'll include them in the public. Earlier, a remark was made that members of Congress didn't know what the National Institute of Standards and Technology (NIST) was until it got a big budget increase. That's really discouraging, that the only way you get attention is when you get more money than someone else does. But it shows that NIST needs to improve its public relations campaign aimed at the Congress. Associations and industry groups can help, but I hope the agencies are doing that themselves.

Now, about road maps. I'm not very familiar with semiconductors and electronics, so I was interested in Kitty Gillman's remarks about things going on that are connected directly to the semiconductor industry's road map and flat panel displays. You cited specific things that government is doing in response to what industry has asked. I hope someone in the agency is telling people about this. I think demonstrating responsiveness to specific requests from industry would be a major improvement, as opposed to saying, "We have this great TRP program, here's how to sign up, and here's the 1-800 number."

It seems to me that industries need to come up with the road maps, and then government and universities need to find out how they can assist with that road map. We heard from the textiles, food, and other industries, but I wonder how many industries are *not* developing road maps on their own initiative, and whether the government has a role in facilitating these projects.

Kitty Gillman: I'd like to respond in a more general way. NIST and the Advanced Technology Program have not elicited road maps, per se, but they have had meetings with representatives from industry to ask, "What do you think? What technology areas should we focus on?" That's not exactly asking for a specific road map, but it is asking industry what your technology needs and priorities are. I think NIST may have done more than anyone else to go out and elicit that kind of response from industry.

Concerning getting word out to the public, if members of industry feel the government has been responsive and helpful to them, and if they like these technology partnerships, then it would be helpful to all of us for industry to let the Congress know that.

Erich Bloch: I have two points. I've always been in favor of the government pursuing a moderate form of industrial policy. But the government should *not* require industry sectors to have road maps. I hope that doesn't have to happen. If industry sectors are not smart enough, forthcoming enough, and interested enough in their own future, then nobody else can do it for them.

My second point is that public involvement and agencies displaying their wares are absolutely important. But the agencies cannot accomplish that by themselves. Individuals in agencies, companies, associations, and so forth have to be more forthcoming in relating their experiences with government programs back to the Congress or the general public. It has to be a two-way street, and I'm afraid that is not happening.

Herm Reininga: Just a couple of comments on industry's perspective. If a problem is easy for industry to solve, then we don't need anybody's help. Also, if a new technology will give a company a competitive advantage, then they won't want to share it with all our competitors. What I think industry needs is help with a number of problems that are too hard for us to solve, that we continually put in the "too hard" box.

Flat-panel displays are an example, because there really isn't a market for a lot of displays of one kind. The market is for small volumes of one-of-a-kind displays.

John Colburn, Center for Advanced Food Technology, Rutgers University: We operate an advanced manufacturing demonstration plant supported by the Defense Logistics Agency, the State of New Jersey, the Industrial Coalition, and the university. I wanted to address a comment Tom Mahoney made earlier with respect to production and processing equipment for the plant floor.

The equipment in our plant, which is approved by U.S. Department of Agriculture (USDA) and the Food and Drug Administration, comes from Canada, Germany, Japan, and the United States. The robot, chosen because it meets USDA requirements, is U.S. made. The sealing equipment is Japanese but will be replaced next month with U.S.-made equipment. Most of our filling equipment has come from New Jersey and small U.S. manufacturers.

So there is a lot of creativity in small U.S. companies able to meet needs in production and processing. The small to mid-sized process industry still has the creativity to make a contribution. But we need to address the integration of equipment into the rest of the process and production. Integration can take up to 6 months, and we haven't had the benefit in the United States of the consortia that exist elsewhere, Italy particularly. We need systems integration to move this new technology from the small to mid-sized process equipment producers into industry.

Tom Mahoney: I didn't mean to overstate the dire condition of the process equipment industry; I have not looked at the statistics lately. But I would guess that, across the board, the U.S. market share in process equipment for most production industries is not very large. Clearly, there are innovative companies, and probably the majority of them are small, in all those industries. There is a lot of opportunity.

Bill McDonough: I represent a small manufacturing company. Someone mentioned that 90 percent of everything manufactured in the United States is produced by small companies with 500 or fewer employees. Recently, I read some U.S. government-published documents about flexible manufacturing systems and flexible computer-integrated manufacturing systems (CIMS) in Japan and Europe. Each document is about a half-inch thick. I found it heartening that there are 117 manufacturing extension centers in Japan that have been in place for a long time. Again, 90 percent of everything manufactured in Japan is produced by small companies, which they define as having fewer than 100 employees. At least half of these companies have flexible CIMS.

To me, that means there is some kind of model out there, and the U.S. Government and all the people sitting here naturally would know something about it. Earlier we heard Dan Koenig and Tom Mahoney speak on behalf of small U.S. businesses. I agree with their comments, but neither one mentioned that there is hope, because another country has done something in this area. Of course, Japan has additional programs, such as tax incentives, to help small manufacturers. The author commented that the United States probably could achieve this in 5 to 10 years.

My point is, I don't want to feel that, in the past, the Department of Energy and Department of Defense have preferred to work with the big companies, because it's nice to go with a big winner. This time, it looks like small manufacturing companies will receive a good share of what we're all trying to do. I'm hopeful, but no one mentioned that there is a model out there.

Daniel Koenig: I sympathize with your position 100 percent, having been there myself. Yes, there is hope. There is a lot of activity under way, and there are ways of getting help. I mentioned that in New York City, we have the Industrial Technology Assistance Corporation (ITAC), which is private and not for profit but receives most of its funding from the State of New York and, we hope, the Federal Government. The ITAC helps small manufacturing concerns upgrade their capabilities and teaches and shows them -- just as in the Japanese model -- how to manufacture, how to design, how to go to market more effectively.

I've also found that "he who helps himself is going to be the most prosperous man on the street." There are many ways to form interesting alliances with local universities, and I think small businesses particularly will get a warm welcome from manufacturing engineering departments, mechanical engineering departments, and industrial engineering departments. Those types of folks, who study this area professionally, are very willing and able to help small companies become more productive -- and for reasonable fees, which are used mainly to pay graduate assistants.

In the United States, we shy away from "big brother" telling you what to do. We do not have a beehive society, we have a very diverse society, and we all want to do our own thing. We take pride in personal initiative and independence. You can go the independent road and get help; it doesn't have to be from the government.

Kitty Gillman: I'd like to point out that NIST has seven manufacturing technology centers that have been in business for several years, and the TRP has provided cost-shared funds for another 28 centers. Not all of them are very experienced yet, but we have 35 centers now of a network we hope will grow to 100 within the next few years. So there are government technology extension centers that can help.

Maryanne Roe, Texas State Technical College, Waco: I would like to thank you for this enlightening conference. We had a lot of discussion about universities and the K-12 system, and I must put in a plug for the role of advanced technical education, not only in manufacturing but also in the maintenance and repair of equipment. That's a very cost-intensive operation when it's done right, but there will be a great need to immerse people in these applications as we enter the next century. So I hope as the National Science and Technology Council looks at the types of technologies in various industry sectors, it also looks at the preparation of people who use and apply the technology that will support the whole effort.

Those technicians support R&D; they are a significant part of smaller manufacturing companies. Many small companies hire very good technicians; we see that a well-prepared and well-educated technician really is the most viable part of technology transfer. Their knowledge base may not be as intensive as the technology is, but they at least know where to access resources to improve their understanding. So the prepared technician will be a significant player for the future.

The aerospace industry, for example, will need technicians for repair and maintenance of air conditioning systems, information processing systems, the whole gamut of technology. And the job will get even more sophisticated as these technologies become more integrated. Curriculum development, preparation of teachers -- this whole area really needs to be examined.

Erich Bloch: That was a very important comment. In the spectrum of education, from kindergarten through Ph.D. programs, we always skip over a couple of areas. First, we always skip over vocational training. You were referring to that in a specific sense, but I want to focus on the broad sense. We haven't done the necessary job in that area, from either a government or an industry viewpoint, to make sure that the human resources required in these areas are being educated and trained in the right way.

The other thing we always skip over is continuing education. Things always stop at the end of high school, or undergraduate programs, or the Ph.D programs. You think you know everything by that time, and 30 years later, you still know that much and think it's good enough. Well, it's not good enough, and it certainly won't be good enough in the future.

Maryanne Roe: One more comment. There is not a good understanding of what technology is, and what it's used for, outside of those who deal with it directly. Therefore, there is no solid grounding for children or adults moving into technical education. We're moving into a time when we all will need knowledge and understanding of the use and application of some form of technology. It's not a matter of either/or, it's a matter of when you gain the understanding.

I think for many people, there is a perception that not going to a university means it's not OK, and that's not a good image for that work force. So there is a need to help the general public understand the value of technology and the different types of opportunities in technology, as well as the preparation for it. We need to enhance the image of technology and the technician as viable parts of the whole enterprise.

Audience Comment: Tomorrow is "bring your daughter to work" day. I hope the industry people here are letting their employees bring their children in to see what the technologies are. In my facility, 195 young women are coming in to look at manufacturing technology.

Cynthia Arnold-McKenna: I think it's "bring your children to work" day; we don't want to be sexist here.

Joe Bordogna: We do have an Advanced Technology Education Program at NSF. This is a serious issue, and I agree with everything that you and Erich Bloch were saying. I'm convinced we don't know how to conduct these programs yet; we have a lot to learn. You'll see more technical training in the next round of TRP awards. There is also a task force being set up at NSF on continuing education.

Cynthia Arnold-McKenna: A number of technical organizations also are very much involved in public education and outreach. I work very closely with the American Chemical Society, and I'm sure there are many others that you could get involved with and really make a difference.

Russell Teasley, University of South Carolina: I liked Bob Hermann's talk. He spoke about the importance of globalization in manufacturing, world-class production, the global economy, global markets, and the need to address those markets. In this day and age, technology development is increasingly a product of international collaboration through joint ventures and strategic alliances.

This brings up a thorny issue for our government labs, agencies, and policies. It is a bit of a dilemma that our technologies are developed through our public laboratories, financed by American taxpayer dollars, yet we don't control what happens to these technologies after they leave our laboratories. Over the past several years, I have been to numerous conferences on technology transfer, particularly as it relates to government laboratories, and I have yet to get a very clear understanding of how our government defines a domestic versus a foreign company and deals with the issue of developing taxpayer-funded technologies, when these technologies are sought by companies we consider to be foreign owned?

It's very important that we address this issue when we set policy. I know there is no easy solution. But foreign companies represent specific technological expertise and very large and worldwide marketplaces. They also represent sizeable amounts of potential capital investment, which can be funneled into U.S. technology development. The Intelligent Manufacturing Systems project is an example of a Japanese initiative addressing technological development on a global perspective. I think we could learn a lot from that perspective.

Kitty Gillman: There are probably eight different laws addressing that very question of foreign participation in taxpayer-supported technology development, and we hope to work with the Congress on this issue. The guiding principle is to make sure programs benefit the U.S. economy and citizens. As you point out, it's a complex series of events that determines whether something benefits the U.S. economy.

For example, in the Partnership for a New Generation of Vehicles (PNGV), some of the best technologies are foreign; if you don't allow foreign companies into the chain of suppliers for the manufacturing technology, the fuel cells, and so forth, then you're just depriving yourself of the world's best technology. Similarly, both a multinational company and a U.S.-based company have to be free to use the technologies resulting from these partnerships in their operations in other countries as well as their own.

We're looking into this issue and trying to develop a sophisticated definition of a benefit to the U.S. economy and get that definition into the laws and regulations for government/industry technology partnerships.

Panel Comment: There is a full set of existing legislation that can be interpreted in various ways with respect to this issue, as Kitty Gillman pointed out. This was a very contentious issue among the lawyers in the days just prior to signing the papers for the PNGV. As a matter of fact, it was the most contentious issue. The final conclusion was an acceptable one, at least for the time being. It was resolved, I think, in favor of the U.S. auto industry and its world marketing capabilities.

Certainly the premise was that, if it benefits the U.S. economy, then it's good. But we have not heard the last of this issue. It always will be a contentious one, but I think a definition of benefit is evolving.

Erich Bloch: We'll never solve this problem in a generic sense. I think we'll make some accommodations and reconciliations, almost on a case-by-case basis. Also, if each country could point to tangible assets and say, "We're giving that up, and we're getting that in return," then this wouldn't be as much of an issue.

I'll give you an example. I chaired the one-day workshop where this issue was discussed with regard to access to the national labs. I was listening to all the pros and cons coming from industry. By the way, industry couldn't decide what they wanted, either. If you eliminate one country -- I won't mention which one -- then the issue wouldn't arise. If we could pick a tangible tradeoff on a more visible level with every country, then we could spare ourselves a lot of discussions.

David Buchanan, College of Textiles, North Carolina State University: My question is similar to the last one, but I want to address the issue of processing machinery being made overseas, at least in some industries. Fifty years ago, the American textile machinery industry dominated the world. It started to lose ground about 1950 and lost it steadily. The conventional wisdom is that the industry didn't want to do the R&D necessary to keep up with its competitors. Today, about 90 percent of these companies are dead; not even an act of Congress could revive them. So for all intents and purposes, there is no American textile machinery industry, except for the remaining 10 percent.

My second point is that this is a global business. Textile machinery is exhibited on a four-year cycle in three places -- the United States, Europe, and Japan. All the same people are there every time, including the American machinery manufacturers who survived. Everyone in the business sells globally. If indeed every technological development in that processing machinery is available globally, then does it really matter whether there is a domestic version of that industry?

Panel Comment: I could talk about this all day. This issue also relates to semiconductors. The argument for SEMATECH was that Japanese equipment providers were not letting the latest, greatest technology go to American semiconductor producers and, therefore, the whole U.S. industry was at risk if we did not have indigenous process equipment capabilities.

Whether that's true or not is open to debate. In other industries, such as machine tools, we don't have much market share anymore. For the most part, that's probably not a problem. As you say, in global industries, the same process equipment is available worldwide and will continue to be. Can you develop a competitive advantage if you have early access to new technology? Maybe. How early? I don't know. I don't have the answers, but I certainly recognize that these issues are part of the debate.

Panel Comment: I'd like to add one thing. I think it makes a difference what industry you're talking about. In the semiconductor industry, which has a new generation of technology every 2 or 3 years, having a domestic industry may make a much greater difference than it does in the textile industry. We did a study on the textile industry for the Office of Technology Assessment, and none of the textile manufacturers we talked to questioned that they had equal access to textile machinery from Switzerland, Sweden, Germany, and Japan, as anybody else did. But there is no such unanimity among semiconductor manufacturers.

Balwant Karlekar, director, Center for Integrated Manufacturing Studies, Rochester Institute of Technology: I have two observations. One mission of my center is to assist small and medium-sized manufacturing companies. We conducted a survey recently to determine the needs of these companies. It turns out that they are all over the map in terms of implementation of various technologies. Some are operating on almost a year 2000 level, whereas others are operating on a 1940s level. Also, we discovered that a technology is considered new and advanced if a company doesn't have it. For some companies that may mean a simple computer-aided design system, and for others it may mean a whole new machining center.

We also found that these companies do not need new technologies as much as they do straightforward business processes. They are interested in issues related to people, culture, and marketing. Many don't even know who their customers are and how they can change their product profile.

We also discovered the limitations imposed by transportation. In other words, if you can drive to a company in a hour, spend a day there, and return home in the evening, then that's a limit on your effectiveness. On the other hand, if some modern technologies can be mass produced so that, in effect, we can have a video conference involving the potential customer and the experts at the center, and this approach can be used at other centers as well, then the distance problem can be eliminated.

Video conferences can help continue the hand holding often needed after an assignment is completed. It is not enough for a group of experts to go into a company, solve the problem, and say, "OK, here is a report, go implement it." We found there is a need to have "service after sales" for up to a year.

Another point concerns manufacturing education. I feel this country operates on an incentive system. If salaries in manufacturing increase, then far more students will gravitate toward manufacturing. When electrical engineers were in great demand, many students flocked to that field. When chemical engineers were in demand, students flocked to that. Today, manufacturing engineering graduates are not in demand, no matter what we hear from leaders in industry or government. Unless and until the leading industries offer substantially higher salaries to manufacturing graduates, students will not be interested in that program or field.

Finally, we have to do something about the K-12 program, because it is graduates of K-12 who form the backbone of the work force in manufacturing.

Cynthia Arnold-McKenna: We have to close off the discussion now. I want to thank the audience for its participation and input, not only at this meeting, but also, hopefully, through continuing input into this process of trying to advance a manufacturing agenda developed by the Federal Government, the private sector, and universities. Thank you all, and thanks to our panel members.

Appendices

Appendix A

List of Participating Organizations

Participating Organizations

Government Organizations (12)

Office of Science and Technology Policy
Office of Management and Budget
Department of Commerce (NIST)*
Department of Defense*
Department of Energy*
Department of Agriculture*
National Science Foundation*
National Aeronautics and Space Administration
U.S. Navy*
U.S. Army
U.S. Air Force
Defense Logistics Agency

Other Organizations (28)

Aerospace Industries Association
American Defense Preparedness Association
American Society of Mechanical Technology
Automotive Industry Action Group
Consortium for Advanced Manufacturing-International
Critical Technologies Institute
Electronic Industries Association
Electronics Manufacturing Productivity Facility
Great Lakes Composites Consortium*
Iacocca Institute
Industrial Technology Institute
Institute of Advanced Manufacturing Sciences
Manufacturing Studies Board
Modernization Forum
National Association of Manufacturers
National Center for Manufacturing Sciences
National Center of Excellence for Metalworking Technology*
National Coalition for Advanced Manufacturing
National Electrical Manufacturers Association
National Initiative for Product Data Exchange
National Security Industrial Association
Oak Ridge Y12 Plant*
Sandia National Laboratories*
Semiconductor Industries Association*
Society of Manufacturing Engineers
South Carolina Research Association*
Work and Technology Institute

*** = Co-Sponsors (12)**

Appendix B

List of Steering Committee Members

Steering Committee

Chairperson

Arati Prabhakar
National Institute of Standards and Technology

Members

Kitty Gllman
Office of Science and Technology Policy

John Pfeiffer
Office of Management and Budget

Michael McGrath
Department of Defense

Warren Chernock
Department of Energy

Dennis Child
Department of Agriculture

Joseph Bordogna
National Science Foundation

Len Harris
National Aeronautics and Space Administration

Steven Linder
U.S. Navy

Col. Davidson
U.S. Army

William Kessler
U.S. Air Force

Donald O'Brian
Defense Logistics Agency

William Lewandowski
Aerospace Industries Association

Leo Reddy
National Coalition for Advanced Manufacturing

Charles Carter
Association for Manufacturing Technology

David Harper
Automotive Industry Action Group

Dale Hartman
Consortium for Adv. Manufacturing-International

Steven Drezner
Critical Technologies Institute

Richard Engwall
Electronic Industries Association

Gary Burkhart
Electronics Manufacturing Productivity

Roger Fountain
Great Lakes Composites Consortuim

Roger Nagel
Iacocca Institute

George Kuper
Industrieal Technology Institute

Thomas Mahoney
Manufacturing Studies Board

Jack Russell
Modernization Forum

William Morin
National Association of Manufacturers

John DeCaire
National Center for Manufacturing Sciences

Howard Kuhn
National Center of Excell. for Metalworking Tech.

William Roland
National Electrical Manufacturers Association

William Conroy
National Initiative for Product Data Exchange

Al Narath
Sandia National Laboratories

James Glaze
Semiconductor Industries Association

Frank McCarty
Society of Manufacturing Engineers

Robert Henderson
SCRA

Brian Turner
Work and Technology Institute

Appendix C

List of Organizing Committee Members

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Appendix D

Comments by Conference Attendees

Comments by Conference Attendees

Dean Thomas Murrin
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I would like to provide a small company perspective. Small companies need special consideration by funding agencies for the following reasons:

1. We are the engine for renewal. We are the future big companies. We are flexible and agile. We are also lean and mean, and street smart.

2. No other country has the infrastructure to spawn high tech companies. Not in Japan, not in Europe. We could and we should take advantage of that.

3. Small funding is equivalent to big funding because we can use this as validation to leverage venture investments from the private sector.

4. In some sense, we are approaching productivity and competitiveness as technical people. We can also approach the issues as businessmen. Big companies have financial resources. Management often lack the resolve in making investment decisions. In addition to funding as a direct subsidy, their decisions can also be swayed some other ways such as changes in Generally Accepted Accounting Practices (GAAP) and tax incentives.

5. Finally, we can learn from the track record of venture funds on Sand Hill Road. Blockbuster successes are very rare and overall nets are extremely low. Here you have administrative costs associated with consortia and too many cooks to spoil the soup.

My urge is for each of you with funding authorities to pay special attention to fund small businesses.

Charles Osiewicki
PBMA (DoA)

Comments follow:

1. During the TEAM presentation, it was pointed out that academia representation at the University level was not the most appropriate way to get manufacturing to the shop floor workers. This was the vocational/junior college/trade school mission and that "they" are not represented in TEAM teams.

I would like to generalize this - "they" are not at this conference, either. They should be - perhaps NIST needs to target them for conferences realizing their limited budgets, and perhaps as a follow-up/summary of your major conferences to disseminate the key points, without the repetition found in multi-speaker addresses to the same basic issues.

2. It becomes increasingly clear that the Manufacturing Technology Centers (MTCs) and/or Manufacturing Extension Partnership (MEP) need to address the connectivity issue. We keep hearing that things are not on the Internet, a BBS or whatever that need to be disseminated. Let the MTCs, MEPs, and clones get this communication technology to the troops.

Dennis E. Wisnosky
Wizdom Systems

My concerns and issues follow below:

1. **Small Business** - Wizdom began in 1986. We have offices in Chicago, Detroit, Washington, DC, Los Angeles, and Warsaw. We are a small business. The speakers representing "small business" certainly did not represent Wizdom. They talked as though all of the problems of small business would be solved by the various forms of Agriculture Extension Centers being established to focus on manufacturing. The centers will provide employment to a new generation of bureaucrats, they will do little to help manufacturing competitiveness. Small business needs customers to help develop technology, and to buy products and services. This is the best kind of help that the Federal Government can provide. Yet, it is nearly impossible for small companies to work on Government technology programs, and it is getting worse. Except for mandatory 8A percentages, ManTech, ATP, TRP and virtually every other program is vectored towards large companies, Federal Labs, and Universities. Small companies have almost no chance to participate. When is small business involvement going to move beyond the viewgraph stage and into reality?

2. **Porcine SBIR** - The SBIR program is not exempt from the problem of the big get bigger with Government help syndrome. Eric Bloc mentioned athe two-tiered proposal process. That is, one team writes the proposal, another does the work. In SBIRs, it is even worse. There are literally SBIR "factories." That is, companies or parts of companies which do almost nothing but SBIRs. When a company gets too big to qualify for an SBIR, it divides like an Amoeba into a qualifying product. Wizdom recently lost an SBIR for the reason that the result would be a commercial product. Pardon me! Why is the gem of Amercian ingenuity being allowed to become another political pork barrel?

3. **Three weddings and a funeral** - This is how I would characterize the relative ManTech positions of DoC, DoE, NSF, and DoD. This is most unfortunate. Through the years, the DoD program has been a stellar success. They have had the need for the best technology, customers in a minotsany, who had no choice but to listen, and very smart internal people. The list of technologies, products, and spin-off companies created is impressive. The IMIP Program was the golden spike that virtually insured that ManTech program results would be coupled to implementation. A couple of years ago IMIP was killed. Today, ManTech is being porked to death, and instead of a sustained integrated program coupled to the true overall needs of the nation, technology du jour is being pursued by the new kids on the block who want quick fixes only. Reading some winning proposals, one might conclude that a winning proposal is the most outlandish proposal, or the one with the highest percentage of acronyms. What is the difference between Agile and Virtual and why shouldn't they both be lean and mean, anyway? How can a single idea bring back, in the next 5 years, half of the machine tool industry that the U.S. has lost in the last 20 years? This was the essence of a winning proposal that I saw. How many more studies do we need? Why is more than half of the TRP money being spent within 100 miles of Washington? These are questions that I believe should be answered by the combined leadership of the agencies leading the new national manufacturing agenda.

Appendix E

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Appendix F

Banquet Speaker

Jacob Rabinow, Consultant

Jacob Rabinow
National Institute of Standards and Technology

It is interesting to note that "Just in Time" now applies to after-dinner speakers.

I decided to talk about several things. One thing I could talk about, of course, is the sad state of American technology. I think it stinks. I even could tell you some of the reasons. I could talk particularly about the two-platoon system of writing proposals, about the first platoon getting the contract and then the second platoon doing the work. I could tell you all sorts of things I've learned, in and out of government. But after dinner is no time to be serious, so I decided to talk about inventions.

I have theories about how one invents. I believe invention is an art form. I think inventing a gadget or a system is no different from writing poetry, composing music, or doing anything else that is original. If that means I put myself into very high company, then so be it. Not all music or poetry is good, however, and that goes for many inventions. I think inventing is a random process. I think it is important to understand the process. So I decided to give you some examples of how inventions are made. I won't focus particularly on important inventions, because trivial inventions are as much fun and as difficult to make.

I've been asked whether I'm always conscious of what I'm doing. No, of course not, but sometimes I am.

Here's my first story. I'm driving home with my patent attorney.from some midwestern business meeting. He says, "Well, Jake, you have nothing to do." (By the way, this is a preamble my friends always use when they want me to do something.) "While you have nothing to do, will you please design a gadget that turns on a light when my telephone rings." I ask why, and he explains that he has an answering service (this is before there were answering machines) and he usually forgets to check in with them. Or, he checks and there is no message, wasting their time and his.

I say: "That's easy. You take a microphone, an amplifier, and a latching relay. When the mike hears the signal, the amplifier amplifies, and the relay locks and the light lights."

He says: "You stink as an engineer. Anybody could have done that. I want something simple and cheap."

I say: "That's hard. Let me think."

Now, this is 1959. So I remember when I came to America in 1921 when I was 11 years old. (I'm 84.) I was helping my uncle sell toys during Christmas, in his store on 125th street near Broadway. One of the toys fascinated me. It was a little cardboard dog house. When you very carefully pushed the dog into the house and then clapped your hands, the dog jumped out. No electronics, of course. The way it worked was this. There was a wire contact at the back of the box, with a little piece of metal touching it. When the box vibrated from the sound of clapping, the contact broke for an instant and released an electromagnet.

Now back to 1959. I say, "Max, I know how to make you a simple device." I go home, take a cigar box, put a loose contact under the cover, a very loose contact -- and I take two resistors and a neon light. A neon light has a very nice property: If you set it halfway between its starting voltage and its extinguishing voltage, it will stay out. But once you light it, and you go back to the same voltage, it stays lit. So I adjust the resistor that shunts this contact. So, with two resistors, a neon light, a lousy contact, and a cigar box, I make this gadget.

I go to Max's office, give him the gadget, and tell him to put it on the desk. He calls the operator and asks her to ring the phone. She does, the light lights, and Max says, "That's clever." I go home feeling very proud, because this thing is really a trivial device.

But as soon as I get home, he calls me and says, "You still stink." I ask what's the matter, and he says: "I can't sneeze, I can't close the door. If I touch the desk, the light lights. The thing lights all the time."

So, we put a time delay on the device and improved it, and it worked. He goes to the patent office and found the toy was patented in 1918, and the picture was exactly as I drew it.

The point is, look at what the brain does. It remembers something 38 years later, remembers the picture exactly. As a matter of fact, are any of you familiar with that dog toy? I once talked to the head of a large company who remembered the dog's name -- Rex. He remembered that he actually owned the toy 56 years earlier. I'd like to see a computer pull that stunt.

So maybe someone thinks, "It's obvious what you did, you looked at the patents on sound-operating devices and found the reference." I respond, "Well, there is a problem in that, when I was 11, I wouldn't have classified it as a sound-operating device, I would have written *dog toy.* Secondly, I spoke only Russian when I was 11 years old, so I would have had to translate my whole Russian memory into English. That's not likely."

I think the dog toy is a clever invention, even though it's useless. Since then, I actually have built one, because when I talk to kids it's fun to clap your hands and have the dog jump out.

I'll tell a few more stories of how the brain invents. I also can be logical, like any other fool. If you tell me you want a back scratcher with a random motion, I can take a computer, make random numbers, get a robot that costs $10,000 to $20,000, and scratch your back with a random motion. The thing is, solving a problem without logic is more fun.

The reason I left the government, by the way, was not to make money. I was chief of one of the ordnance divisions at the National Bureau of Standards (now the National Institute of Standards and Technology [NIST]), and in 1952 they decided, contrary to the present attitude, that we were doing too much applied work and not enough basic science. The ordnance laboratory was to be broken away and turned into the Harry Diamond Laboratory. I didn't want to leave the Bureau, and I didn't want to work under military control -- not because I didn't want to build weapons, but because I didn't want to work for a boss who came in for three years and then left.

I spent my engineering life at the Bureau of Standards doing a lot of "illegal" work; that is, every now and then, I'd do something that was not supposed to be done. And I had smart-enough bosses who looked the other way. By the way, a good manager is one who knows when not to watch you.

There is a Rabinow law that says, "Everything you do illegally, you do efficiently." (I'm glad so many of you are hardened crooks.) The first reason is, you don't waste time writing a proposal. Second, you don't tell what stuff you will need. When you're in jail, you don't put in a requisition for three files and a hacksaw, you just do what you can with what you have. Also, you say that you're doing it only during lunch hour, which is a lie (you do it from morning 'til night if you have to), but you do it all unofficially -- which means no records are kept.

There is one other beautiful thing about illegal work: When a project doesn't work, you bury it quickly and quietly. If you do an approved professional job, then you keep the project alive as long as possible, because you hope someone else will inherit it and can be blamed for it later. So, if an illegal project works, you may become a hero, and if it doesn't, nobody knows. That's how I developed some clutches, reading machines, and many other things. I was very lucky. That doesn't mean you can permit *much* illegal work, but you certainly can permit a little.

Well, I left the Bureau and opened my own consulting firm, with one mechanic and myself. People always came and saw my inventions, but they never wanted my inventions. They wanted me to work on their problems, not my problems. But my inventions were good advertising.

I get a phone call. I'll give you the exact words.

"Mr. Rabinow?"
"Yes."
"This is Bob Berks."
"Mr. Berks, who are you?"
"I'm the world's greatest portrait sculptor."
"What can I do for you?"
"They tell me you are a genius."
"If you are the world's greatest portrait sculptor, then I'm a genius."

Bob Berks is the guy who did President Kennedy's head at the Kennedy Center. He is a good portrait sculptor -- not the world's best, and not a genius. Unfortunately, I worked with geniuses during the war, and the arrogance gets kicked out of you when you realize how smart other people are, people who do things easily that you have to work so very hard on.

So I say: "What can I do for you, Mr. Berks?"
"Can you cut metal?"
"What kind of metal?"

"Seventeen-foot statues."
"Oops, that's not easy. What metal?"
"Stainless steel."
"You'd better come to Washington, and we'll talk."

He came to Washington, and since then we've been very good friends. He had the commission to make statues of some famous blacks. One of them was Mary McClaude Bethune, who was a great educator. The statue, by the way, stands on Pennsylvania Avenue, S.E. I didn't cut it, by the way.

The problem was this. He wanted to shape the original statue with his hands, out of clay or some other plastic, about three or four feet high. Then he wanted it to be followed electronically with a profile follower, and he wanted a machine to cut the thing out of stainless steel, 17 feet high.

I began to think about how to make the machine. I knew how to follow a statue with an electronic follower, and I even knew how to make machine that would cut metal, with a grinder or cutter at the end of an arm. The problem gets to be interesting when you have an arm sticking out 30 feet, and another arm at a right angle to that. And there is a motor with the cutter at the end. The machine gives the instructions -- so much out, so much in, so much this way -- but the arm will sag, due to its weight. You can calculate the sag and have a computer correct it, but that isn't very elegant. The problem I had is: "How do you make an arm that sticks out from here to there, do cutting at the end, and not have it sag?"

There are two easy ways. One I figured out, one a high school kid did later. The interesting thing is that all of you sitting here can solve this problem. It doesn't take any fancy engineering, and you don't have to be a mechanical engineer. I'll give you five minutes. All of you know the answer; the trouble is, as with all inventions, you have to take something that normally has nothing to with machinery, arms, or cutting statues.

The answer is, you do the whole thing under water, so the arm is neutrally buoyant. Then it doesn't sag or vibrate, and you can keep the temperature under control and actually suck away the chips as you cut. I've got a patent on this process. I thought it was a cute idea. My brother is an engineer too, older than I am, and he said, "That's either the worst or the best invention you ever made."

So Bob Berks went to the Ford Foundation and said, "We can make profiles of all the great statues in the world, record them digitally on tape, and use one of Rabinow's machines. Then, if anybody breaks a great statue, we could duplicate it in whatever size it has to be done." The Ford Foundation asked him how much money he wanted, and we said about $250,000. They offered him half that. I've always been afraid that one day he would come to me with a check for $250,000 and say, "Start cutting under water." He never did.

That story shows the kinds of things you have to think through. A high school kid who heard me tell that story said: "There's another way of doing it -- you put the whole thing in orbit. There's no gravity in orbit, so the arm won't sag there, either." It's not very practical to cut statues in orbit, but that's a good way to get rid of gravity. But the machine will vibrate.

Here's a story about an invention that was successful. My wife gave me a watch in 1945. It was a mechanical watch (those were the days before quartz crystal watches). By the way, we at NIST now can record time down to something like a second per million years. We at NIST can measure time better than anybody else in the world can, and we'd like to do it even better.

Anyway, mechanical watches don't keep perfect time. So what you do, is, you unscrew the back, and there is a regulator inside, a little lever that says "fast" one way and "slow" the other. You move it faster if the watch is slow, then you screw the back on, and the timekeeping gets better. And after two or three settings, it's correct.

Then I began to think about how to make this adjustment automatic, so that I would not have to open the watch. This was one of my good commercial inventions. Everybody here can invent this. All you have to know is that, inside of watches is a lever you move to speed up or slow down the watch. What did I do? Please think. I'll wait. Remember, I pulled the stem and moved the hands forward, because the watch had been slow. What else did I do when I did that? Yes, that is correct, when I moved the hands forward, I also changed the rate slightly. I did a couple of other things.

What you just sorted out is what I did, except my attorney and I made some real money out of it, as you'll see later. What I did is simply make a mechanism so that, if your watch is slow and you move the hands forward, you also speed up the watch slightly. It doesn't make any difference how much.

Then another immediate problem arose. What happens when you go to Chicago and have to move the watch back a whole hour? And what happens if you forget to wind it? I arranged things so that, if you change the time by more than 15 minutes, there is no correction in speed. Small time corrections resulted in an adjustment in speed, but big corrections did not. I also had to decide whether to make the speed change proportional to the setting, or digital, so that corrections would be independent of the motion of the hands. It turns out that digital is the correct choice, but the industry never believed me and they made it proportional.

Back to the story. I get publicity. I make the device on the back of a clock and get a good patent. The first call I get is from the president of Hamilton Watch Co., and he says: "I'd like to see your watch with the magnetic clutch in it."

I said, "It has no magnetic clutch, that's a separate invention. You're mixing up two different things." He invites me to his factory in Lancaster, Pennsylvania. I go to Lancaster and show him the back of my clock and the parts of the clock that make this adjustment. It's a trivial thing to do.

He says, "That's very, very clever, but we can't use it."
"Why can't you use it?"

"We advertise a perfect watch, so how could we advertise anything better?"
"Is your watch perfect?"
"No, it's like any other good 17-jewel watch."

I say: "Can't you forget what you say each year and announce that the watch that was so good last year is even better this year? Like Cadillac does every year? They announce the best car you can make, but the next year they forget that and say it's a much better car. This has been going on for 50 or 60 years."

He says, "No, we can't do that."

But he did take me through the plant, and I learned something very interesting: that you cannot make a watch correct, even if you make every part perfect. The reason is that when a watch moves the balance wheel (the pendulum) one way, there is a reaction against the case. In other words, if I push this lectern, the lectern pushes me back. So when the pendulum goes one way, the case goes the other way. The actual case of the watch moves in opposition to the balance wheel.

I ask, "What do you do about that?"

He says: "Because we don't know which case will be fitted to which movement, we make all the movements fast at the factory, because we can't set them correctly -- there is no way of knowing what the case will be like. Every case has a different effect on the movement. We also don't know if the man wears it all day (if it's a man's watch), whether he has a hard wrist and a tight band or a loose band -- because those variations couple different masses to the watch. We also don't know whether he sleeps alone or not. That also makes a difference, because it affects the temperature."

Anyway, I learned a great deal about watches but I didn't sell my invention. For seven years, I showed it to every manufacturer in the United States and some in Europe, and they all said, "That's very clever, and it works, but who needs it? Watches are good enough, so why bother. It means change."

Then I invented a particle clutch, which is in the NIST lobby with an exhibit of clutches, including one from Renault and one from Subaru. For that I got a gold medal and a raise in salary of $200 a year, which made my salary slightly higher than my boss's, which was all right. He was very liberal.

The clutch was interesting to manufacturers, so Chrysler Corp. called and asked me to come tell them more about the clutch, which they were testing. We had dinner that night with some Chrysler engineers, and I told them about the watch regulators, and they said: "We hate automobile clocks. They are junk. They're cheap. You may pay $48 in a Cadillac for the same watch that's in a Chevy for $15. And the watch is only worth $2 or $3."

I said, "You have the nerve to charge $43 bucks for that piece of junk?" He said: "People who buy Cadillacs don't ask what the clock costs. It's part of the Group B accessories. Anyway, we don't like the clock." So what happened later is that he told his chief engineer about my clock regulator.

Months later, I was riding home with the president of Westclox. We were both consultants to the Pentagon. During the taxi ride, he asks, "Have you sold the clock yet?"

"No."
"What do you want for this gadget?"
"Ten thousand dollars a year minimum and two cents a clock."
"Two cents a clock? You've got a deal."

We shake hands, and he gets off at his hotel. I go to my office in the taxi, and no sooner do I get back to my office than I get telephone calls from all the other clock manufacturers, who say they'll pay me more money than he offered if I sell the clock to them.

I say: "I've been trying to sell it to you for seven years. I know all of you by your first names. You buy it from him now."

So he sub-licensed the clock patents to the others after he bought my patent rights, and he made more money than he paid me. I got a penny apiece, and my attorney got a penny apiece, so we each made about $30,000 a year for 20 years. The clock was used on all American cars and I was very proud of it.

I tell you this story to illustrate the difficulty of selling a thing that works. And by the way, the advantage of my regulator was not only that it regulated the clock but also that it reduced the manufacturing costs, because it eliminated the need for a manual control. They used to have a screw through the glass, and you had to turn it with a small screwdriver.

Now I will tell you about another invention, which didn't sell but may interest those of you who represent automobile companies. I was driving home from some meeting in a car with another Bureau of Standards engineer. I'm pushing the foot switch to dim the lights when cars approach me, and I say: "Sandy, there ought to be an automatic dimmer for the headlights," and he starts to laugh. I ask, "What's so funny?"

"I thought of that," he says. "I went to the patent office and there are hundreds of patents on automatic dimmers."

I begin to wonder why these inventions aren't being used. The obvious approach is to take a photo cell and put a lens in front of it, so that when a lot of light hits it, the photo cell operates a relay and dims your lights. Then I realized that this is no good, because you don't want to dim on ambient light, you want to dim on specific bright spots. So I say: "If you put a scan system in front of the cell, so it scans like a television scanner, then you can tell when it sees a light."

Does anyone want to guess when the first patent on television was issued in the United States? It was 1875. A guy named Carey, an telegraph operator in Boston, noticed that his resistors changed resistance when sunlight hit them. He realized that he had something that responded to light, and he figured out how to send an image with a lot of wires. Line-by-line scanning as we know it was invented by a Pole named Nipkow in 1884.

Modern TV goes way back before radio. I read the German patent by Nipkow, who used a revolving disk. So I use the Nipkow disk in my headlight dimmer. It's a small disk with holes in it. It scanned the image, and when there was a bright light you got a big spike of current from the photo cell, and the device dimmed the lights. I received a good patent on this and made working models.

General Motors Corp. (GM) was very interested. I went to their lamp division in Anderson, Indiana, and we put my dimmer on the Oldsmobile that belonged to the chief engineer, and he drove the car with me, my mechanic, my patent attorney, and the inventor of their dimmer. We drove around all night. It's an experience to drive around with the chief engineer of a GM factory. He went 120 miles an hour without batting an eye, because he wanted to overtake cars to see how the dimmer worked on the tail lights.

I ask, "Don't you get tickets?"
He says, "We own this city. All the cops know me, so I don't get tickets."

By the way, I'm still alive, so he knew what he was doing. Anyway, my dimmer worked much better than his did. We got to his home at 3 o'clock in the morning. And I say, "Well?"

He says: "It's beautiful, but I won't buy it." I ask why.

"Because it costs an extra buck for the scanning system. It has the same photo cell, the same lens, and the same power supply as ours does." (In those days, you used a photo multiplier with a 1,000-volt power supply.) "Ours cost $22 to make, and yours would cost $23. We sell ours for $85 in the Caddy, and yours would be sold for $90. I want something cheaper and simpler."

I say: "If I had that, you'd be in Washington instead of my being in Anderson. I can't make it cheaper and simpler."

Chrysler and Ford Motor Co. also liked my dimmer, but I never sold it.

I'm telling this story to illustrate also how driving the dimmer around Washington was very useful. The first difficulty was this. You're driving up a hill, and there is a pole with a street light a little over the hill. The light looks like it's on the road and it has the same intensity and color as a headlight. The dimmer, of course, dims. So how do I prevent this? That's another problem all you engineers can solve. How can the gadget distinguish street lights from headlights?

That's a very interesting problem, and again, you cannot solve it with logic. But you can try to keep groping in your head: What is the difference between a street light and a headlight of the same intensity, size, and color? The difference is that the street light is AC-operated, while the headlights are DC-operated. That means the street light has a flicker rate of 120 cycles. I can easily design a circuit that detects a 120-cycle flicker and tells the dimmer "don't dim." And I got a patent on that.

Another problem arose with my dimmer, a more interesting problem. You're driving with the headlight dimmer on your car, the road curves, and there's a bright reflecting sign. I'm driving straight into a perfect mirror and I see a car approaching -- but it's me. The dimmer thinks there's another car. Of course, the gadget will dim. I wanted to prevent that from happening.

There is a scene in one of the early James Bond movies where the villain puts a mirror on the street, and the hero is driving into it; he tries to avoid himself but finally crashes -- into the mirror, of course. Reflecting signs are like this. But I solved that problem, too. It took days of thinking. Now, you could modify your lights and put special signals into them, but you want to leave the lights and the circuits alone. Yet somehow the gadget has to know that it's seeing its own lights.

Before I tell you how that was done, a brief story. When I told the chief scientist of the Ordnance Division of the Bureau of Standards that I had invented a headlight dimmer, he started to laugh, just like my partner engineer had laughed. I say, "What's so funny?"

He says: "I lived in Germany under Hitler, and somebody in Berlin invented a headlight dimmer. They put it in some cars, and the following thing would happen. Two people would be approaching each other, and one would lower his lights. The other guy, being polite, then would lower his. And the first man didn't have much light, so he'd brighten his headlights again. Then the other guy would get mad and raise his lights, and they had more accidents than they had before. So we were forbidden to have headlight dimmers."

I say, "Well, that could be taken care of; there are tricks."

Anyway, the history of headlight dimmers wasn't very good when I became involved.

The way the headlight dimmer knows it's seeing its own light is interesting. Actually, it doesn't know, so it dims. But the instant it dims, the other lights go down at the same time. Then the dimmer assumes that it's me and the lights come right up again. It happens so fast that it's just a flick.

So you ask: "Couldn't it be that the other guy really does dim his lights at the same instant you do?" Of course, but it never happens in practice. I drove my car with the dimmer for years. The two drivers would have to dim and brighten in the same fraction of a millisecond. That is very unlikely.

So I got another patent on that feature. By the time I finished I had six or seven patents on headlight dimmers, and if anyone wants to buy unused headlight dimmer patents, I'll sell them for $2 cash. The reason I told you this is that the thinking that goes into nice inventions is not something you could program a computer to do. You have to grope around in your mind; you may find something useful, or you may not.

I've been asked many times whether you can teach this art form to other people. The answer is yes. That doesn't mean everyone can become an inventor, any more than you could teach everybody to be a composer. But if you take 1,000 people, some can be inventors, particularly kids. It's a lot easier to get young children to answer questions than it is adults. Adults are afraid to look stupid. If you want to be an inventor, you've got to look stupid once in a while. It's part of the business.

In fact, inventions are inherently funny, for two reasons. First of all, they can be stupid and idiotic. Second, if they are right they can be a surprise, like a good joke, a punch line. I guess if something is correct and unexpected, then it's inherently funny. When one of these ideas hits me, I have to smile -- because it's cute, not because it's practical or going to win a medal or something. It's like hearing the punch line of a good joke.

And you can teach this. First, you have to tell people not to be afraid, to try things mentally and not be embarrassed. I was lecturing at the University of California at Berkeley for a month in 1972. The first day, I say to the graduate students, "I'm going to talk about inventions." Immediately, the students say: "Who needs inventions? Who needs practical things? Who needs materialism?" This was a time when they were all against materialism. It's very easy to be against materialism when you're rich like Berkeley students.

So I say: "I can explain on many different levels why practical things matter, but I'll tell you a simple way of looking at it. I lived in Siberia for five years, and the toilets were outside. The temperature in the winter reaches 40 or 50 degrees below zero. How would you like to use an outside toilet at that temperature?"

A student asks, "Fahrenheit or Centigrade?"

I say: "If you knew your physics, then you'd know that -40 degrees Centigrade also happens to be -40 degrees Fahrenheit. They cross at your behind. It doesn't feel cold, it hurts. Do you still want to talk about materialism?"

The student thinks for a minute and says: "I think I get your point. I can see that sometimes materialism has a bearing."

But it was interesting that they were very much afraid to try things. By the end of the eight lectures, however, they had learned that there's nothing shameful about being wrong, and they got into the spirit. They figured, "If this jerk can do it, then I can do it." And people can.

I gave the Berkeley students a famous problem: How do you measure the height of a big building with a barometer? In the case of the World Trade Center in New York, which is 1,000 feet high, you go up to the roof, look at the barometer, and record the reading. Then you go down to the basement and look at the pressure again. Then you can look up a table and find out how high the building is.

But I asked them for 12 *other* ways to determine the building's height. That gets more interesting. There are many ways to do this; I'll give you two. You go to the roof, drop the barometer, and use a stop watch to see how long it takes before it hits the ground. That tells you the height of the building.

One of the kids came up with a more elegant way. You take the barometer, find out who the building architect is, and go there and say: "I have a deal for you." You can see they learned how to be inventive -- they weren't afraid to try something out of the ordinary.

The thing that's interesting is, if people invent and talk about inventions (and many of my friends do), they always come to me with a "million-dollar" invention. Nobody ever comes to me with a $10,000 invention. You have to tell them that a million-dollar invention is hard to make.

When my older daughter, who is now a lawyer in Connecticut, was six years old, she heard my wife complain that the maid never emptied the bag in the vacuum cleaner. (In those days, vacuum cleaners didn't have bells and whistles or tell you: "empty me.") So my daughter says, "Daddy, can't you rig something up so that when the vacuum cleaner bag gets too heavy, a bell will ring?"

I say yes. Max, my patent attorney and a partner in many of my deals, offers to look it up. He goes to the patent office and finds a patent: The vacuum cleaner bag rests on a spring, and when the spring goes down far enough it touches a contact and rings a bell. So Max comes to our house and reads it to my daughter, and she starts to cry. Her idea had been stolen from her. I say: "Jean, you ought to be proud, you're playing big-league ball. Adults patent new things, and you thought of it, too." You see that she lived in an atmosphere where people discussed such things.

My younger daughter got a patent when she was 14 years old. I had made a little camera for myself; it weighed two ounces and had a mechanical shutter. The trouble with a mechanical shutter is that, as you press it, the sudden change in pressure makes the camera jump a little, so the pictures blur.

I say to my two daughters: "I would like to have a release that doesn't shake the camera when I take a picture."

My older daughter says: "Get a rubber tube, at the end of which you have a bulb, like the professionals do." I say I don't want a two-ounce camera with a big rubber tube.

And my younger daughter says: "Can you have photo cell on a camera?" I say sure. She says: "Why don't you just wave your finger past the photo cell? Don't touch the camera, trigger it."

My patent attorney got her a patent on it. Eastman Kodak Co. said, "That's very clever, but we don't need it." But when my daughter applied for early admission to Pembroke College (she also had very good marks) they asked what other credentials she had. She told them about her patent, and they accepted her. She is now a computer programmer for Lotus Development Corp.

So if you live in an atmosphere where people encourage and enjoy inventions, you can learn to invent. It's like any art form. If people like opera, people sing opera. If they like music, they play music. If you like inventions in your firm or family or among your friends, then you will invent. Because there is always some problem that irritates people, and when it does, they invent something to solve it.

I want to add something, because this audience is full of people who are at the top of the technical pyramid -- that is, you are supposed to know how to make and produce things. You're near the top and I'm at the bottom. I start with the invention and hope it reaches you reasonably fast, so you can manufacture it. And, if you make it, maybe I'll make it. And this is one of the reasons I talk about inventions. I think inventions are necessary for technology, because technology depends on screwball ideas -- good ideas and bad ideas.

I would like to talk about one other thing. I was talking to Sherman Fairchild, one of the richest men in the country. I don't know whether he is still alive. Among other things, he owned a bay in Long Island and he had to close it to shipping once a year so they would know he owned it. Apparently there are rules saying that if you don't close the bay, then it's public property. So he closed it once a year with chains. He also owned the largest single block of IBM Corp. stock in those days. He owned Fairchild Semiconductor, Fairchild Camera, and other businesses.

We were sitting in his home in Manhattan talking about inventions and patents, and he says: "You know, inventors do more than just get patents and glory. They are very useful in a factory. They solve many day-to-day problems."

Which, of course, we do. The job of an engineer like myself is not to invent things I can talk about at lectures but to solve day-to-day problems, such as how do you make something simpler, cheaper, or better, or fix something that doesn't work. Usually we are asked to "fix it but not change it," to make it work right but not do anything that will make it different or more expensive. That's always an interesting problem.

So Sherman Fairchild says: "You know, Jack, I think inventions are not worth much, because I have a few patents of my own. But I think inventors are very valuable people."

Thank you very much.

Question: You mentioned you wrote a book. Is it about inventions?

Answer: I have given many talks in my life. Let me tell you about the first time I was interviewed on TV. The year was 1948. I had just invented the magnetic particle clutch. In those days, the newscaster would give the evening report and I'd be sitting next to him. Then he would introduce me, and we would talk about the clutch.

My wife was watching a TV set with a five-inch screen at some friend's house. And the newscaster finishes giving the news, and he says: "I now have to introduce a great genius sitting next to me." Not realizing that the camera has shifted to me, I say to myself: "He is full of bull." My wife reads my lips and is having hysterics. The newscaster keeps talking about what a great guy I am and I don't know you're supposed to watch for the camera and not make derogatory remarks. I learned after a while to keep my mouth shut and not make funny noises.

Anyway, I've been on TV many times, and after you finish a talk like this, people come over and say: "Why don't you write a book about your stories?" Usually when I talk about my inventions, it takes a long time -- an hour, an hour and a half. I have trouble talking for just half an hour. It really is hard to condense. (There's a story about Abraham Lincoln that he wrote a very long letter to a friend. The friend asked how Lincoln had the time to write such a long letter. Lincoln said, "I didn't have time to write a short one.")

Anyway, after people suggest a few times that I write about my inventions, I say, OK, I'll write the book. So, I made an outline of my inventions by groups. My ordnance work, my photography work, my post office work. (I automated the post office. If your letters don't come on time, don't blame me.) Then I dictated the book by talking to a microphone. And some professional secretary typed it and laughed at the right parts.

The book is published by San Francisco Press. My wife suggested the title *So I Made a Better Mousetrap*, and I wanted to add a subtitle, *But the Rats Wouldn't Buy It.* But the publisher didn't like that. They suggested *Inventing for Fun and Profit*. Fun it was, profitable it has been occasionally.

If you go to any good store and say you want *Inventing for Fun and Profit*, you'll do me a big favor, and I'll get two bucks out of it. It's gone through two printings. It's not the kind of book that sells a lot, but it did sell. And it sounds just the way I talk. That's not accidental, because I had one chapter corrected to put it into good English, and it didn't sound like me. So I said: "Nothing doing. I want it to sound like me." And it does. You'll read some of the jokes I told today, all over again.

Before you go, I've got to give you the bottle problem. And you're allowed to call me anytime, collect if you like (don't do that from Australia, but from anyplace else), with the answer. The problem, which is easy to solve, is this:

Two men find a glass bottle on a desert island. It is full of water, absolutely full to the very top. They have no utensils, and each one wants to drink half the water in the bottle. It is possible for one person to drink half the water, and the other person can watch him to be sure it's half and then drink what's left. They can divide the bottle *exactly* in half. The bottle has no symmetry, it's glass, and it's transparent, of course, so they can see what they're doing. It can be done without any other utensils.

I once gave this problem to a man I was interviewing for a job, and I told him that if he solved, he could call me. He left at 5 o'clock that night after he had dinner at our house. He called me at 3 o'clock in the morning. I say, "Where are you, Larry?"

He says: "I was driving on New Jersey Turnpike going home and I solved the problem. So I got off the Pike and called you at 3 o'clock in the morning to tell you that I can do the problem."

I must tell you that we hired him, and he became a chief engineer in due time.

It is a problem where no semantics are involved, there are no trick words. The bottle is full of water to the very top, and anybody here can drink exactly half, and I'll drink the other half. And it can be done with any level of accuracy. If the Bureau wants to do it, we can do it probably to within one percent or half a percent.

Don't ask your friends to help, that wouldn't be fair. It's in my book; I have the answer hidden somewhere. That's a good way to sell the book. It just occurred to me.

Question: Do your ideas ever come to you through a dream?

Answer: No. I dream technical things sometimes, and I think of the mechanics. And I have had ideas when I just woke up and I was thinking of the problem the night before. Suddenly I think I have an approach. And I do it sometimes when I shave. But I never invented anything when I was asleep.

I was driving to work one day when it suddenly dawned on me that I know how to make a pick-proof lock. I invented pick-proof locks because I used to pick locks for my girlfriends. I suppose they ought to hear this.

I used to go out when I was young in Brooklyn College, and I would come home with a girlfriend, and she didn't have any keys to the door. It took me many years to figure out that it wasn't accidental. She wanted to wake up her family so I'd go home. But by the time we got home, we were more friendly than when we had left, and she and I decided we'd like to get into the house without waking up the family. So I carried gadgets in my pocket so I could open a door without damaging the lock. It's quite easy with most old locks.

I became very interested over the years in how to make pick-proof locks. I solved the problem after some 40 years of thinking, and I have patents on a lot of pick-proof locks, but there is little use for such locks today. Burglars today are very crude; they don't pick locks, they tear the door down. It's not the elegant business it used to be.

The Central Intelligence Agency and Federal Bureau of Investigation do pick the locks of so-called enemies, and everyone else, I am told, picks the locks in our embassies. Knowing something of secret service business, I know that if they just exchanged information, they would save a lot of money both ways. They always know each other's secrets anyway, so it seems to me they should just give their prints to each other. But they play the game and they pick locks, and so I designed some pick-proof locks.

Anyway, it can happen suddenly that things connect in your brain. This piece connects with that piece, and it fits. An idea for an invention could happen for no particular reason, like thinking of a name. You're doing something completely different, and suddenly a problem you've been working on comes back with a solution. It's always startling, because it's so sudden. It isn't that you slowly approach it, you just suddenly know you can cut statues under water.

The expression used to be called "flash of genius." Forget the genius bunk, it's a flash.

Question: inaudible.

Answer: To do that, you have to decide which functions you're going to combine. And the answer is, you cannot do this; you do not know any functions at all. The thing that comes to you when you work on the toy dog is that you thought of something you saw when you were 11. It isn't anything you would produce logically, like you had a list you could draw from.

The amount of information in your head is absolutely fantastic, enormous -- billions and billions of things you've seen, heard, combined, and read about. And out of that, one of those things fits, maybe more than one, and there is no logical way to do it. It's like music. There are 88 notes on the piano, but the 88 notes can be combined in different ways, and the possible number of different sequences is infinite. So you cannot say that I could write Beethoven's Fifth using a logical approach. Imagine what you could do in a symphony -- not only with the 88 notes of a piano but also whatever else other instruments can do. The composer thinks of the various combinations.

Question: Which of your inventions do you like the most?

Answer: That's a very difficult question. First of all, you don't invent a single thing. You invent a portfolio. For a clutch there are 12 patents, and there are 44 for a reading machine, which I also invented. There are couple of dozen on post office equipment. So, I can't say any one invention is my favorite. It's like you're asking me which of my two daughters I love the most. I don't know.

There are some things you like. The headlight dimmer was undoubtedly a good invention because it was elegant and simple and it did the job. The subsequent inventions were good, too. The magnetic clutch, which got me the most publicity and a medal, was an obvious invention. Anybody could have done it, so I don't feel proud, except I got more publicity and more glory than it deserved. I don't know which I like best.

I think my reading machine was one of the good ones, because I was the first to say that a letter "A" is not a letter "A" because it does something specific but because, of all the letters in the alphabet, it is closer to an "A" than any other character. I don't know if I'm making sense to you. But the machine looks for the character -- and the characters are very poor "As", smudgy, dirty, missing pieces. The machine compares the character with a whole alphabet and says, "It's a lousy

`A', but it's more an `A' than anything else." And my machine did that, right at the beginning, and that changed the whole art of reading machines. And this concept is used in voice recognition. So, I feel very proud of it.

But which one do I like most? I don't know.

I think when I made a telephoto lens for my Leica camera and coupled it to the range finder, that got me more mileage in the Bureau of Standards than anything else I've ever done, because anybody that cuts threads by hand and makes a handmade lens obviously can walk on water. The shop was my oyster from then on. And it helped a lot. This is the kind of thing you like, something simple. The rest of the people can say, "So what? So you made a lens for yourself. Big deal." But for me it was a big deal.

I really can't answer your question easily. I know some things are junk and some things are good, and the ones I mention in public are good.

Appendix G
Advanced Technology Program (ATP) Tutorial

The Advanced Technology Program

CONFERENCE ON MANUFACTURING TECHNOLOGY NEEDS AND ISSUES

April 26-28, 1994
NIST
Gaithersburg, MD

Rosalie Ruegg
Chief Economist
Advanced Technology Program
National Institute of Standards
and Technology

Tel 301-975-6135
Fax 301-921-6319
e-mail: ruegg@micf.nist.gov

Advanced Technology Program

MISSION

- Stimulate U.S. economic growth by developing high-risk and enabling technologies through programs proposed and cost shared by industry

ATP ELIGIBILITY

- Individual companies
  - No more than 3 years
  - Up to $2 million total
  - NIST pays only direct costs

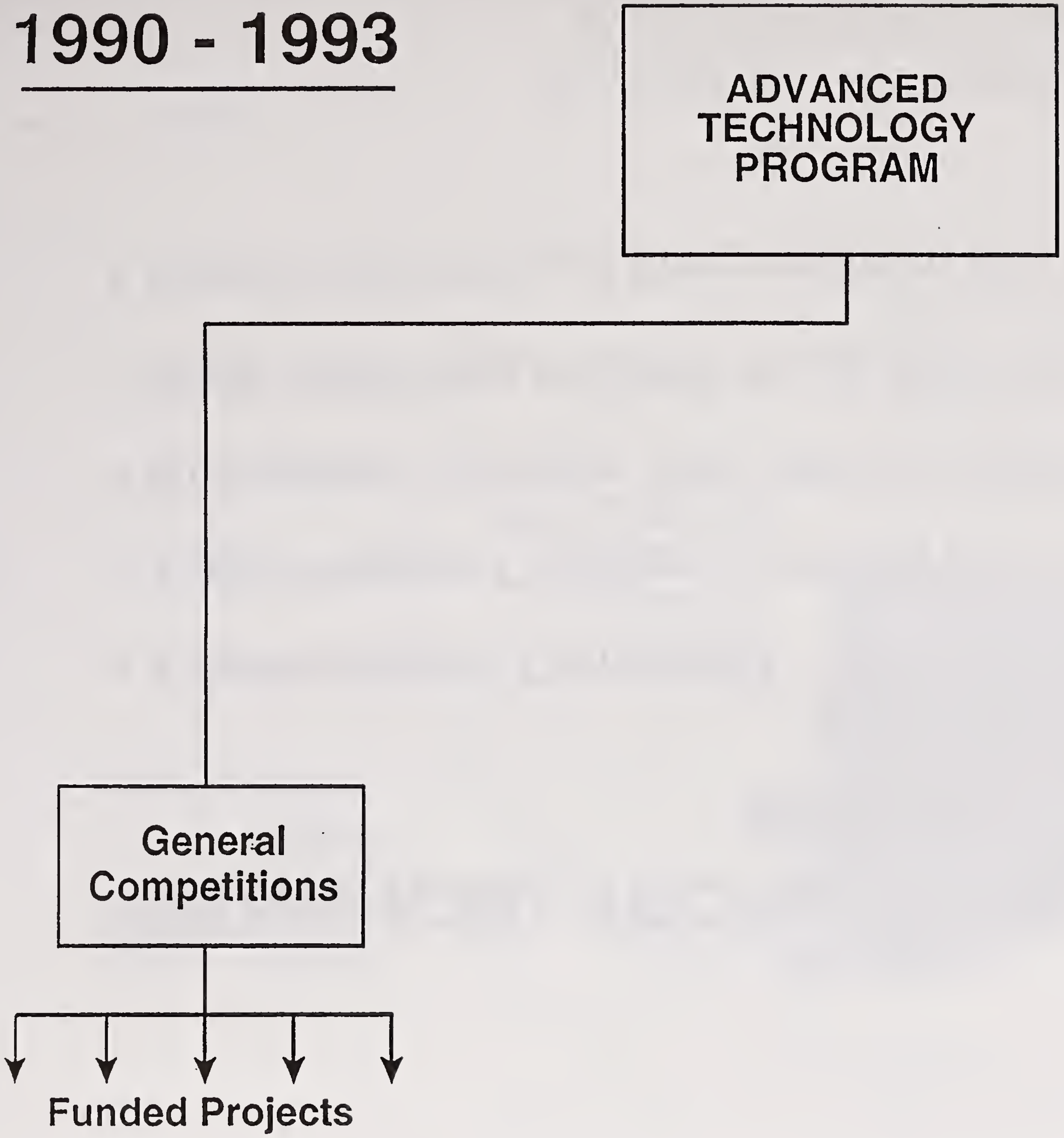
- Joint ventures
  - No more than 5 years
  - No limit on award amount
  - NIST share less than 50%

- No direct funding to universities, government agencies or non-profit independent research institutes

ATP BASIC CHARACTERISTICS

- Unique mission focus - - high-risk enabling technology development to stimulate U.S. economic growth
- Partnership with industry - - industry conceives and proposes ideas, executes and cost-shares projects; ATP applies selection criteria
- Focused and general competitions - - for depth and breadth
- Competitive selection process - - technical and business reviews
- Sunset provisions - - for both programs and projects
- Performance metrics - - for both process and programs

1990 - 1993



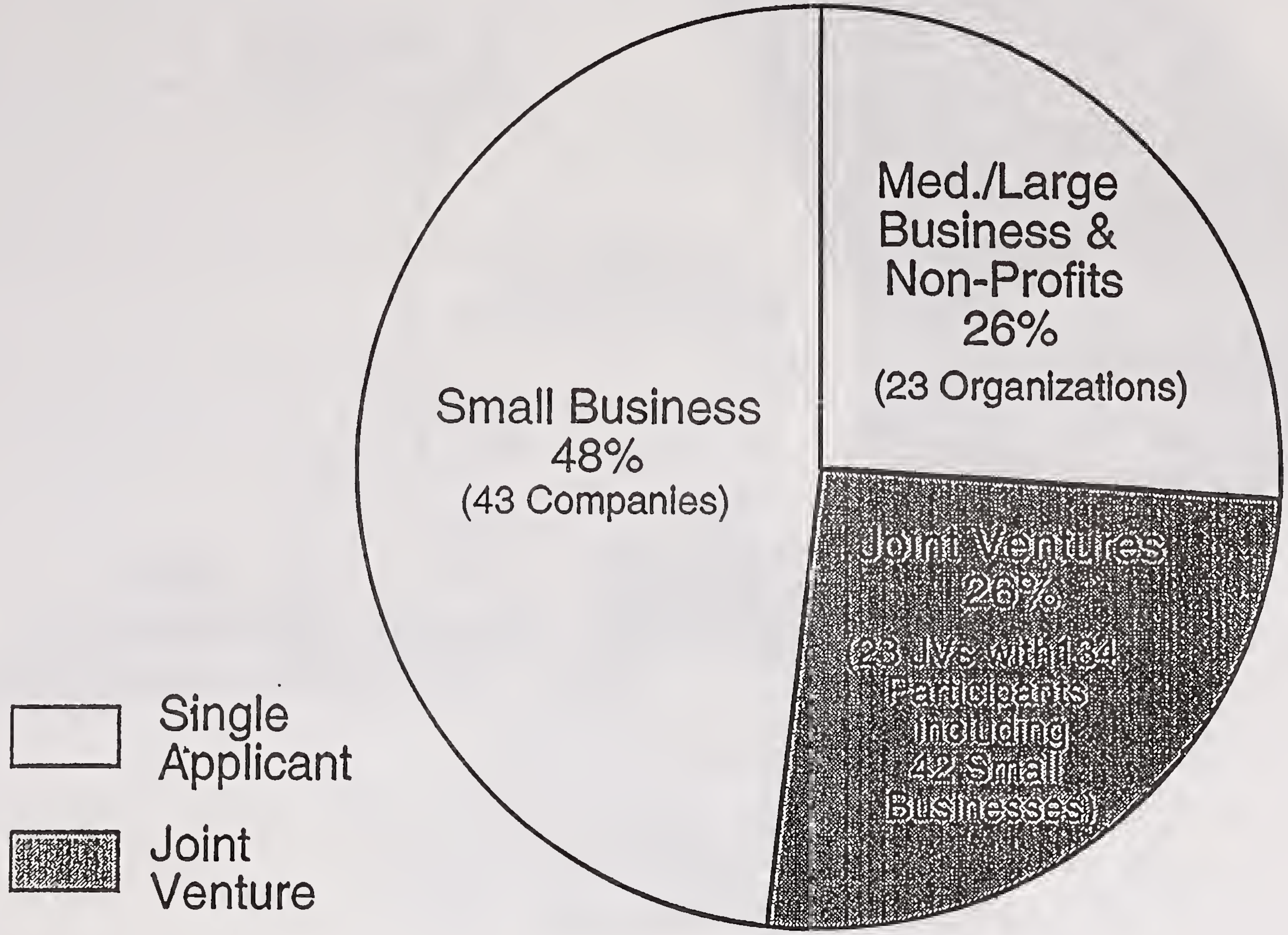
ADVANCED TECHNOLOGY PROGRAM
General Competitions
Funded Projects

ADVANCED TECHNOLOGY PROGRAM:
Status

- 4 Competitions Completed
- 1,000 Projects Totalling $3 Billion of R&D Proposed
- 60 Projects Totalling $400 Million of R&D Funded
- 25-30 Additional Projects Soon to be Announced
- Planned Scale-up of Program from $10 Million to $750 Million

ATP COMPETITIONS 90-01, 91-01, 92-01 & 93-01

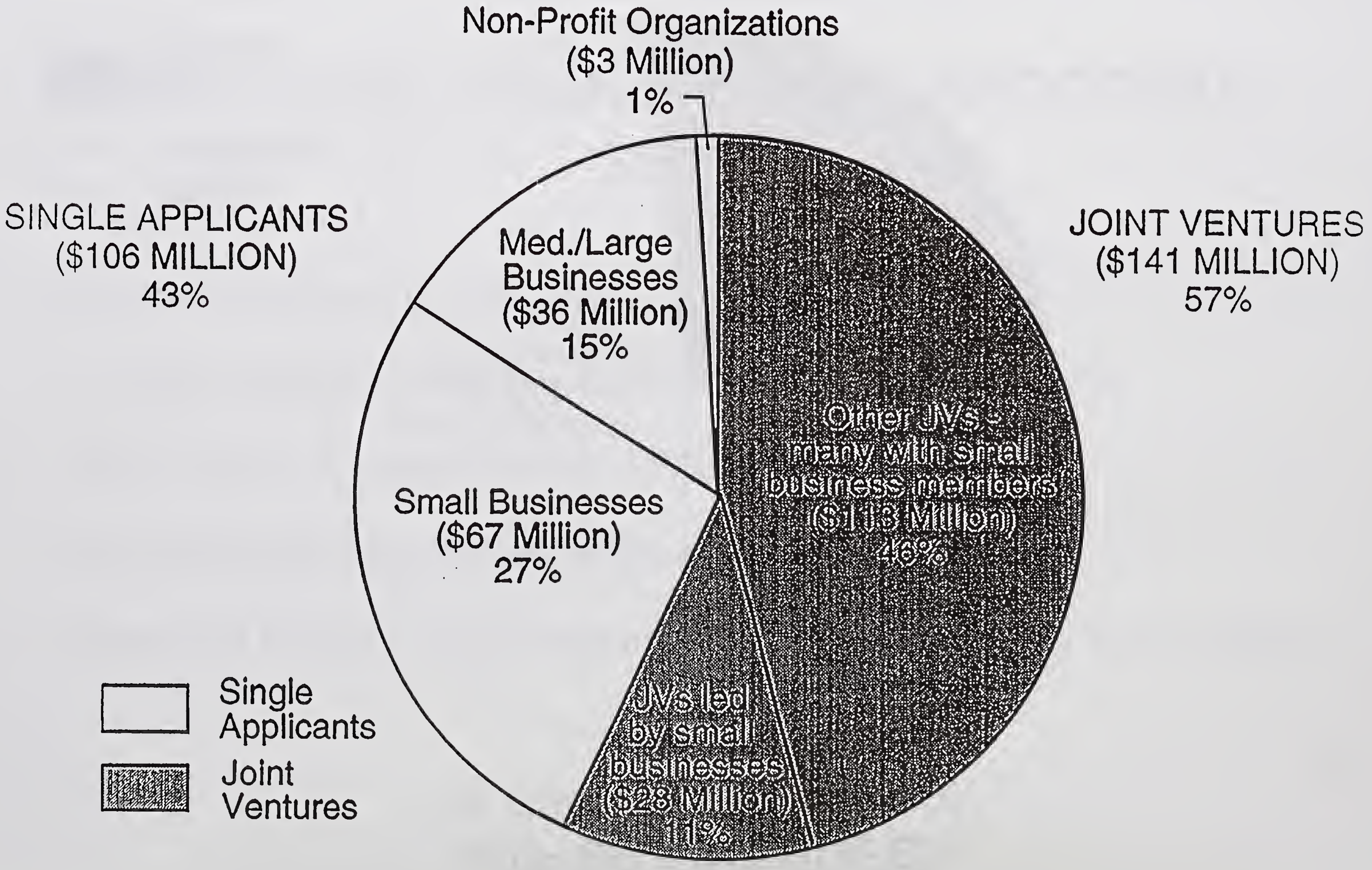
ATP 89 AWARDEES
BY TYPE OF ORGANIZATION



ATP COMPETITIONS 90-01, 91-01, 92-01 & 93-01

$247 MILLION OF ATP FUNDS AWARDED

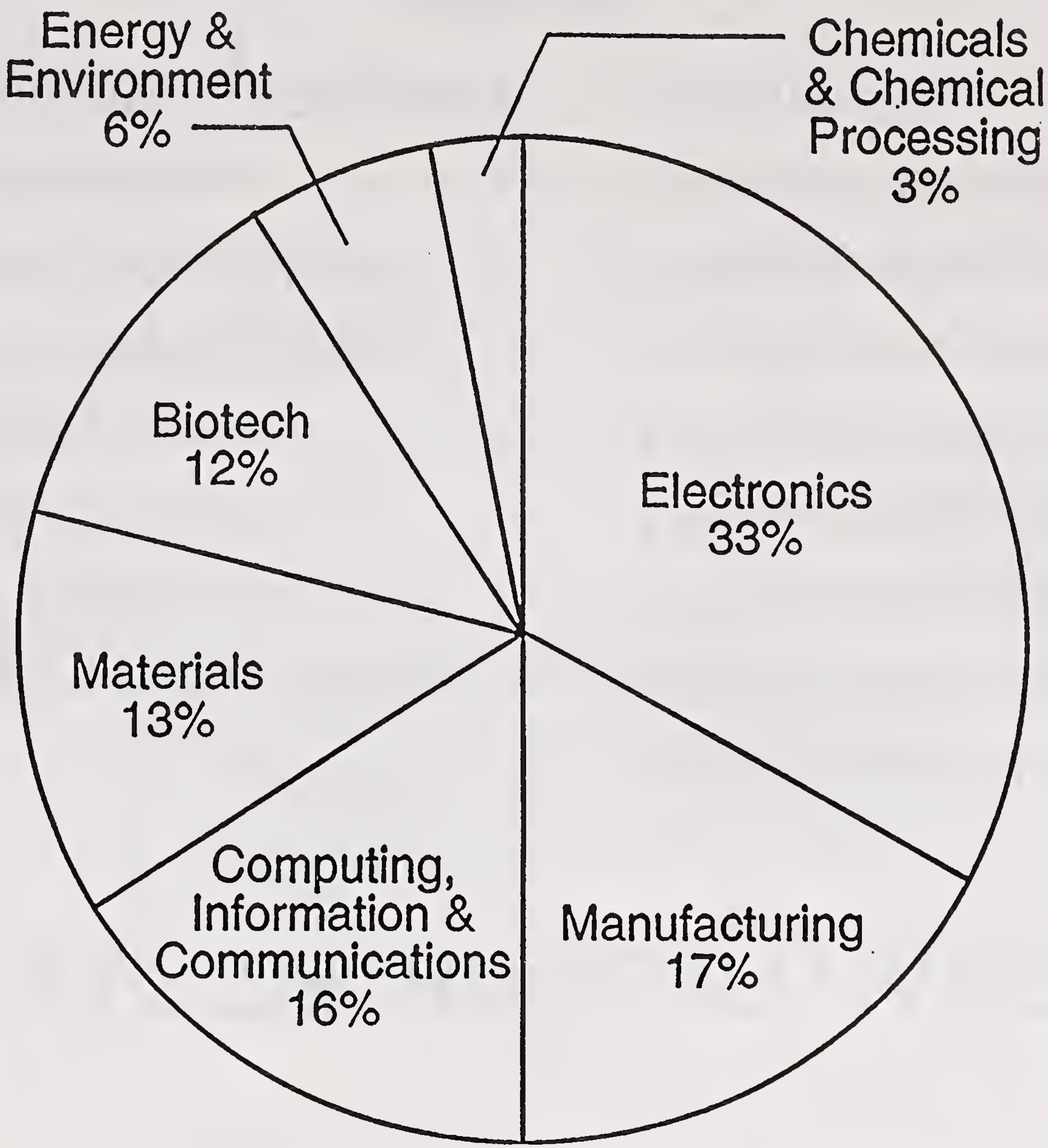
BY TYPE OF ORGANIZATION



ATP COMPETITIONS 90-01, 91-01, 92-01 & 93-01

TECHNOLOGIES FUNDED BY ATP

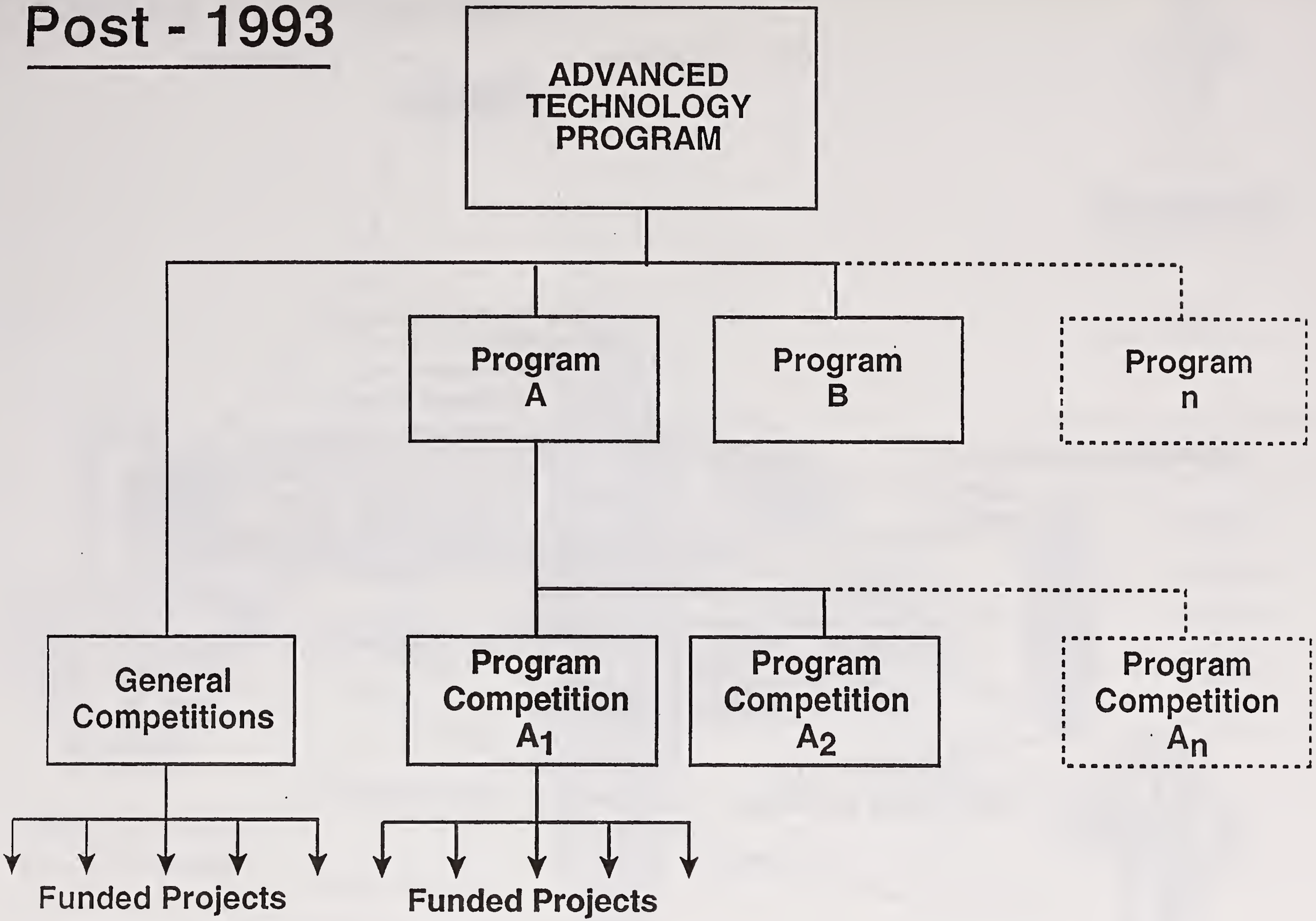
AS A PERCENT OF $247 M AWARDED



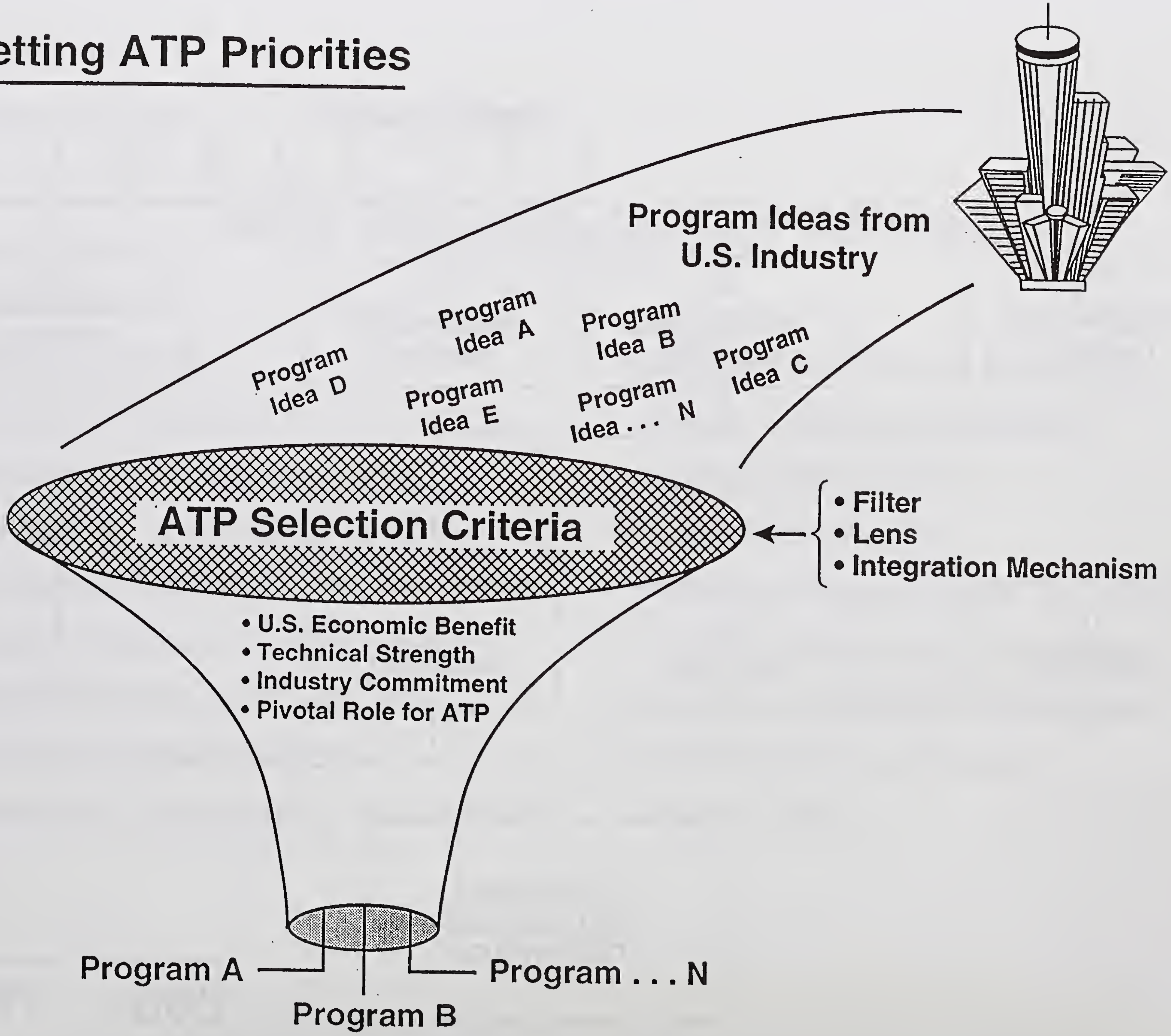
ATP TECHNOLOGY AREAS

- Machine Tools
- Image Recognition & Processing
- Semiconductor Processing
- Genetic & Tissue Engineering
- Flat Panel Displays
- Lasers, Optics & Electro-optics
- High Performance Computers
- Optical Communications
- Ceramics, Composites, & Polymers
- Automated Mfg. & Robotics
- Motor Vehicle Assembly
- Plastic Recycling
- Superconductors
- Energy Conservation & Distribution
- X-ray Lithography & Optics
- Optical & Magnetic Storage
- Printed Wiring Boards
- Illumination

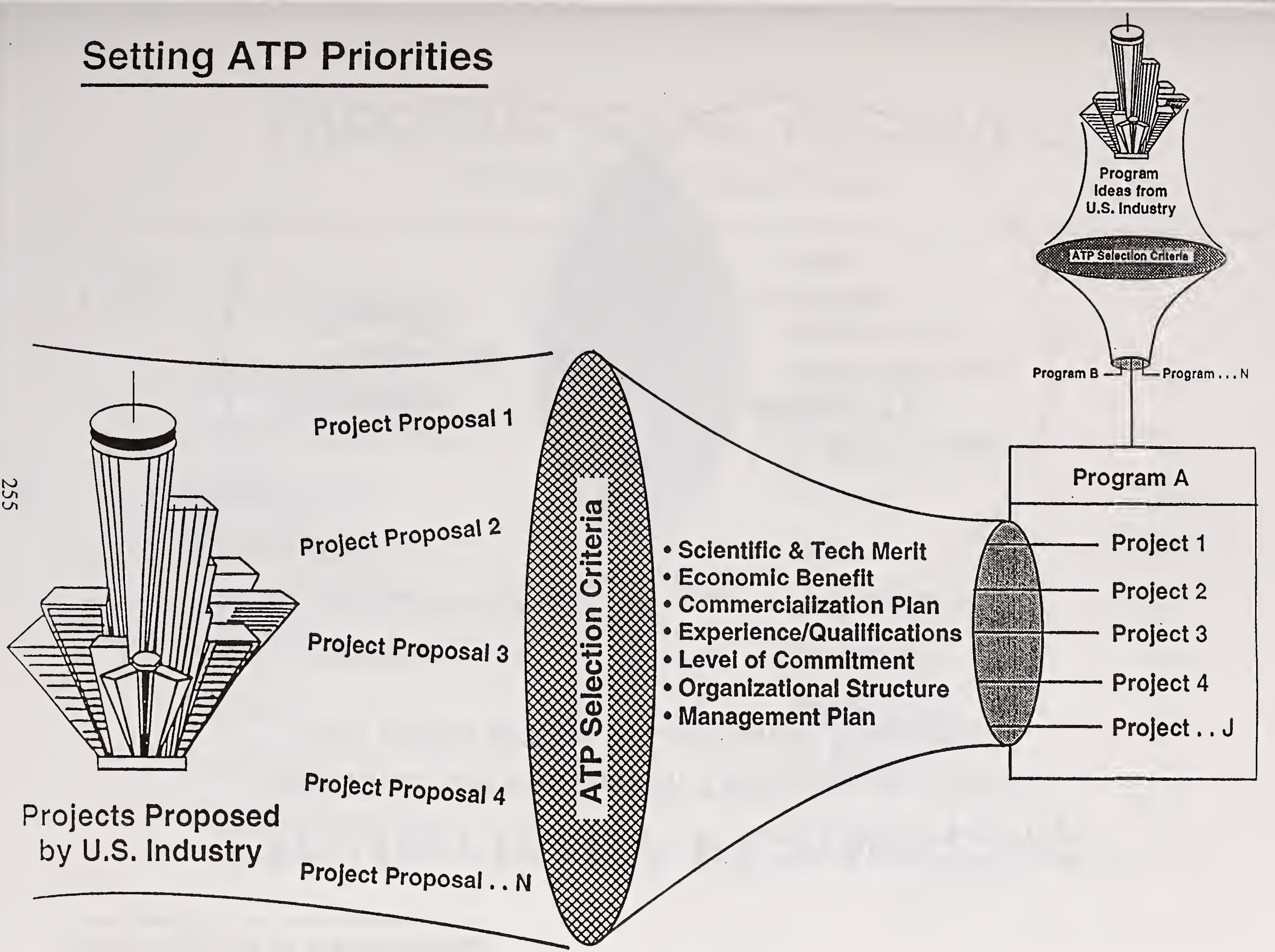
Post - 1993


ADVANCED TECHNOLOGY PROGRAM
Program A
Program B
Program n
General Competitions
Program Competition A_1
Program Competition A_2
Program Competition A_n
Funded Projects
Funded Projects

Setting ATP Priorities



Setting ATP Priorities



Program
Ideas from
U.S. Industry

ATP Selection Criteria

Program B

Program . . . N

Projects Proposed
by U.S. Industry

Project Proposal 1

Project Proposal 2

Project Proposal 3

Project Proposal 4

Project Proposal . . N

ATP Selection Criteria

- Scientific & Tech Merit
- Economic Benefit
- Commercialization Plan
- Experience/Qualifications
- Level of Commitment
- Organizational Structure
- Management Plan

Program A

Project 1

Project 2

Project 3

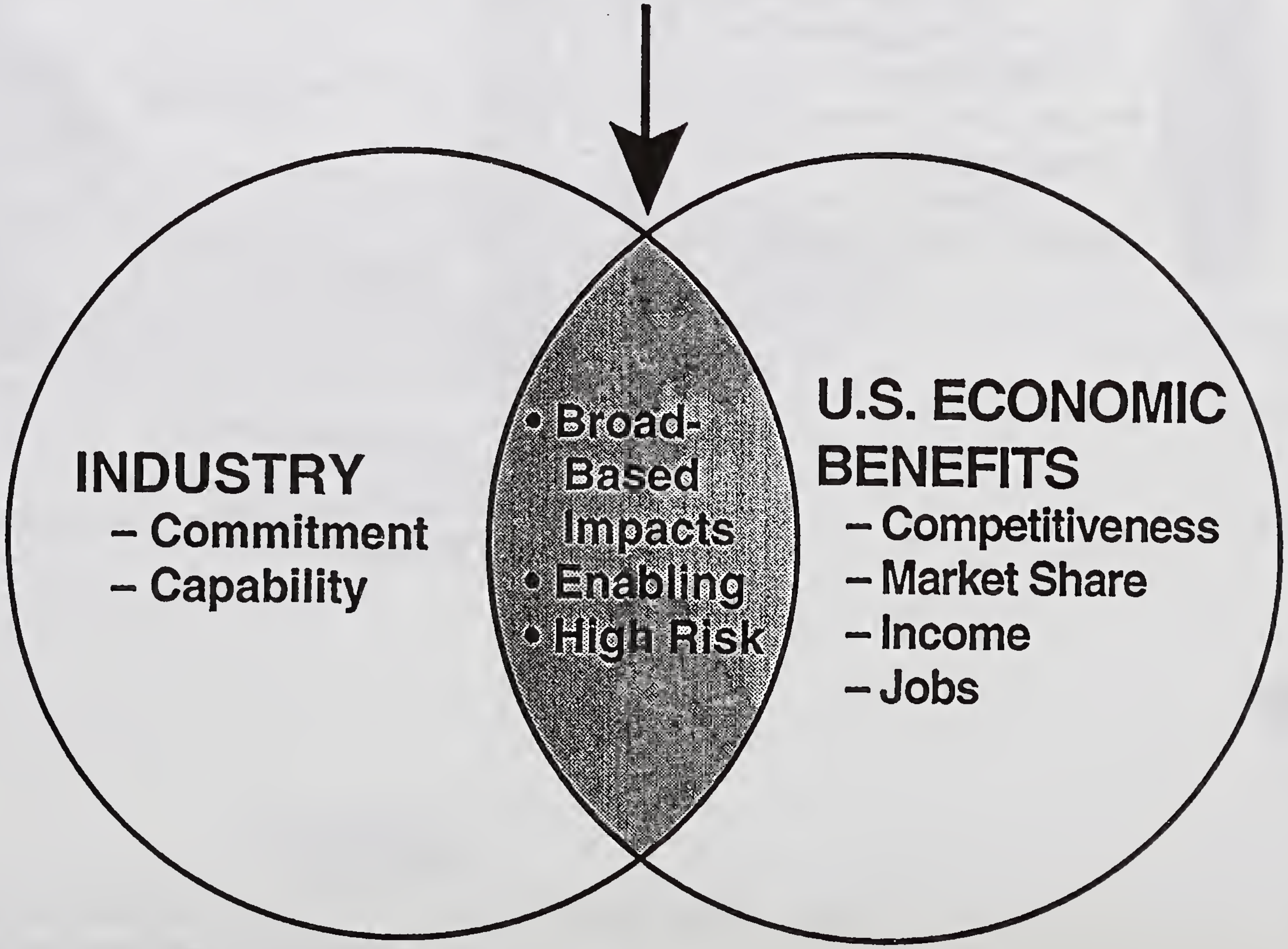
Project 4

Project . . J

Setting ATP Priorities

ATP / INDUSTRY PARTNERSHIP

Identifies Market-Driven Technology Goals that serve National Economic Interests



INDUSTRY
- Commitment
- Capability

- Broad-Based Impacts
- Enabling
- High Risk

U.S. ECONOMIC BENEFITS
- Competitiveness
- Market Share
- Income
- Jobs

PROGRAM IDEAS RECEIVED

(Through February 1994)

- 550 submissions - - ideas still coming in

Biotechnology	51	Chemical	18
Communications	31	Construction	12
Electronics	64	Energy	29
Environment	25	Food	12
Instrumentation	10	Manufacturing	54
Mass Storage	7	Materials	68
Optics	15	Packaging	21
Services	14	Software	73
Transportation	29	Other	17

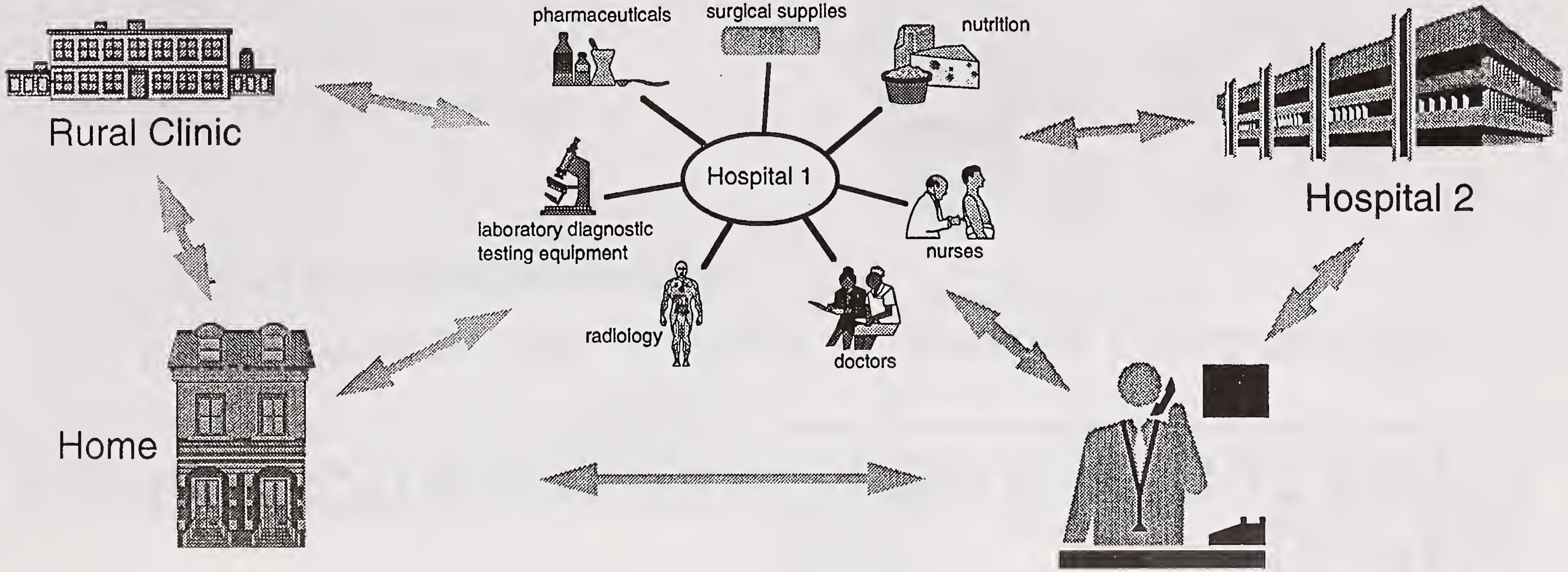
EXTENSIVE INDUSTRY PARTICIPATION

- Industry generated nearly 600 10-page program ideas
- Workshops attended by 3,000 +
  - General Public Meeting
  - Advanced Materials
  - Digital Data Storage
  - Manufacturing Intelligently
  - Biotechnology
  - CIM for Electronics
  - Software (6)
  - Healthcare Info. Tech.
- Program managers made lists of papers public, triggering additional industry dialog
- Many trade associations, professional societies and ad hoc groups held extensive planning meetings
- Key government managers from other agencies attended workshops

INFORMATION INFRASTRUCTURE FOR HEALTHCARE

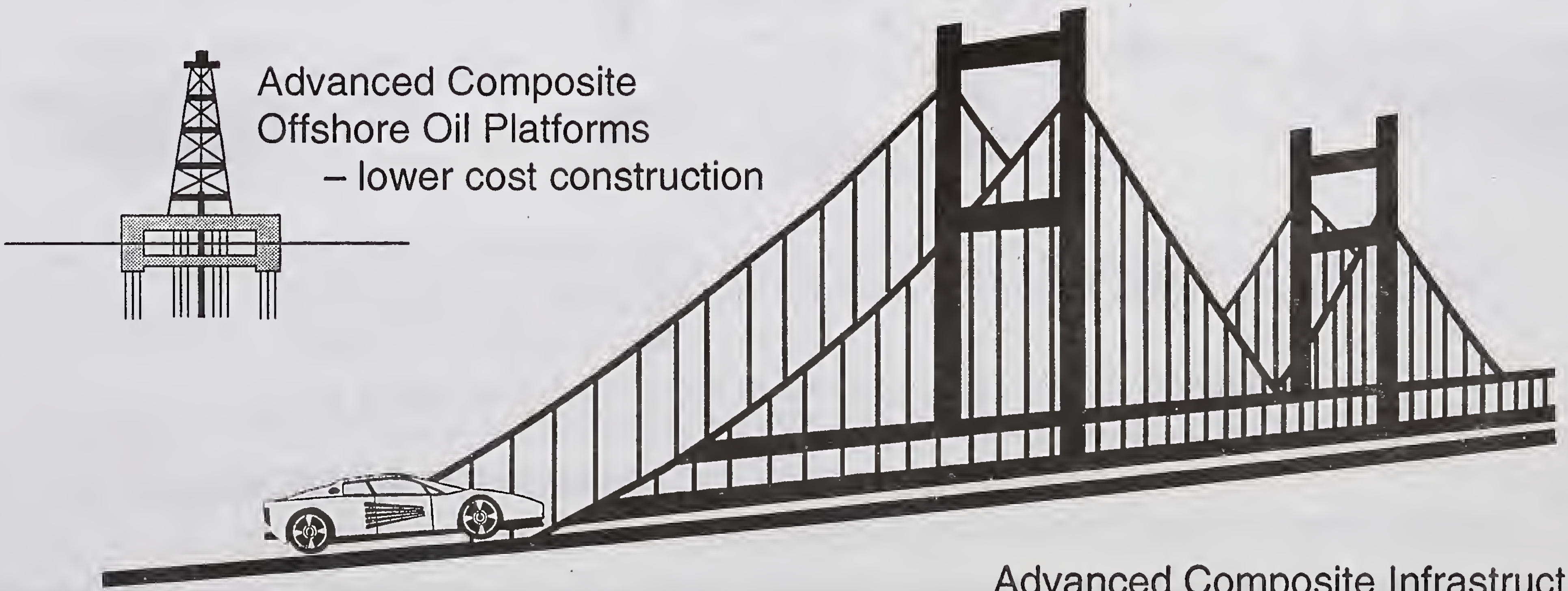
$ 180 million over 5 years to develop the information infrastructure technologies needed to:

- Cut dramatically the 20% of the U.S.'s $1 trillion healthcare cost spent on paper work
- Improve quality and flexible delivery of care by faster, broad access to better information



MANUFACTURING COMPOSITE STRUCTURES

- $160 million over 5 years to develop manufacturing technologies to enable:



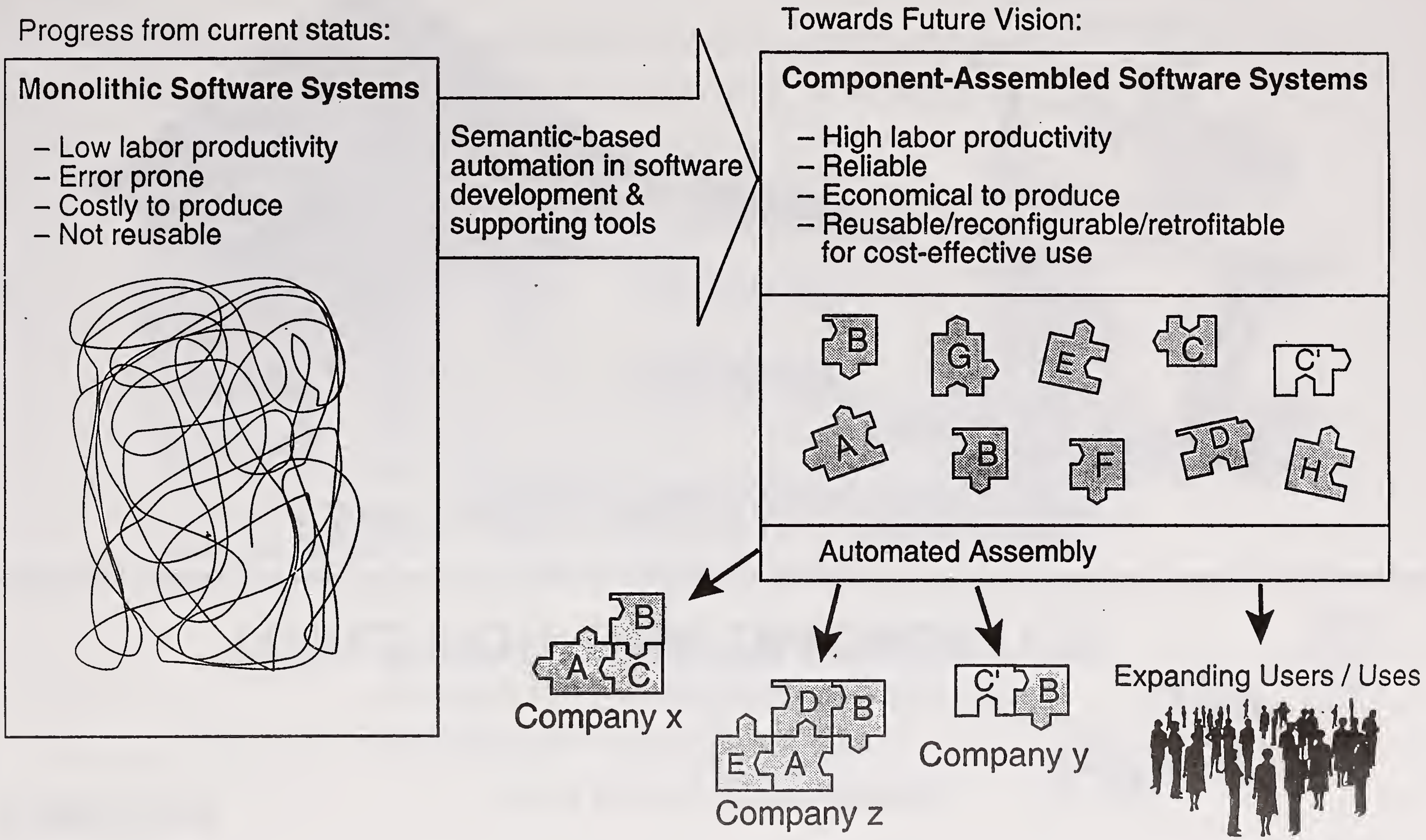
Advanced Composite
Offshore Oil Platforms
  – lower cost construction

Advanced Composite Vehicles
  – fuel efficient
  – recyclable
  – safe

Advanced Composite Infrastructure
  – extended life
  – low maintenance
  – reliable (built-in monitors)

COMPONENT-BASED SOFTWARE

- $150 million over 5 years to enable:



Progress from current status:

Monolithic Software Systems

- Low labor productivity
- Error prone
- Costly to produce
- Not reusable

Semantic-based automation in software development & supporting tools

Towards Future Vision:

Component-Assembled Software Systems

- High labor productivity
- Reliable
- Economical to produce
- Reusable/reconfigurable/retrofitable for cost-effective use

Automated Assembly

Company x

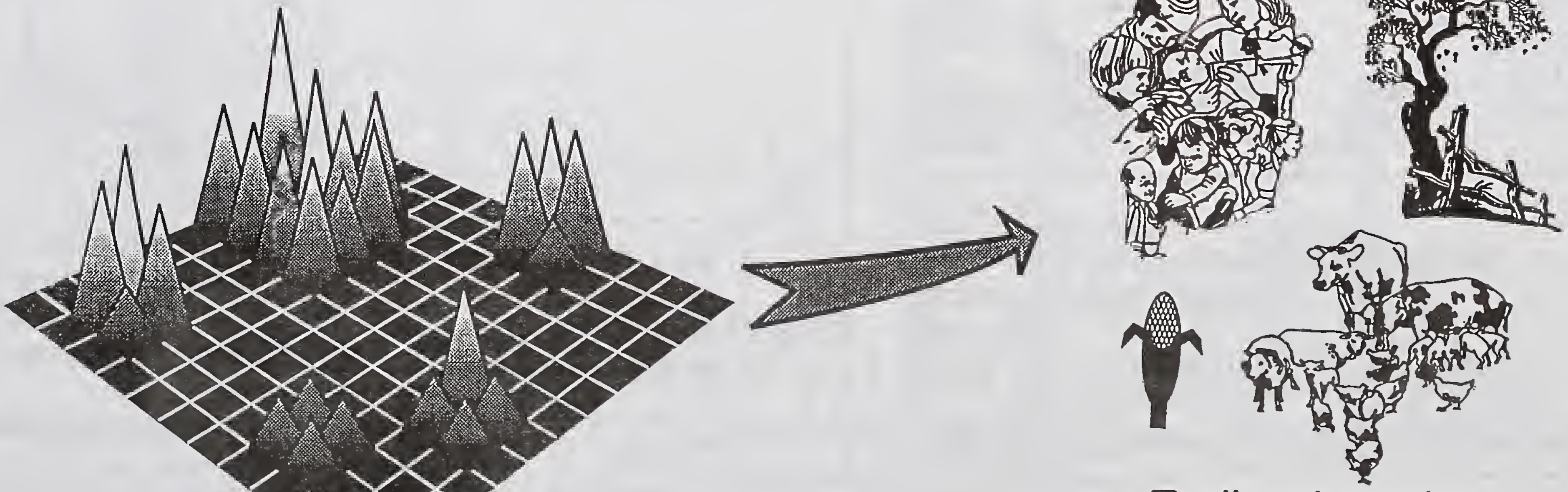
Company z

Company y

Expanding Users / Uses

TOOLS FOR DNA DIAGNOSTICS

- $150 million over 5 years to develop:



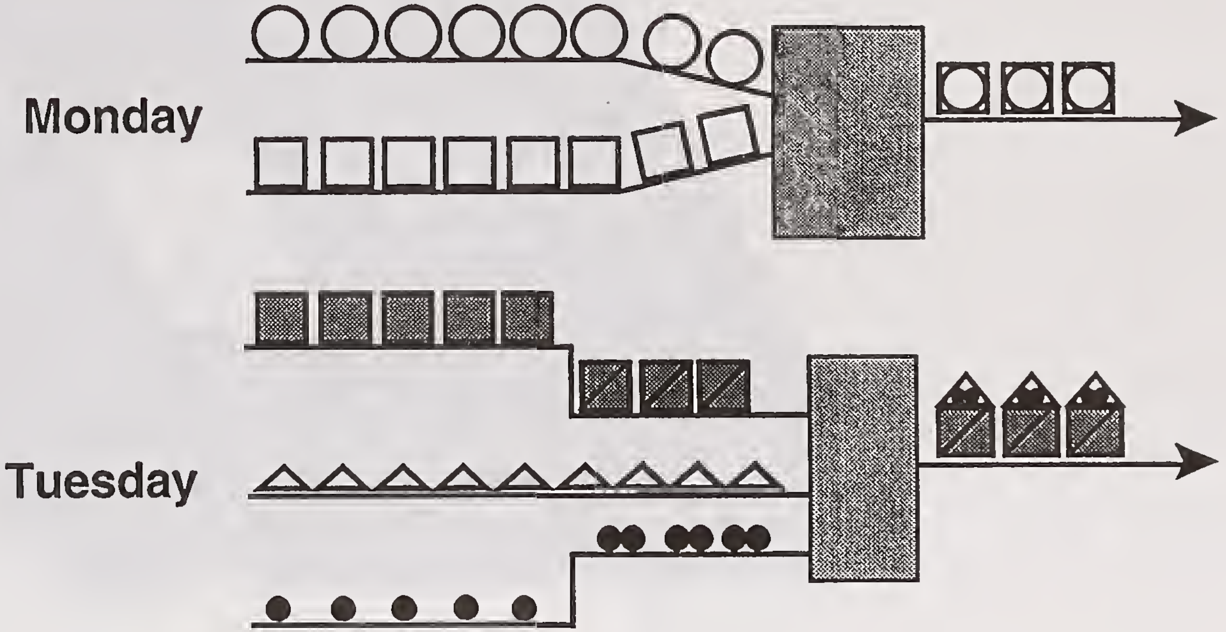
DNA Diagnostic Tools for
Detection of:
- Disease
- Disease Susceptibility

- Earlier detection
- Cheaper detection
- More reliable detection
- Improved disease prevention / control / treatment

COMPUTER - INTEGRATED MANUFACTURING FOR ELECTRONICS

- $110 million over 5 years to develop technology for interoperable, reconfigurable, adaptable electronics manufacturing

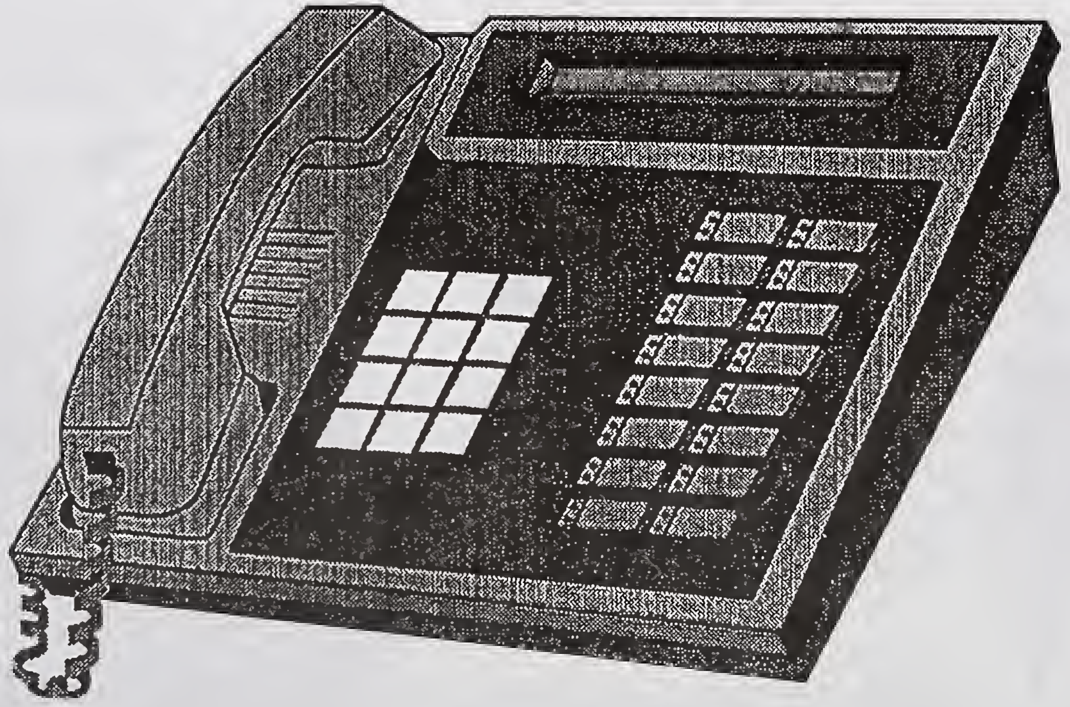
Manufacturing Execution Systems



- Cut manufacturing cycle time in half
- Decrease operating and downtime costs
- Accelerate products to market

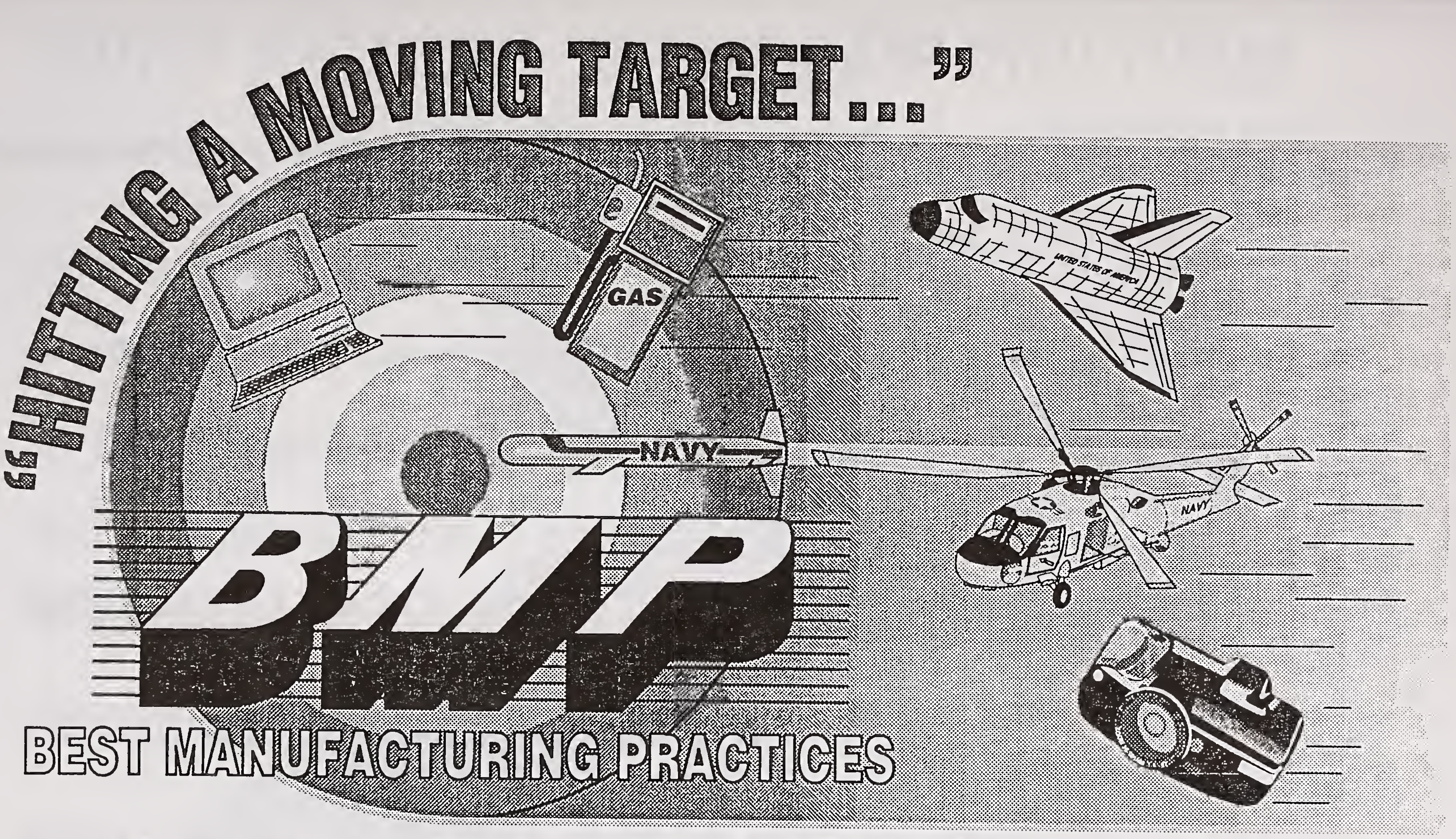
. . . . in a $700 billion industry

Advanced Technology Program
Phone Number



1 - 800 - ATP FUND
287 3863

Appendix H
Best Manufacturing Practices (BMP) Tutorial

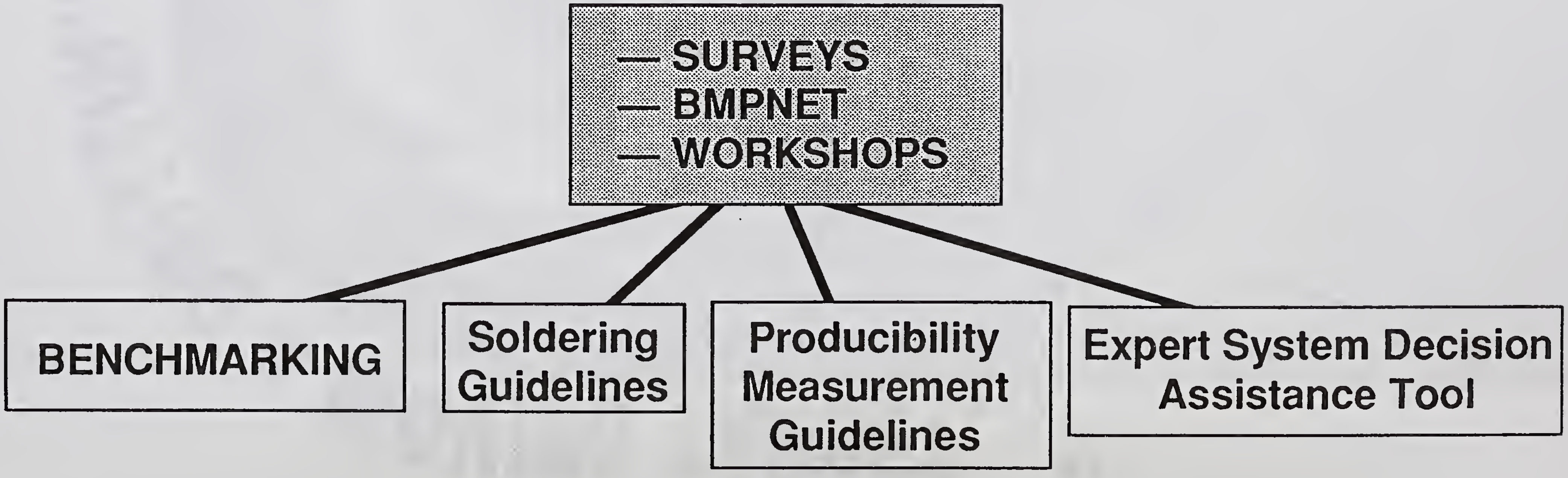


KEEPING PACE WITH THE BEST

ERNIE RENNER
DIRECTOR, BMP PROGRAM
OFFICE OF NAVAL RESEARCH
ARLINGTON, VA 22217
(703) 696-8482

A LOT OF PEOPLE TALK ABOUT PROBLEMS — BMP IS DOING SOMETHING

- MANY OF INDUSTRY'S PROBLEMS ARE SIMILAR
- SOLUTIONS JUST ARE NOT SHARED
- BMP OFFERS AN ACTION-ORIENTED APPROACH



— SURVEYS
— BMPNET
— WORKSHOPS

BENCHMARKING

Soldering Guidelines

Producibility Measurement Guidelines

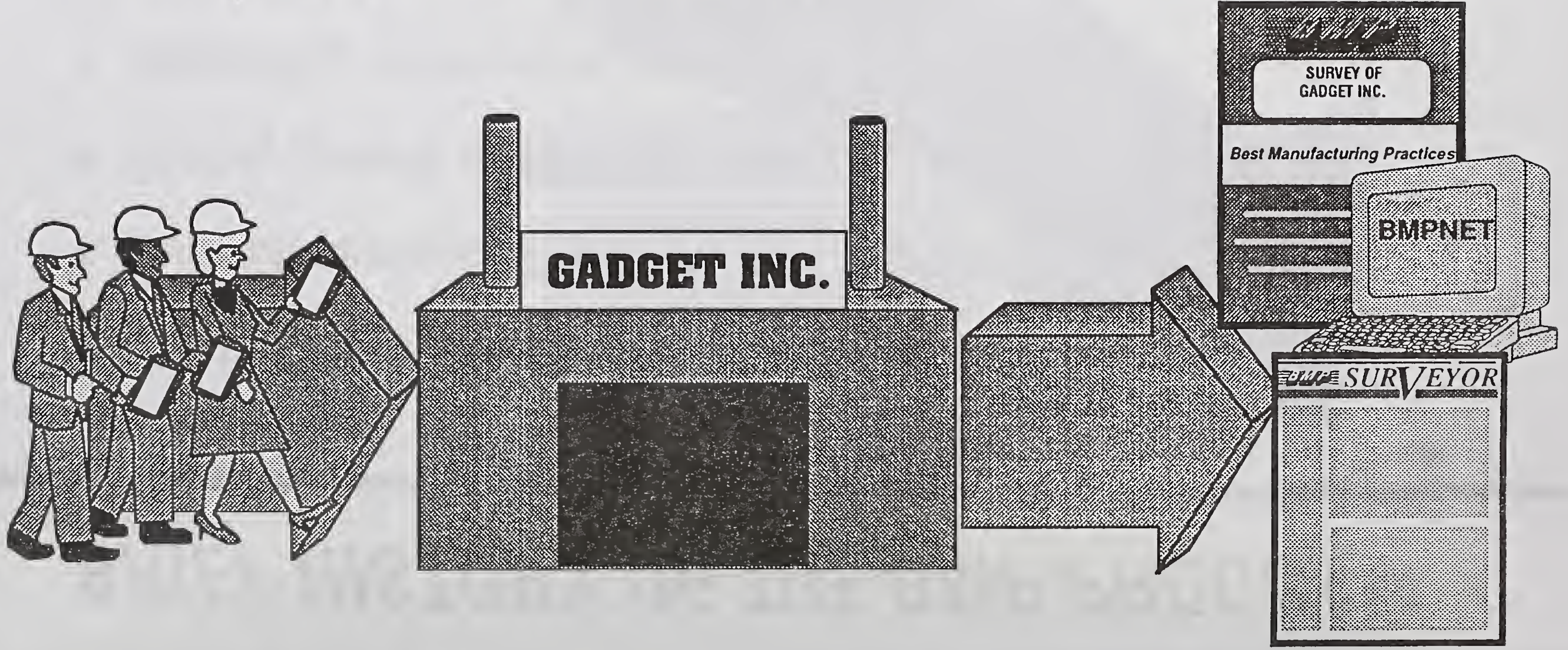
Expert System Decision Assistance Tool

BRIEF HISTORY OF THE BMP PROGRAM

- Started 1985 to find excellence in Navy contractors
- Over 50 surveys of industry and government
- Steady growth of BMPNET users
- Expanding surveys of non-military companies
- Unique tech transfer facilitator partnering with:
  - Defense
  - Commerce
  - NASA
  - Energy
  - FAA
  - Industry

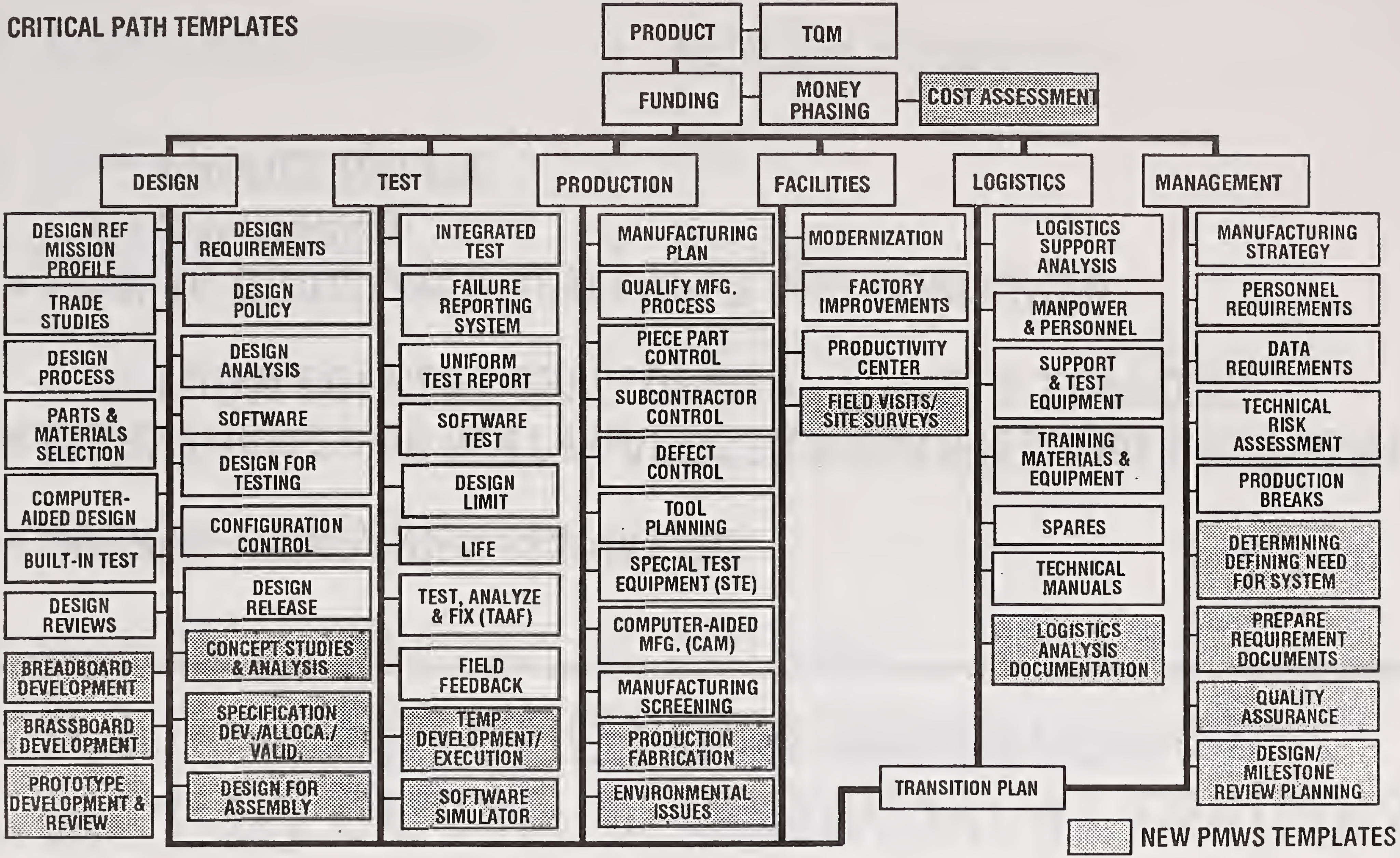
SURVEYS:
THE HEART OF THE BMP PROGRAM

- Surveys document best practices at defense/commercial companies, and government activities
- Reports validated information
- Results provide data for the BMPNET



BMP SURVEYS BASED ON...

CRITICAL PATH TEMPLATES



VALUE OF BMP RECOGNIZED BY LEADERS IN AMERICAN INDUSTRY

- OVER 60 COMPANIES SURVEYED
- MORE THAN 2,000 BEST PRACTICES IDENTIFIED AND DOCUMENTED
  - FROM CONCEPT DEVELOPMENT TO FIELD SUPPORT
- HOW-TO GUIDELINES DEVELOPED AND PUBLISHED
  - SOLDERING
  - PRODUCIBILITY

COMPANIES SURVEYED

- LITTON
- TEXAS INSTRUMENTS
- HARRIS
- CONTROL DATA
- ITT
- UNISYS
- BELL HELICOPTER
- McDONNELL-DOUGLAS
- STANDARD INDUSTRIES
- WATERVLIET
- HONEYWELL
- GENERAL DYNAMICS
- IBM
- HUGHES
- ROCKWELL
- MOTOROLA
- GTE
- NORTHROP
- ENGINEERED CIRCUIT RESEARCH
- CONAX

COMPANIES SURVEYED (Cont'd)

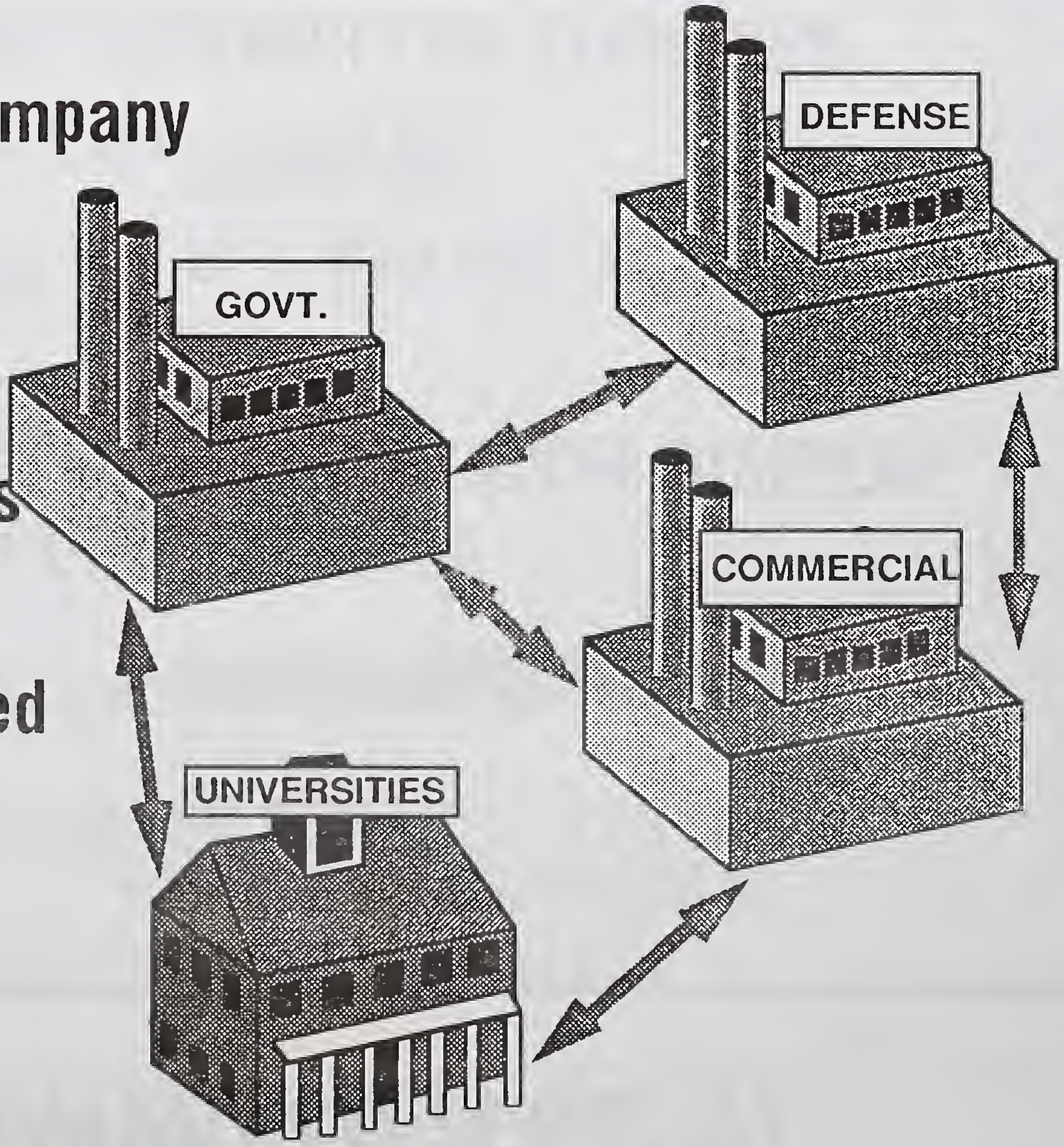
- TELEDYNE INDUSTRIES
- WESTINGHOUSE
- TRICOR
- BOEING
- TEXRON LYCOMING
- NAVAL AVIONICS CENTER
- KURT MANUFACTURING
- RAYTHEON
- TANDEM
- HEWLETT-PACKARD
- LOCKHEED
- GENERAL ELECTRIC
- TRW
- TMC
- NORDEN SYSTEMS
- UNITED ELECTRIC CONTROLS
- MAGNETEK DEFENSE SYSTEMS
- AT&T FEDERAL SYSTEMS
- CHARLESTON NAVAL SHIPYARD
- DIGITAL EQUIPMENT CORP.

COMPANIES SURVEYED (Cont'd)

- COMPUTING DEVICES INTERNATIONAL
- MARSHALL SPACE FLIGHT CENTER
- MARTIN MARIETTA ENERGY SYSTEMS
- PHILADELPHIA NAVAL SHIPYARD
- CRYSTAL GATEWAY MARRIOTT
- ALPHA INDUSTRIES
- NADEP PENSACOLA
- NADEP JACKSONVILLE
- NSWC – CRANE DIVISION
- R.J. REYNOLDS TOBACCO COMPANY
- HAMILTON STANDARD

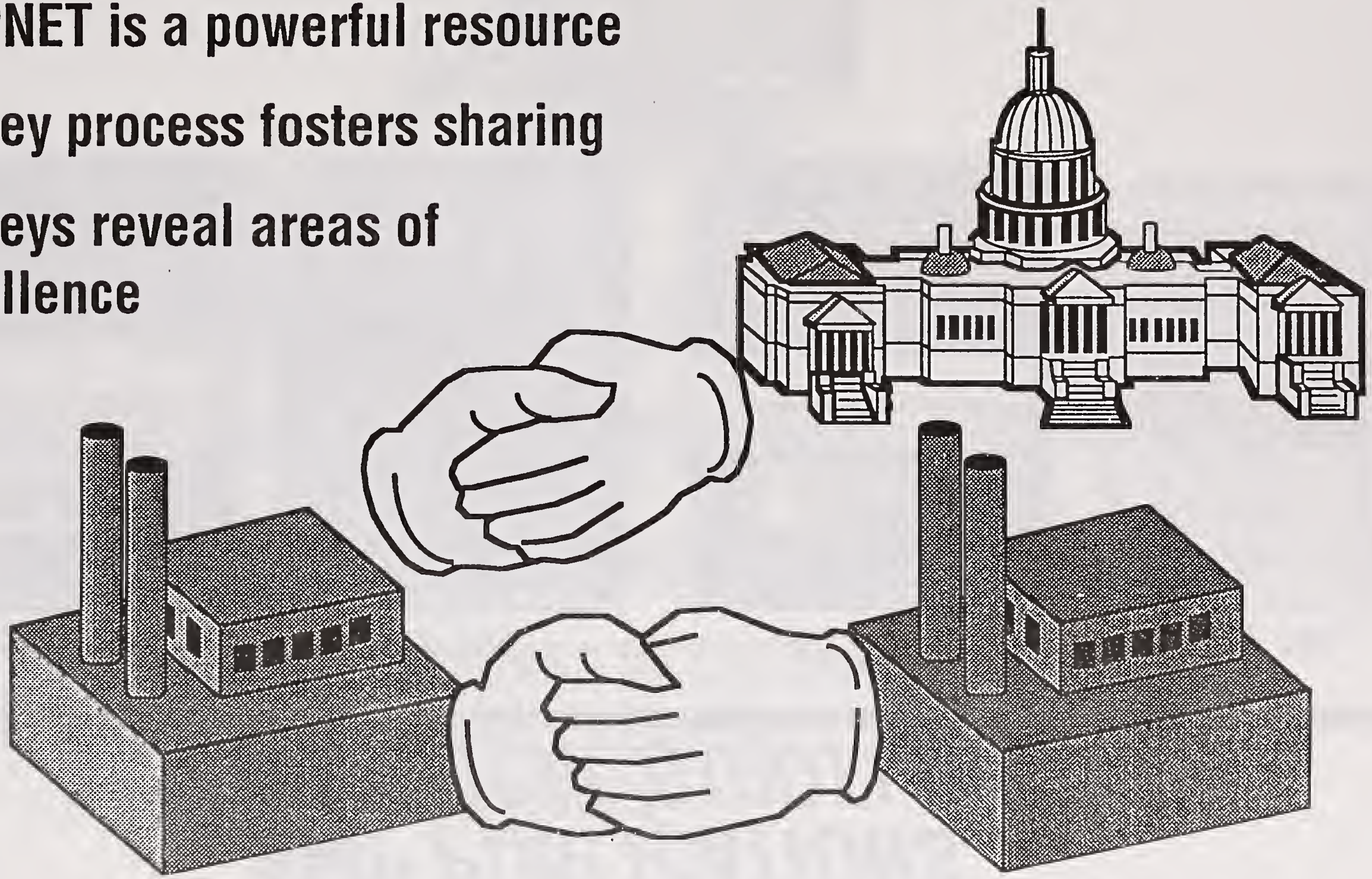
BENEFITS TO INDUSTRY

- Benchmarking at no cost to the company
- BMP publicizes best practices
- Company recognition
- PMWS, BMPNET, and publications facilitate technology transfer
- Common problems are documented and resolved
- Competitive edge is maintained



BENEFITS TO GOVERNMENT

- Technology transfer saves the government money
- BMPNET is a powerful resource
- Survey process fosters sharing
- Surveys reveal areas of excellence



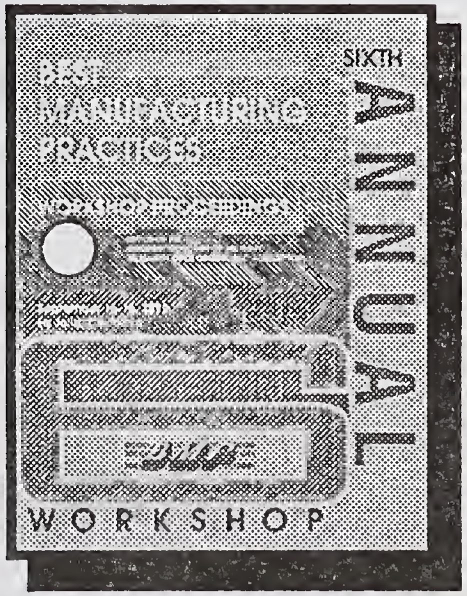
BMP PUBLICATIONS...
TECHNICAL GUIDELINES

1985-1992

RAYTHEON MISSILE
SYSTEMS DIVISION

Best Manufacturing Practices

1987-1992

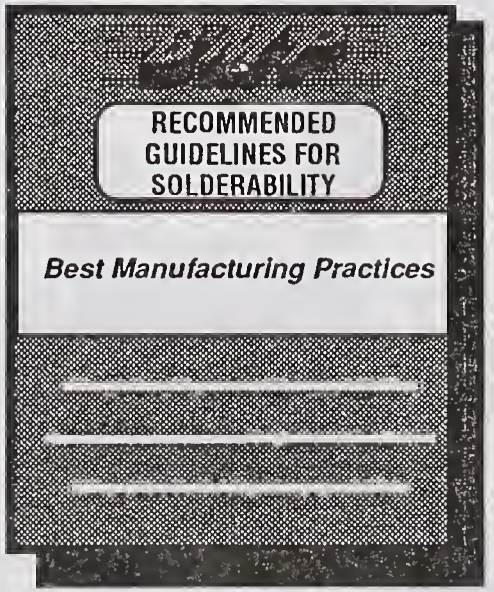


BEST
MANUFACTURING
PRACTICES

WORKSHOP PROCEEDINGS

SIXTH
ANNUAL
WORKSHOP

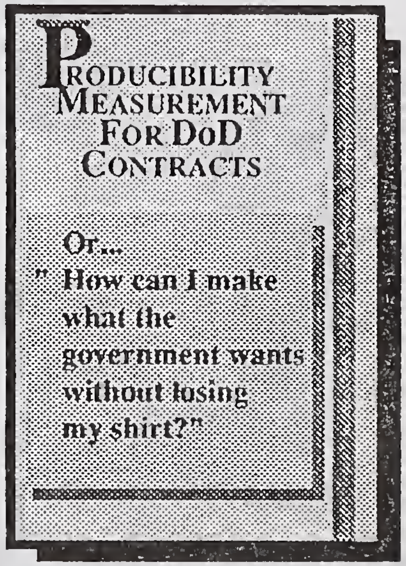
JULY 1990



RECOMMENDED
GUIDELINES FOR
SOLDERABILITY

Best Manufacturing Practices

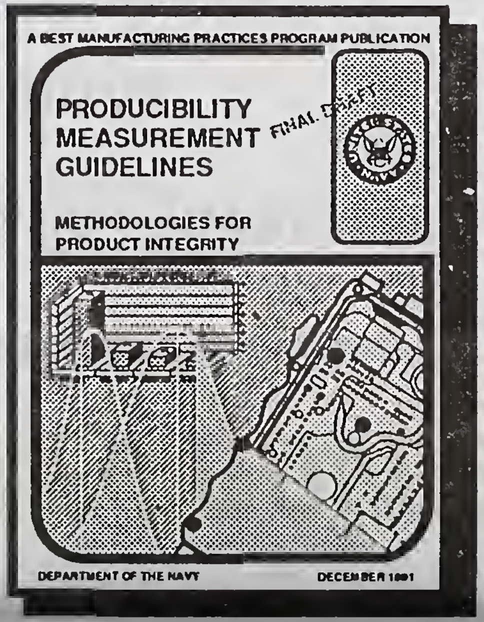
JULY 1990



PRODUCIBILITY
MEASUREMENT
FOR DOD
CONTRACTS

Or...
" How can I make
what the
government wants
without losing
my shirt?"

DECEMBER 1991



A BEST MANUFACTURING PRACTICES PROGRAM PUBLICATION

PRODUCIBILITY
MEASUREMENT
GUIDELINES

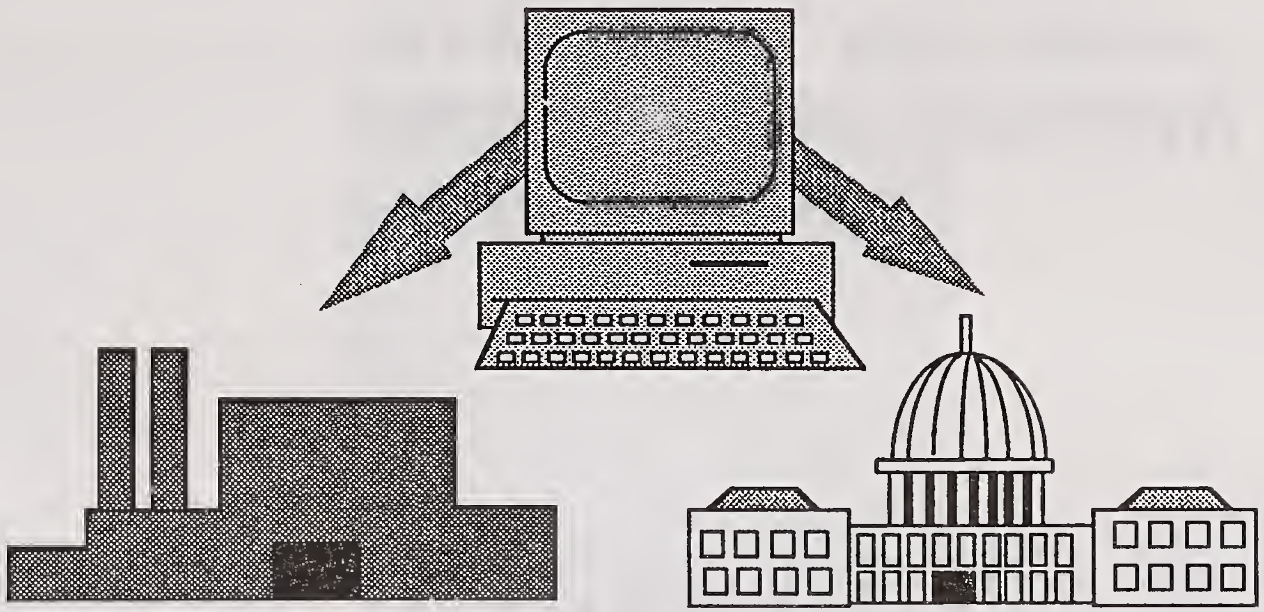
FINAL DRAFT

METHODOLOGIES FOR
PRODUCT INTEGRITY

DEPARTMENT OF THE NAVY

DECEMBER 1991

KEEPING PACE WITH THE BEST

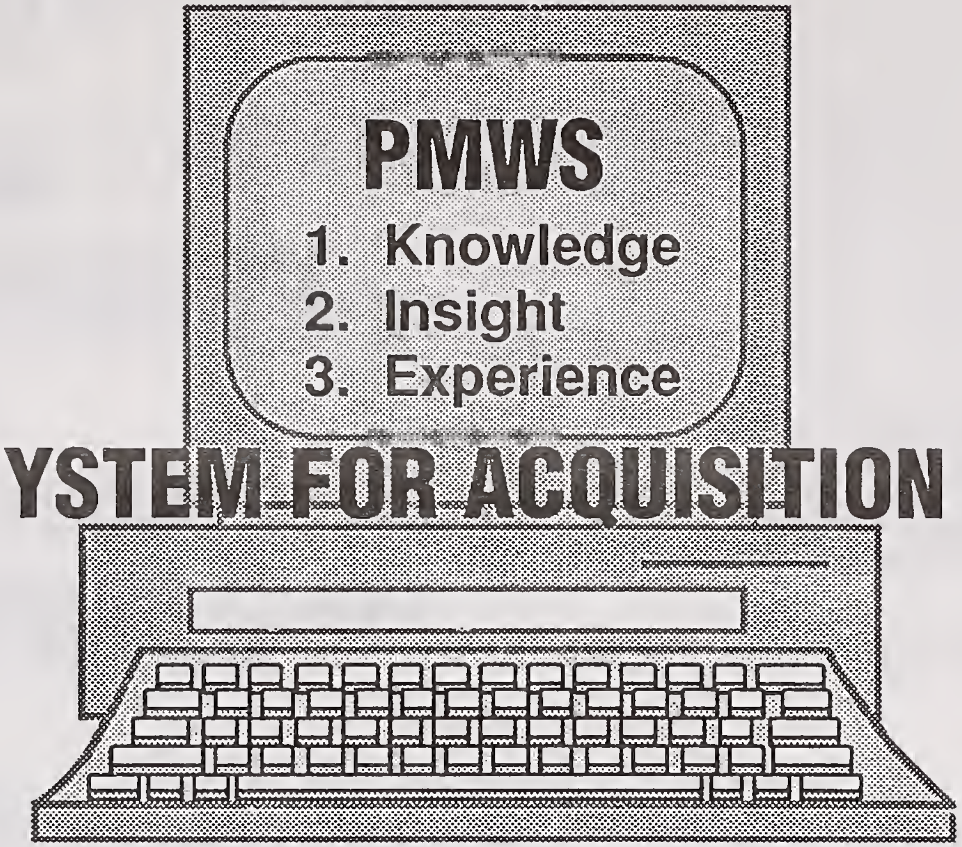


- AMERICAN INDUSTRY AND GOVERNMENT TEAMING TO SHARE THE BEST
  - — NEW IDEAS, METHODS, AND MATERIALS
- A WAY TO AVOID SURPRISES IN THE WORLD'S MOST COMPLICATED TECHNICAL PROCESS
  - — DEFENSE ACQUISITION

FOR MORE INFORMATION ON BEST MANUFACTURING PRACTICES, PLEASE CALL:

ERNIE RENNER
DIRECTOR, BMP PROGRAM
OFFICE NAVAL RESEARCH
ARLINGTON, VA 22217
(703)696-8482

PROGRAM MANAGER'S WORKSTATION



AN EXPERT SYSTEM FOR ACQUISITION MANAGEMENT

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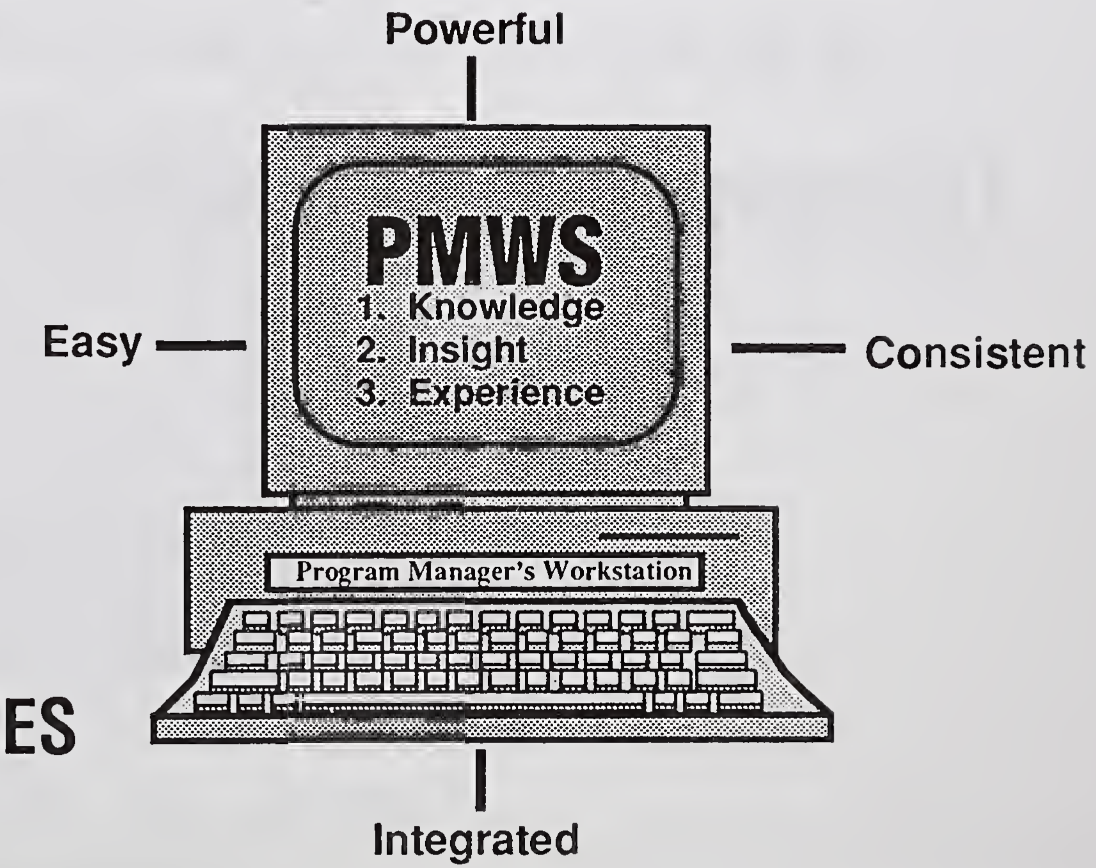
OFFICE NAVAL RESEARCH
ARLINGTON, VA 22217
(703) 696-8482

BMPNET: PROGRAM MANAGER'S WORKSTATION

AN EXPERT SYSTEM DECISION ASSISTANCE TOOL

- KNOW-HOW
  - — RAPID ACCESS TO KEY INFORMATION
- TRIMS
  - — RISK ASSESSMENT PROGRAM
- BMP DATA BASE
  - — VERIFIED BEST PRACTICES



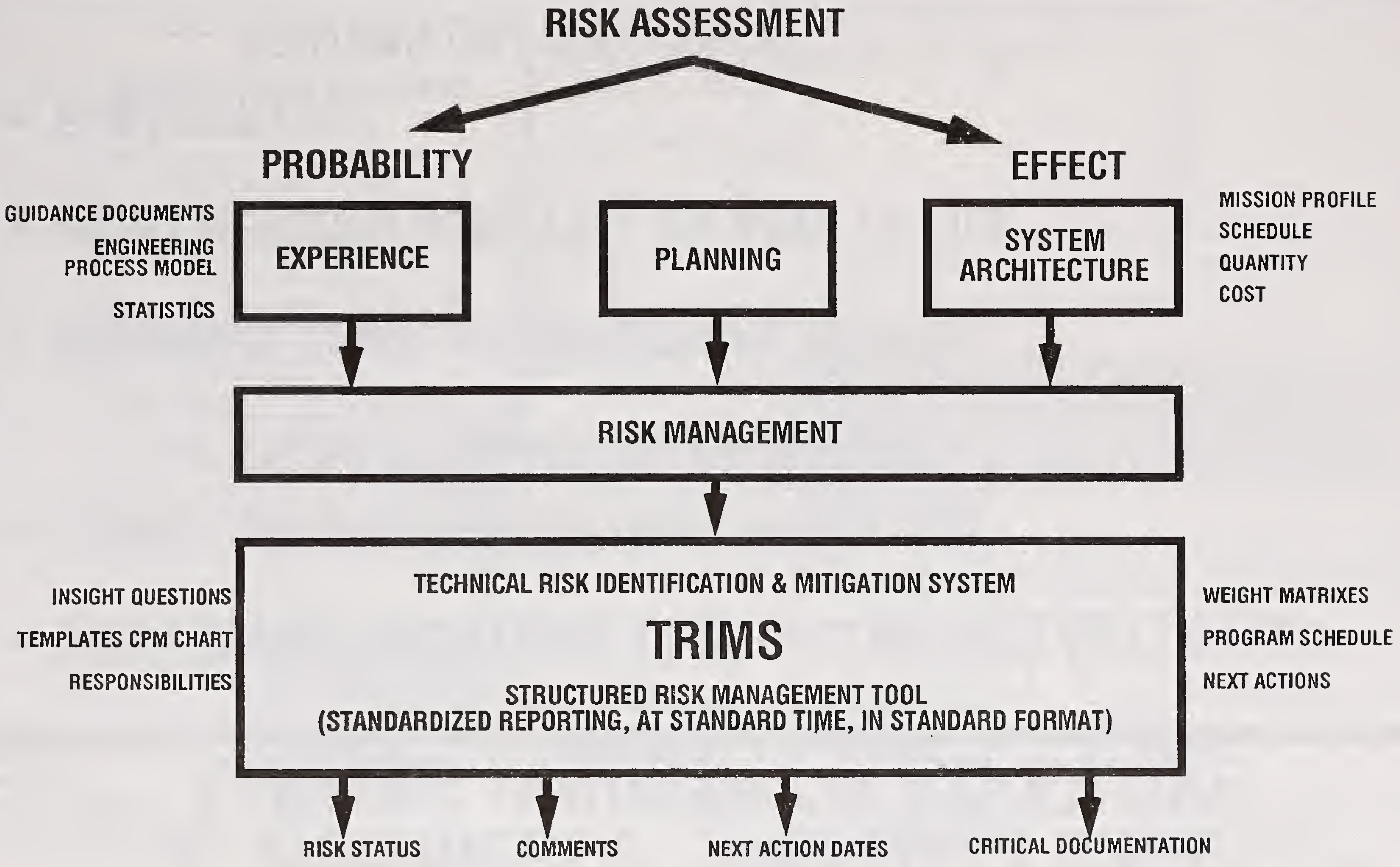
1. *KNOWLEDGE "KNOW-HOW" GUIDANCE AND COMPLIANCE*

- FAST ACCESS TO KEY INFORMATION
- CUTS DOCUMENT SEARCH TIME BY UP TO 95%
- SPECIAL LOGIC-DRIVEN MENUS
- EXCLUSIONARY ENGINE, FINDS WHAT YOU WANT
- ON-LINE USERS MANUAL
- A LEARNING TOOL FOR NEW PERSONNEL

2. *INSIGHT "TRIMS" RISK REDUCTION*

- BASED ON DoD 4245.7-M, NAVSO P-6071, DoD 5000 series (.1, .2, .2-M)
- TIED TO PROGRAM DOCUMENTATION, NOT TECHNOLOGY DRIVEN
- TRACKS PROGRAM MANAGER'S GOALS & RESPONSIBILITIES
- RANKS RISK (HIGH, MEDIUM, LOW)
- USER FRIENDLY, DOWNLOAD TO PROTECT, TAILORABLE
- IN USE BY NUMEROUS PROGRAMS

RISK MANAGEMENT PROCESS



RISK ASSESSMENT

PROBABILITY

EFFECT

GUIDANCE DOCUMENTS

ENGINEERING PROCESS MODEL

STATISTICS

EXPERIENCE

PLANNING

SYSTEM ARCHITECTURE

MISSION PROFILE

SCHEDULE

QUANTITY

COST

RISK MANAGEMENT

INSIGHT QUESTIONS

TEMPLATES CPM CHART

RESPONSIBILITIES

TECHNICAL RISK IDENTIFICATION & MITIGATION SYSTEM

TRIMS

STRUCTURED RISK MANAGEMENT TOOL
(STANDARDIZED REPORTING, AT STANDARD TIME, IN STANDARD FORMAT)

WEIGHT MATRIXES

PROGRAM SCHEDULE

NEXT ACTIONS

RISK STATUS

COMMENTS

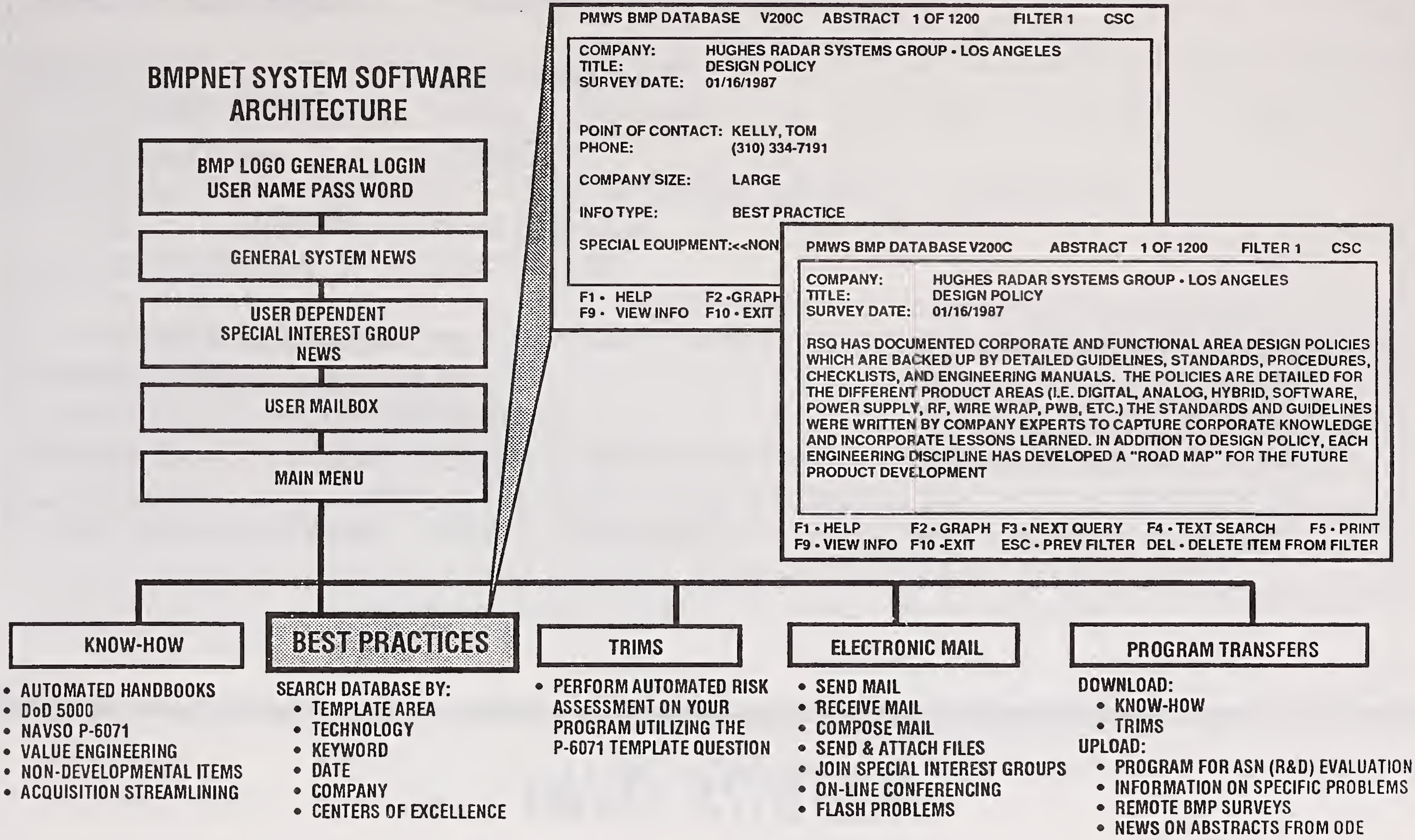
NEXT ACTION DATES

CRITICAL DOCUMENTATION

3. *EXPERIENCE "BMP DATA BASE"*
TAPPING INDUSTRY'S EXPERTISE

- DON'T INVENT SOLUTIONS TO PROBLEMS ALREADY SOLVED
- OVER 1,500 DOCUMENTED BEST PRACTICES
  - — FROM DESIGN TO MANAGEMENT
- KEYWORD, TEMPLATE OR SCROLL SEARCH
- PRINT REPORTS REMOTELY OR SAVE TO FILE
- E-MAIL HELP
  - — CENTERS OF EXCELLENCE
  - — COMMON INTEREST GROUPS

THE BEST PRACTICES DATA BASE



BMPNET SYSTEM SOFTWARE ARCHITECTURE

- BMP LOGO GENERAL LOGIN USER NAME PASS WORD
- GENERAL SYSTEM NEWS
- USER DEPENDENT SPECIAL INTEREST GROUP NEWS
- USER MAILBOX
- MAIN MENU

PMWS BMP DATABASE V200C ABSTRACT 1 OF 1200 FILTER 1 CSC

COMPANY: HUGHES RADAR SYSTEMS GROUP • LOS ANGELES
TITLE: DESIGN POLICY
SURVEY DATE: 01/16/1987

POINT OF CONTACT: KELLY, TOM
PHONE: (310) 334-7191

COMPANY SIZE: LARGE

INFO TYPE: BEST PRACTICE

SPECIAL EQUIPMENT:<<NON

F1 • HELP F2 •GRAPH
F9 • VIEW INFO F10 • EXIT

PMWS BMP DATABASE V200C ABSTRACT 1 OF 1200 FILTER 1 CSC

COMPANY: HUGHES RADAR SYSTEMS GROUP • LOS ANGELES
TITLE: DESIGN POLICY
SURVEY DATE: 01/16/1987

RSQ HAS DOCUMENTED CORPORATE AND FUNCTIONAL AREA DESIGN POLICIES WHICH ARE BACKED UP BY DETAILED GUIDELINES, STANDARDS, PROCEDURES, CHECKLISTS, AND ENGINEERING MANUALS. THE POLICIES ARE DETAILED FOR THE DIFFERENT PRODUCT AREAS (I.E. DIGITAL, ANALOG, HYBRID, SOFTWARE, POWER SUPPLY, RF, WIRE WRAP, PWB, ETC.) THE STANDARDS AND GUIDELINES WERE WRITTEN BY COMPANY EXPERTS TO CAPTURE CORPORATE KNOWLEDGE AND INCORPORATE LESSONS LEARNED. IN ADDITION TO DESIGN POLICY, EACH ENGINEERING DISCIPLINE HAS DEVELOPED A "ROAD MAP" FOR THE FUTURE PRODUCT DEVELOPMENT

F1 • HELP F2 • GRAPH F3 • NEXT QUERY F4 • TEXT SEARCH F5 • PRINT
F9 • VIEW INFO F10 •EXIT ESC • PREV FILTER DEL • DELETE ITEM FROM FILTER

KNOW-HOW

- AUTOMATED HANDBOOKS
- DoD 5000
- NAVSO P-6071
- VALUE ENGINEERING
- NON-DEVELOPMENTAL ITEMS
- ACQUISITION STREAMLINING

BEST PRACTICES

SEARCH DATABASE BY:
- TEMPLATE AREA
- TECHNOLOGY
- KEYWORD
- DATE
- COMPANY
- CENTERS OF EXCELLENCE

TRIMS

- PERFORM AUTOMATED RISK ASSESSMENT ON YOUR PROGRAM UTILIZING THE P-6071 TEMPLATE QUESTION

ELECTRONIC MAIL

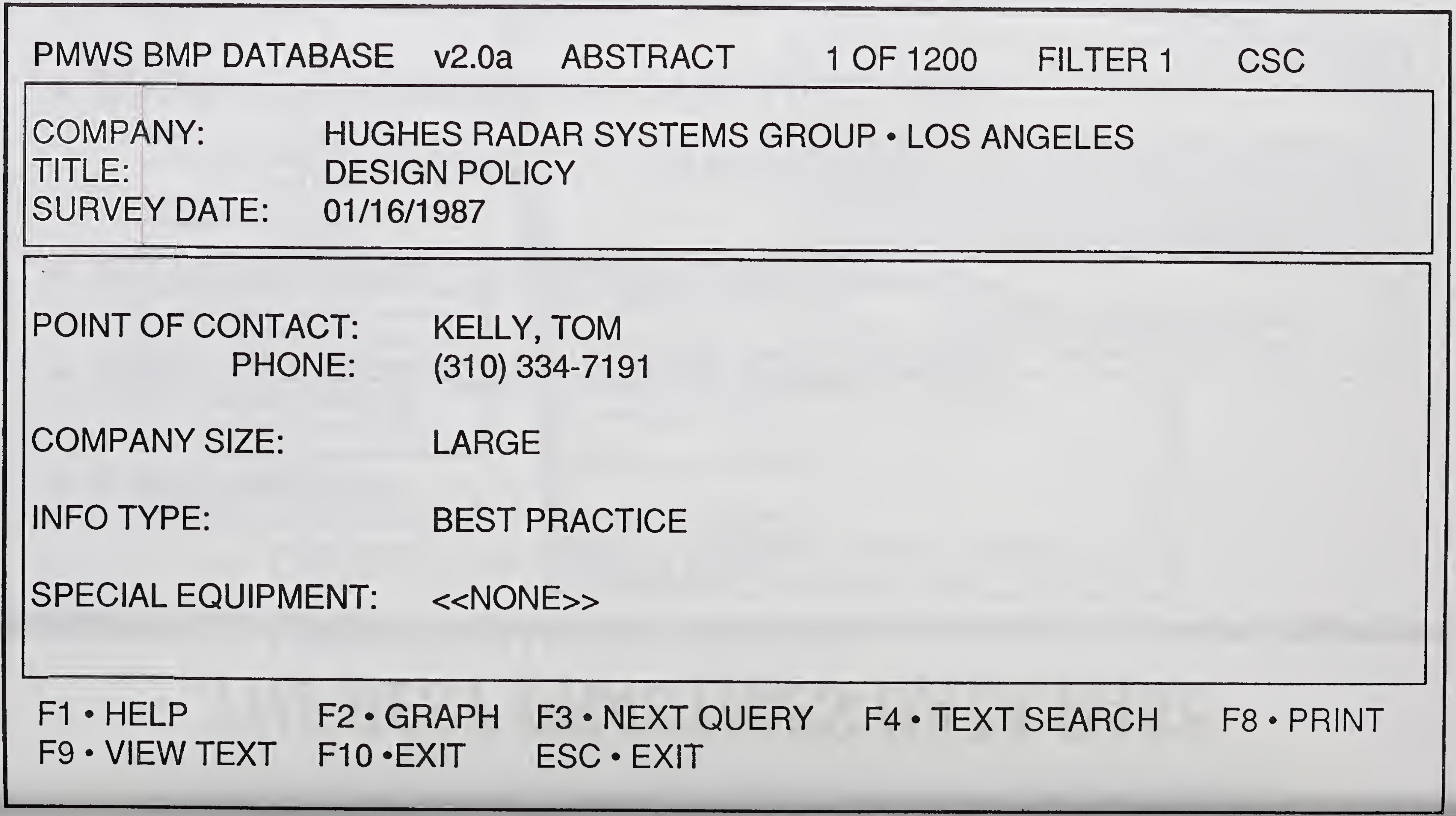
- SEND MAIL
- RECEIVE MAIL
- COMPOSE MAIL
- SEND & ATTACH FILES
- JOIN SPECIAL INTEREST GROUPS
- ON-LINE CONFERENCING
- FLASH PROBLEMS

PROGRAM TRANSFERS

DOWNLOAD:
  - KNOW-HOW
  - TRIMS

UPLOAD:
  - PROGRAM FOR ASN (R&D) EVALUATION
  - INFORMATION ON SPECIFIC PROBLEMS
  - REMOTE BMP SURVEYS
  - NEWS ON ABSTRACTS FROM ODE

INFO SCREEN



PMWS BMP DATABASE v2.0a ABSTRACT 1 OF 1200 FILTER 1 CSC

COMPANY: HUGHES RADAR SYSTEMS GROUP • LOS ANGELES
TITLE: DESIGN POLICY
SURVEY DATE: 01/16/1987

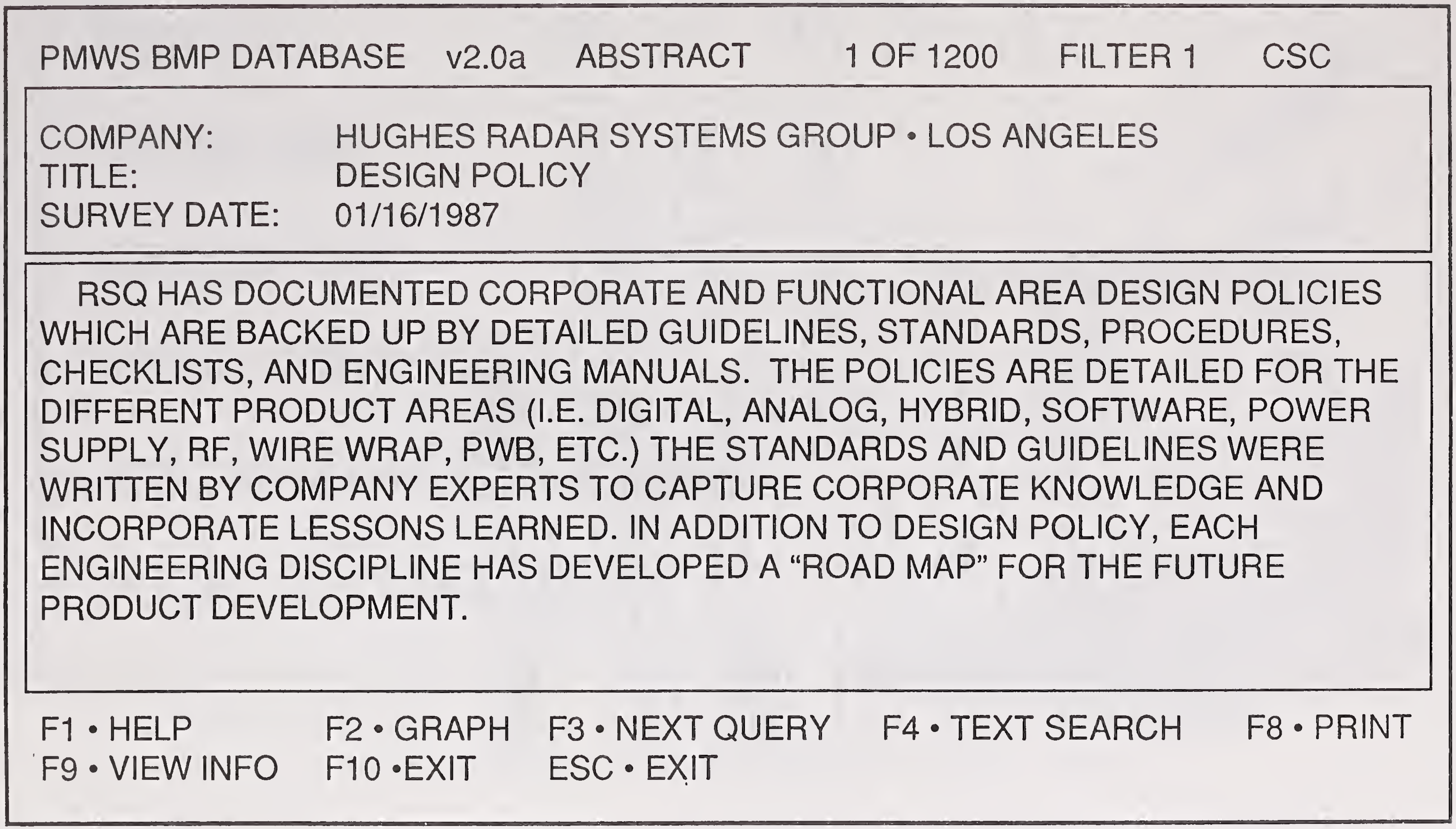
POINT OF CONTACT: KELLY, TOM
PHONE: (310) 334-7191

COMPANY SIZE: LARGE

INFO TYPE: BEST PRACTICE

SPECIAL EQUIPMENT: <<NONE>>

TEXT SCREEN



PMWS BMP DATABASE v2.0a ABSTRACT 1 OF 1200 FILTER 1 CSC

COMPANY: HUGHES RADAR SYSTEMS GROUP • LOS ANGELES
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BMP◆NET SPECIAL INTEREST GROUPS (SIGs)

(AS OF 31 JUL 93)

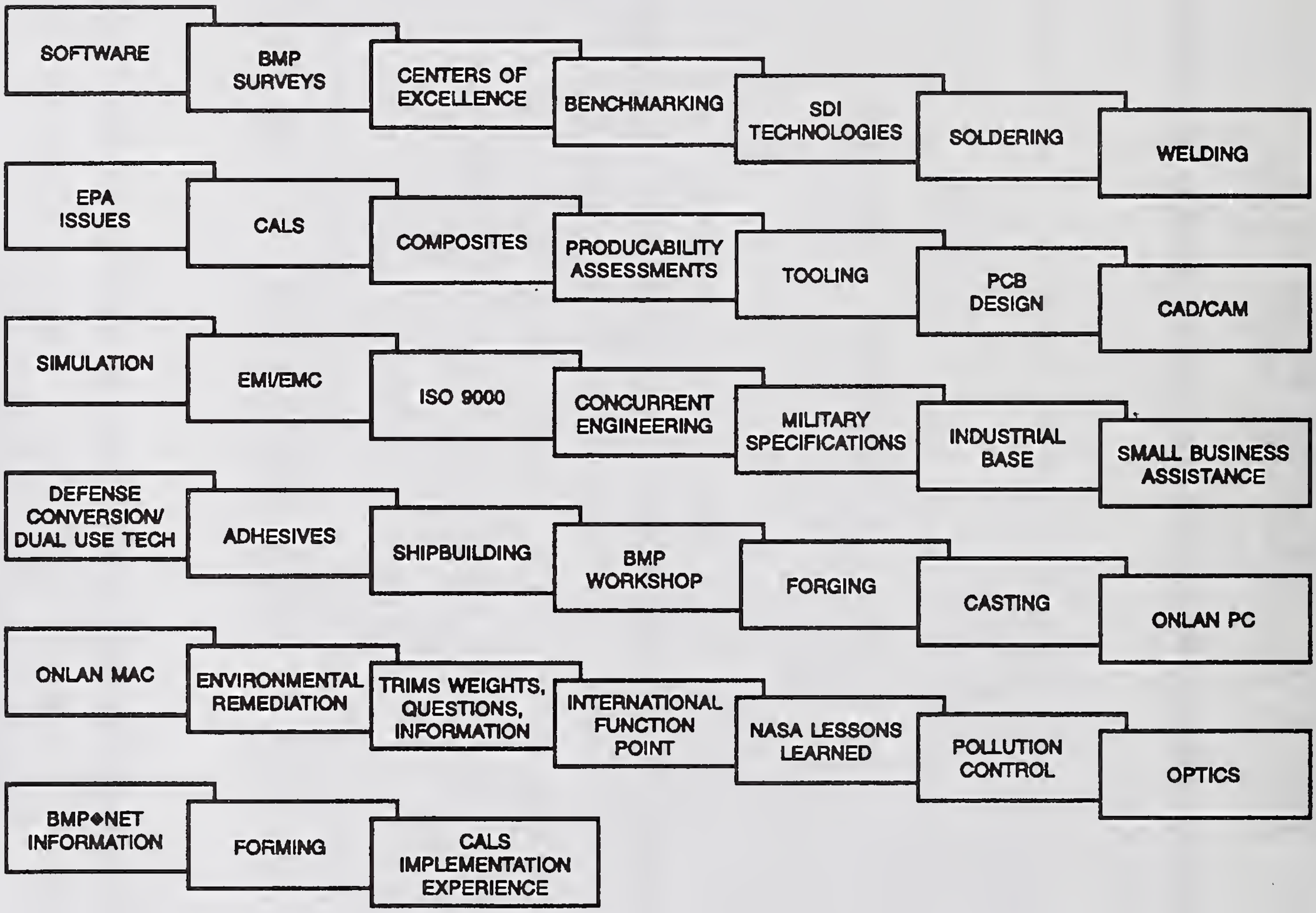
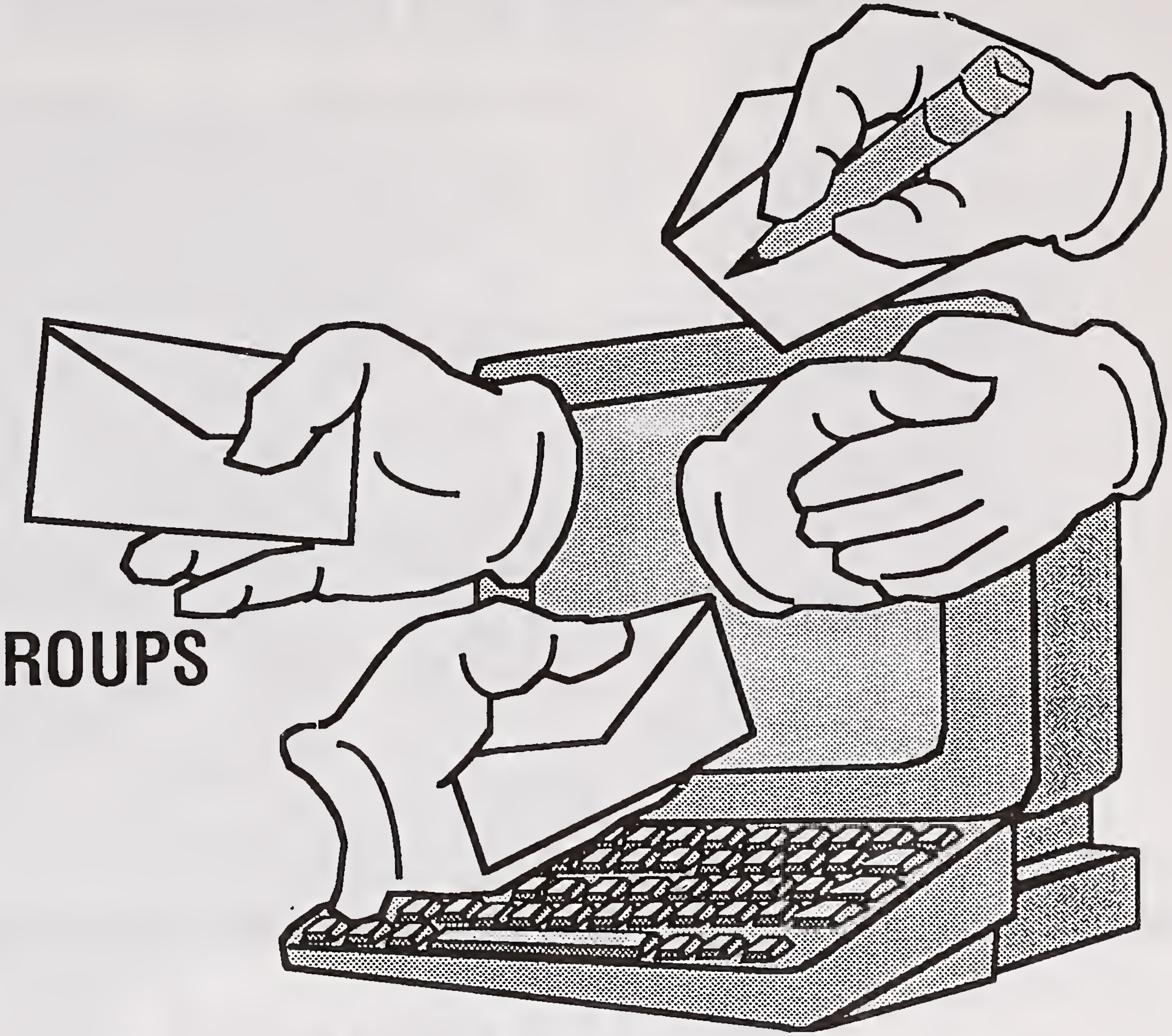


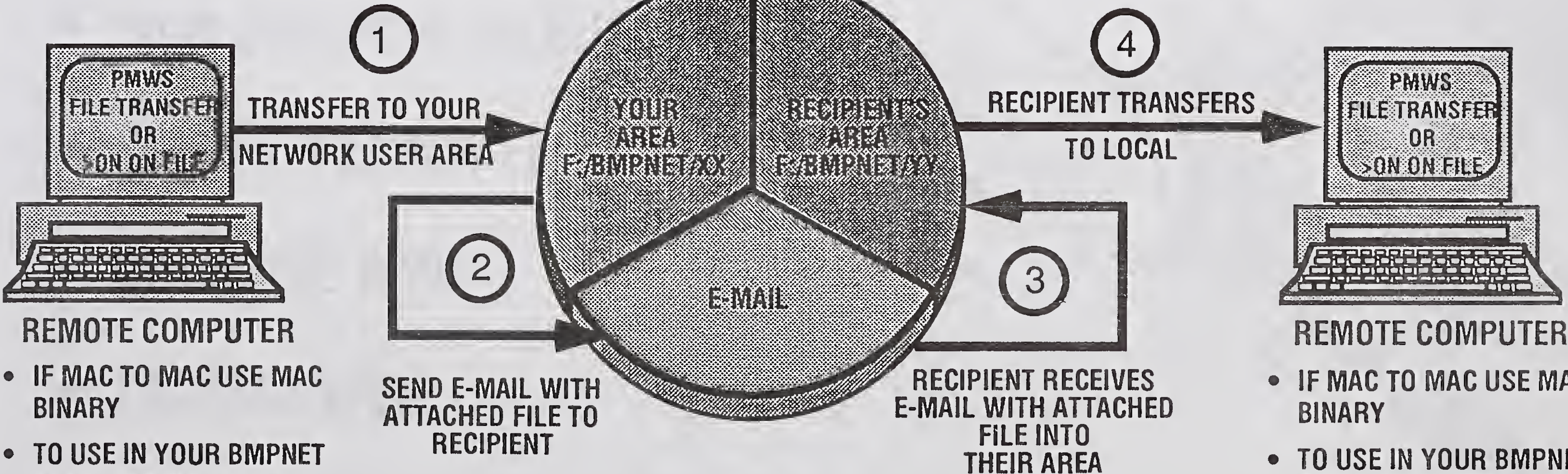
Figure 7. The BMP◆NET serves a diversity of technical expertise

ELECTRONIC MAIL

- SEND MAIL
- RECEIVE MAIL
- COMPOSE MAIL
- SEND & ATTACH FILES
- JOIN COMMON INTEREST GROUPS
- ON-LINE CONFERENCING



BMPNET FILE TRANSFER



TRANSMIT

① TRANSFER TO YOUR NETWORK USER AREA

REMOTE COMPUTER

- IF MAC TO MAC USE MAC BINARY
- TO USE IN YOUR BMPNET AREA STOP AFTER ①
- IF MAC TO IBM USE DEFAULT OR TEXT

② SEND E-MAIL WITH ATTACHED FILE TO RECIPIENT

③ RECIPIENT RECEIVES E-MAIL WITH ATTACHED FILE INTO THEIR AREA

BMPNET FILE STORAGE

- START AT ② IF FILE IS ALREADY IN YOUR BMPNET AREA
- START AT ④ IF FILE IS ALREADY IN YOUR BMPNET AREA

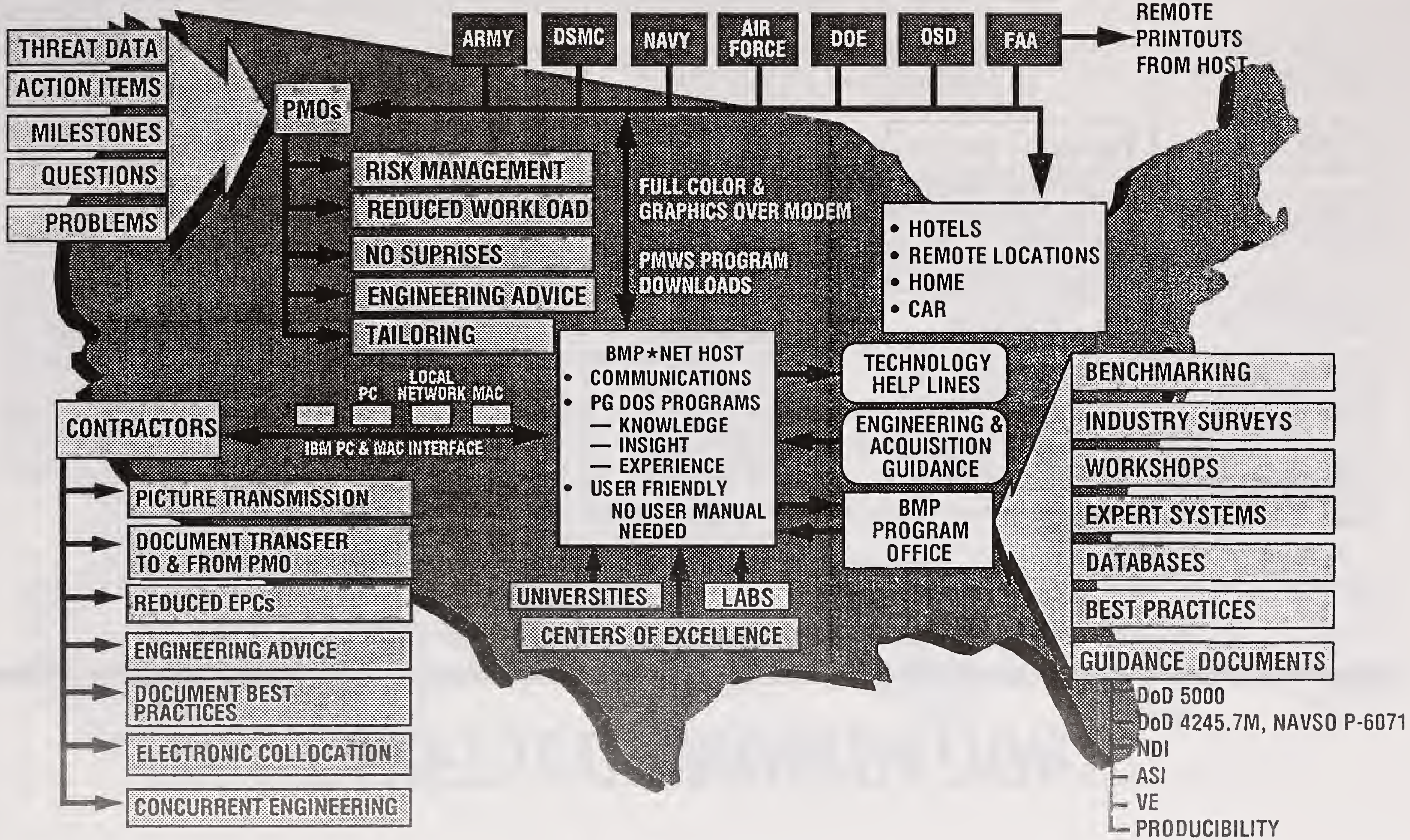
RECEIVE

④ RECIPIENT TRANSFERS TO LOCAL

REMOTE COMPUTER

- IF MAC TO MAC USE MAC BINARY
- TO USE IN YOUR BMPNET AREA STOP AFTER ③
- IF MAC TO IBM USE DEFAULT OR TEXT

BMP PROGRAM
TECHNOLOGY TRANSFER NATIONWIDE



THREAT DATA
ACTION ITEMS
MILESTONES
QUESTIONS
PROBLEMS

PMOs

RISK MANAGEMENT
REDUCED WORKLOAD
NO SUPRISES
ENGINEERING ADVICE
TAILORING

ARMY
DSMC
NAVY
AIR FORCE
DOE
OSD
FAA

REMOTE PRINTOUTS FROM HOST

FULL COLOR & GRAPHICS OVER MODEM

PMWS PROGRAM DOWNLOADS

- HOTELS
- REMOTE LOCATIONS
- HOME
- CAR

BMP*NET HOST
- COMMUNICATIONS
- PG DOS PROGRAMS
  - — KNOWLEDGE
  - — INSIGHT
  - — EXPERIENCE
- USER FRIENDLY
  NO USER MANUAL NEEDED

PC
LOCAL NETWORK
MAC

CONTRACTORS

IBM PC & MAC INTERFACE

PICTURE TRANSMISSION
DOCUMENT TRANSFER TO & FROM PMO
REDUCED EPCs
ENGINEERING ADVICE
DOCUMENT BEST PRACTICES
ELECTRONIC COLLOCATION
CONCURRENT ENGINEERING

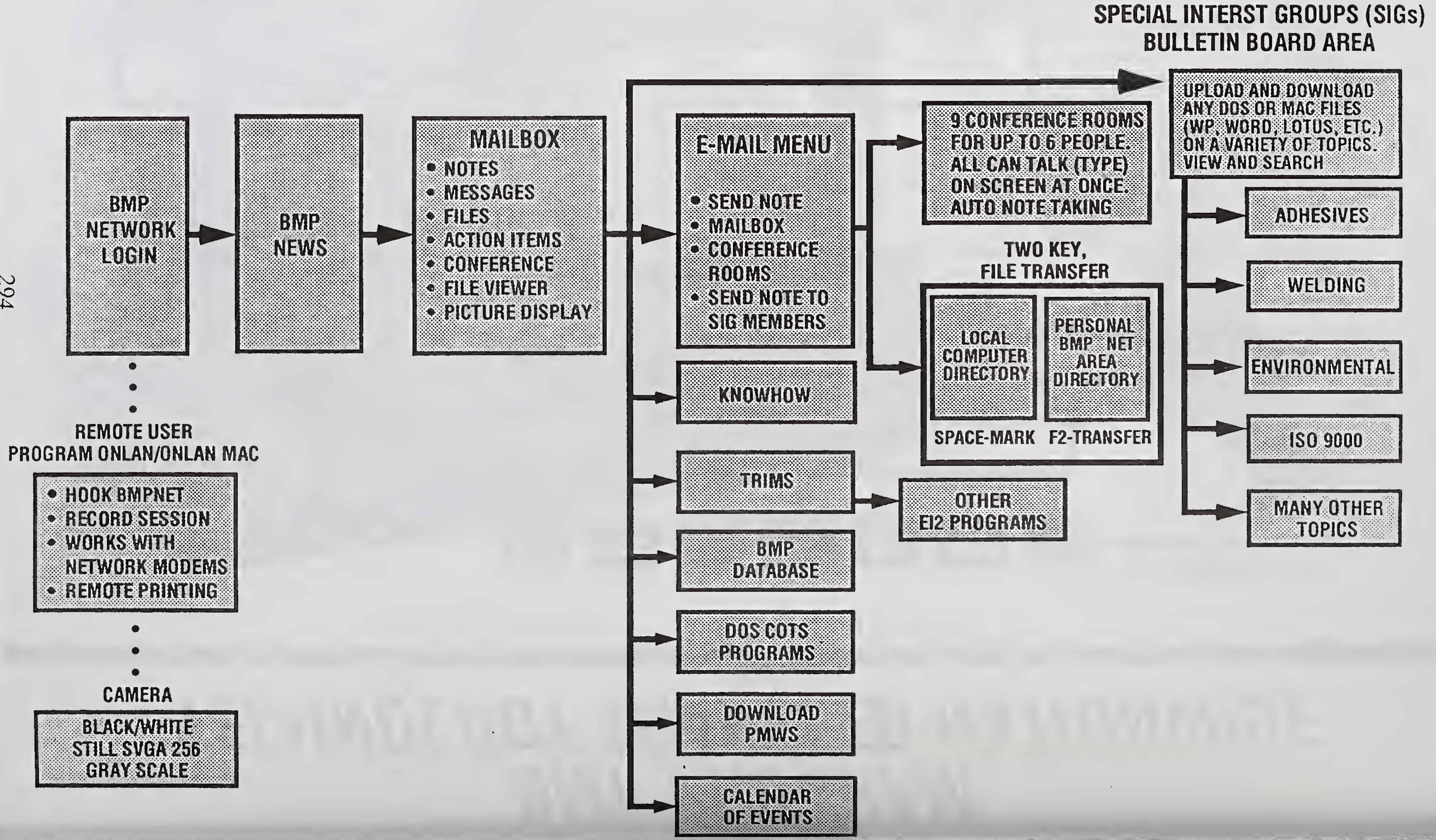
UNIVERSITIES
LABS
CENTERS OF EXCELLENCE

TECHNOLOGY HELP LINES
ENGINEERING & ACQUISITION GUIDANCE
BMP PROGRAM OFFICE

BENCHMARKING
INDUSTRY SURVEYS
WORKSHOPS
EXPERT SYSTEMS
DATABASES
BEST PRACTICES
GUIDANCE DOCUMENTS
- DoD 5000
- DoD 4245.7M, NAVSO P-6071
- NDI
- ASI
- VE
- PRODUCIBILITY

BMP◆NET (COMMUNICATIONS)

BMP◆NET IS A DOS TIMESHARE HOST. USER CAN RUN OR DOWNLOAD PMWS SOFTWARE



BMP NETWORK LOGIN

BMP NEWS

MAILBOX
- NOTES
- MESSAGES
- FILES
- ACTION ITEMS
- CONFERENCE
- FILE VIEWER
- PICTURE DISPLAY

E-MAIL MENU
- SEND NOTE
- MAILBOX
- CONFERENCE ROOMS
- SEND NOTE TO SIG MEMBERS

9 CONFERENCE ROOMS FOR UP TO 6 PEOPLE. ALL CAN TALK (TYPE) ON SCREEN AT ONCE. AUTO NOTE TAKING

TWO KEY, FILE TRANSFER

LOCAL COMPUTER DIRECTORY

SPACE-MARK

PERSONAL BMP NET AREA DIRECTORY

F2-TRANSFER

KNOWHOW

TRIMS

OTHER EI2 PROGRAMS

BMP DATABASE

DOS COTS PROGRAMS

DOWNLOAD PMWS

CALENDAR OF EVENTS

SPECIAL INTERST GROUPS (SIGs)
BULLETIN BOARD AREA

UPLOAD AND DOWNLOAD ANY DOS OR MAC FILES (WP, WORD, LOTUS, ETC.) ON A VARIETY OF TOPICS. VIEW AND SEARCH

ADHESIVES

WELDING

ENVIRONMENTAL

ISO 9000

MANY OTHER TOPICS

REMOTE USER
PROGRAM ONLAN/ONLAN MAC

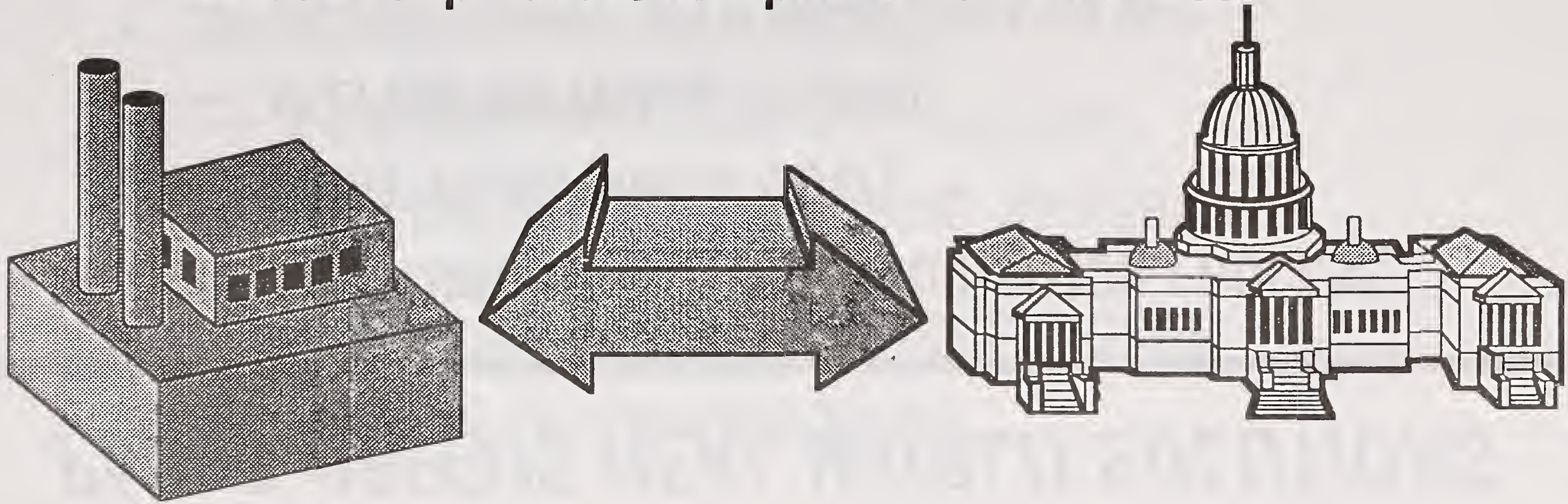
- HOOK BMPNET
- RECORD SESSION
- WORKS WITH NETWORK MODEMS
- REMOTE PRINTING

CAMERA

BLACK/WHITE STILL SVGA 256 GRAY SCALE

VITAL TO INDUSTRY & GOVERNMENT

- Technology transfer between companies — saving time and money by reducing repetitive problem solving
- Networks between Government and Industry in a positive way
- Finds best practices and promotes excellence



PMWS OFFERS REAL WORLD SOLUTIONS

- REDUCE RISK THROUGHOUT THE ACQUISITION PROCESS
  - — WHAT TO DO (KNOW HOW)
  - — KEEPING ON TRACK (TRIMS)
  - — WHERE TO GET HELP (BMP DATA BASE)
- FROM CONCEPT THROUGH PRODUCTION
- TESTED BY GOVERNMENT & INDUSTRY
- TAUGHT AT DSMC

HOW TO ACCESS PMWS

- FAX REQUEST TO (703) 696-8480
- CALL BMP*NET
  - (703) 538-7697 (2,400 BAUD MODEMS)
  - (703) 538-7267 (9,600 & 14.4kb MODEMS)
    - WHEN ASKED FOR USER PROFILE
      - PC USERS TYPE DOWNPC <RETURN>
      - MAC USERS TYPE DOWNMAC <RETURN>
    - CALL BACK USING PMWS MODEM PROGRAM
      - FOLLOW THE INSTRUCTIONS

BEST MANUFACTURING PRACTICES INFORMATION REQUEST FORM

Mail or fax completed form to:

Best Manufacturing Practices
2101 Crystal Plaza Arcade, Suite 271
Arlington, VA 22202
Fax: (703) 271-9059

Name: ____________________

Title: ____________________

Company: ____________________

Division: ____________________

Address: ____________________

____

Phone: ____________________ Fax: ____________________

Please send me the following information:

☞ Best Manufacturing Practices Survey Reports - See reverse to indicate those reports you desire.

Program Managers Workstation (PMWS) Software: ☐ Mac ☐ IBM

Video Tapes: ☐ BMP ☐ PMWS ☐ Producibility Measurement

☐ Producibility Measurement for DoD Contracts, or "How can I make what the government wants without losing my shirt?"

☐ Producibility Measurement Guidelines (NAVSO P-3679)

☐ Recommended Guidelines for Solderability (Jul 90)

☐ Best Practices, "How to Avoid Surprises in the World's Most Complicated Technical Process" (NAVSO P-6071)

☐ Transition from Development to Production (DoD 4245.7-M)

☐ Please contact me about a Best Manufacturing Practices Survey

☐ Please place me on the Best Manufacturing Practices mailing list

BMP SURVEY REPORTS AVAILABLE

☐ ALPHA INDUSTRIES (Nov 93) ·
METHUEN, MA

☐ AT&T (Sep 91)
FEDERAL SYSTEMS
GREENSBORO, NC

☐ BOEING (May 90)
AEROSPACE & ELECTRONICS

☐ CONAX FLORIDA CORP. (May 92)
ST. PETERSBURG, FL

☐ COMPUTING DEVICES INTL. (Oct 92)
BLOOMINGTON, MN

☐ DOE - OAK RIDGE (Mar 93)
OAK RIDGE, TN

☐ GTE (Oct 88)
GOVERNMENT SYSTEMS CORP.
NEEDHAM HEIGHTS, MA

☐ HEWLETT-PACKARD (June 92)
PALO ALTO FABRICATION CENTER
PALO ALTO, CA

☐ HAMILTON STANDARD (Oct 93)
FARMINGTON, CT

☐ LITTON (Oct 88)
DATA SYSTEMS DIVISION
VAN NUYS, CA

☐ LITTON (Feb 91)
GUIDANCE & CONTROL SYSTEMS DIV.
WOODLAND HILLS, CA

☐ LITTON SYSTEMS, INC. (June 89)
AMECOM DIVISION
COLLEGE PARK, MD

☐ LOCKHEED (Aug 89)
AERONAUTICAL SYSTEMS COMPANY
MARIETTA, GA

☐ LOCKHEED (Aug 89)
MISSILE SYSTEMS DIVISION
SUNNYVALE, CA

☐ MAGNATEK DEFENSE SYSTEMS (Mar 92)
ANAHEIM, CA

☐ MARRIOTT CRYSTAL GATEWAY (Aug 93)
ARLINGTON, VA

☐ MCDONNELL DOUGLAS AEROSPACE WEST
(Apr 93)
HUNTINGTON BEACH, CA

☐ NASA (Jan 93)
MARSHALL SPACE FLIGHT CENTER
HUNTSVILLE, AL

☐ NAVAL AVIATION DEPOT (Mar 93)
JACKSONVILLE, FL

☐ NAVAL AVIATION DEPOT (Mar 92)
NAVAL AIR STATION PENSACOLA
PENSACOLA, FL

☐ NAVAL AVIONICS CENTER (Jun 91)
INDIANAPOLIS, IN

☐ NORDEN SYSTEMS (May 91)
NORWALK, CT

☐ PHILA. NAVAL SHIPYARD (June 93)
PHILADELPHIA, PA

☐ RAYTHEON (Sept 91)
MISSILE SYSTEMS DIVISION
ANDOVER, MA

☐ R.J. REYNOLDS (July 93)
WINSTON-SALEM, NC

☐ TANDEM COMPUTERS (Jan 92)
CUPERTINO, CA

☐ TEXTRON LYNCOMING (Nov 90)
STRATFORD, CT

☐ TRICOR SYSTEMS, INC. (Nov 89)
ELGIN, IL

☐ TRW (Mar 90)
MILITARY ELECTRONICS & AVIONICS
DIVISION
SAN DIEGO, CA

☐ UNITED ELECTRIC CONTROLS (Jun 91)
WATERTOWN, MA

☐ WATERVLIET ARSENAL (July 91)
WATERVLIET, NY

** SURVEYS NOT ON THIS LIST ARE AVAILABLE THROUGH THE PROGRAM MANAGER'S WORK STATION (PMWS) OR DTIC.

Appendix I

Cooperative Research and Development Agreements (CRADAs) Tutorial

NIST Technology Development Programs of Interest to Industry

- ***Cooperative Research and Development Agreements (CRADAs)***
- Manufacturing Extension Program
- Small Business Innovation Research Program (SBIR)
- Advanced Technology Program (ATP)

Types of Working Relationships

CRADAs

- Guest Researcher Agreements
- Industry Fellows Program
- Facility Use Agreements
- Purchase Order (Contract R&D)

NIST

CRADA

Authorized by Stevenson-Wydler Technology Innovation Act (Section 3710a)

Agreement under which NIST and partner(s) perform research *together*

NIST

CRADAs

Are Used for Joint Research Projects of Mutual Interest when:

- *Intellectual Property Issues*
- *Confidentiality of Research Results*
- *Protection of Collaborator's Proprietary Information*

are Important

NIST

CRADA

NIST *may* contribute:

- personnel
- equipment
- materials
- lab space
- intellectual property

CRADA

Industrial Partner(s) *may* contribute:

- personnel
- equipment
- materials
- lab space
- intellectual property
- *funds**

*No automatic matching requirement - laboratories determine what terms are acceptable

NIST

CRADA AGREEMENTS CONSIST OF:

Standard CRADA Form

Appendix A
- Who's involved
- Objective
- Who does what
- Who contributes what

Appendix B
Modifications and Exceptions to the Standard CRADA Agreement Specific to a Given Collaboration

CRADA Process

- NIST researcher and partner's researcher develop work statement

- NIST researcher:
  *prepares Appendix A

  *gets lab approval

  *sends to CRADA Officer

- CRADA Officer:
  *reviews standard CRADA with partner's representative,

  *prepares Appendix B (if necessary)

  *sends CRADA out for signature

CRADAs

Are driven by the Laboratories

Are usually initiated by individual NIST and industry researchers who have identified a mutually beneficial project

Depend on the allocation of resources by the Lab Directors and Section Chiefs.

NIST

Contacts

Specific Research Initiatives:

Lab Management and Technical Personnel (refer to Guide to NIST)

General Information on CRADAs:

Technology Partnership Program
NIST Building 221, Room B-256
Gaithersburg, MD 20899
ph 301-975-3084 fax 301-869-2751

*Bruce Mattson, Chief

*Terry Lynch
Chemical Science and Technology, Manufacturing Engineering, Computer Systems, Building and Fire Research

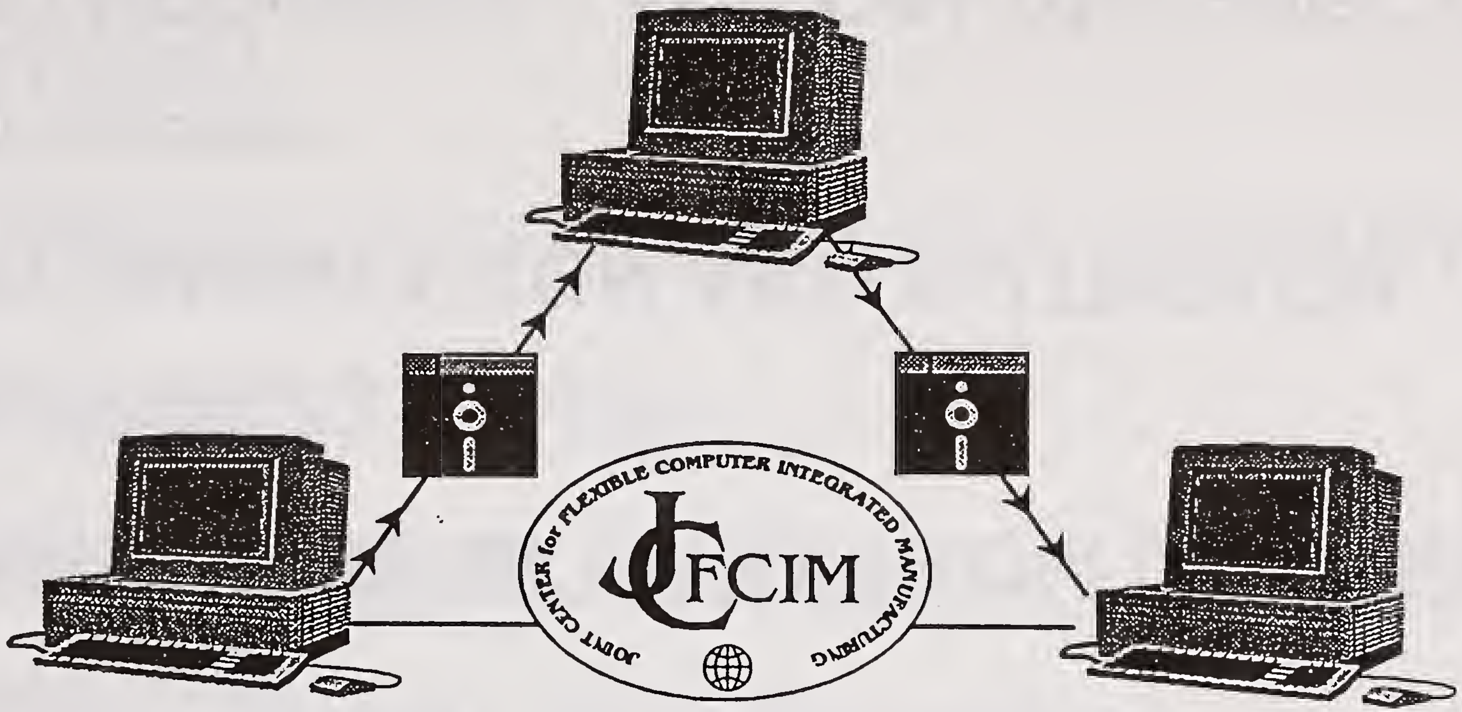
*Mike Blaney
Materials Science and Engineering

*Bill Lyndon
Electronics and Electrical Engineering, Physics

Appendix J

Flexible Computer Integrated Manufacturing (FCIM) Tutorial

DOD FCIM
OVERVIEW AND MODEL



MANUFACTURING TECHNOLOGY NEEDS AND ISSUES

28 April 1994

NIST, Gaithersburg, Maryland

Patricia A. Byrne
Tecnical Director, Joint Center for
Flexible Computer Integrated Manufacturing

INTRODUCTION

- DOD FCIM OVERVIEW AND MODEL
  - Patricia Byrne
- IMPORTANCE OF FCIM FROM DLA VIEW
  - Don O'Brien
- IMPLEMENTATION AND OUTREACH
  - Pam Gaudiose
- PARTNERSHIPS - AN FCIM PERSPECTIVE
  - Dennis Rogosch

DOD FCIM
OVERVIEW AND MODEL

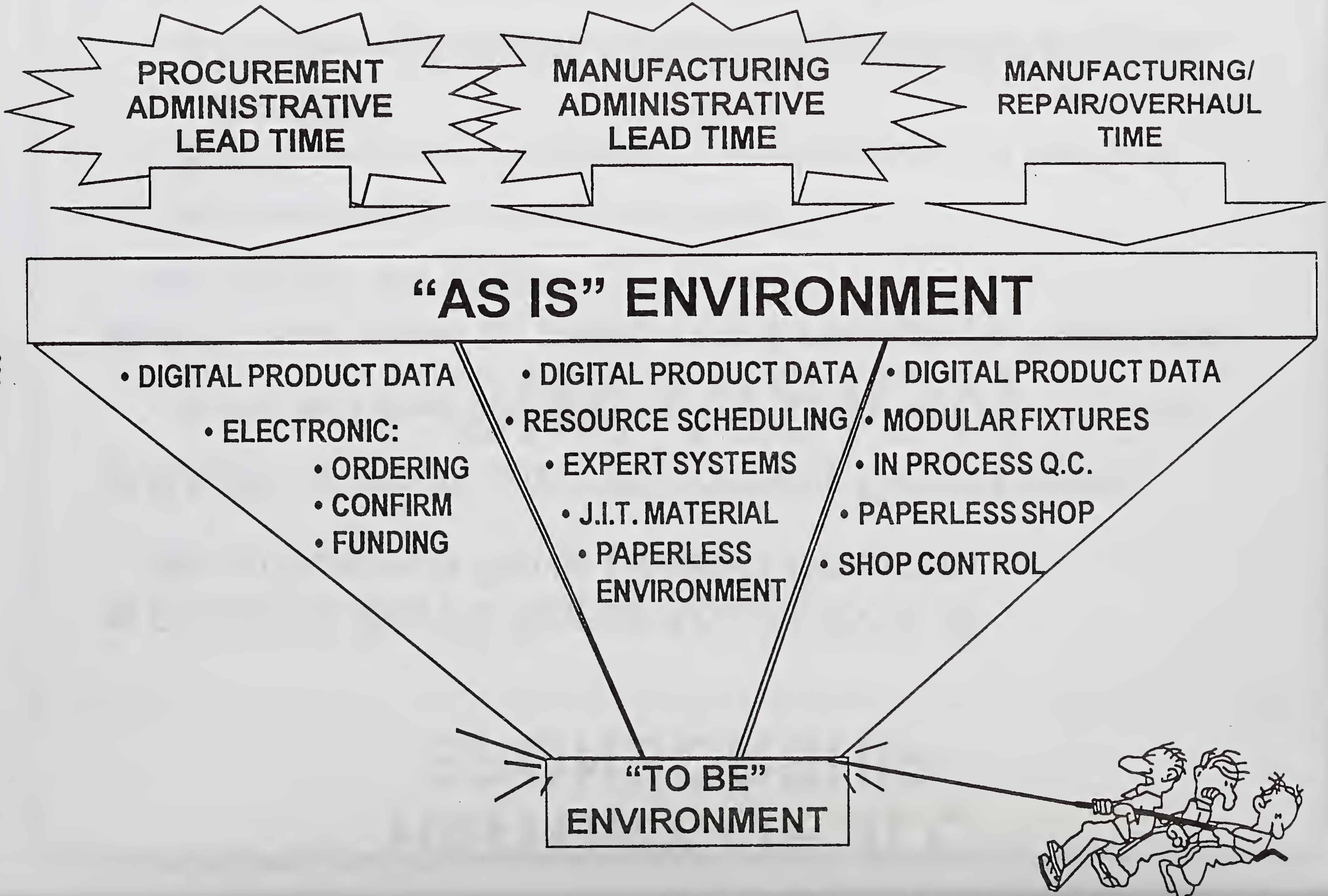
- VISION
- ORGANIZATION AND PARTICIPANTS
- PROCESS MODEL
- VISION REVALIDATED
- FUNCTIONAL BOUNDARIES
- INTERFACES AND RELATIONSHIPS
- SUMMARY OF LESSONS LEARNED

FCIM VISION

HISTORY OF JLC SPONSORSHIP

- Roots in Navy's Rapid Acquisition of Manufactured Parts (RAMP) Program
- RAMP a major success during Desert Storm
  - 78% lead time reduction across 18 Navy and 3 Army parts
- JLC saw need to make rapid response "business as usual" through:
  - Developing / exporting technology
  - Re-engineering / integrating manufacturing and business processes
  - Overcoming business, cultural, and organizational barriers
- Joint FCIM Initiative launched 4 June 1991

THE CHALLENGE: TO REDUCE CYCLE TIME



PROCUREMENT ADMINISTRATIVE LEAD TIME

MANUFACTURING ADMINISTRATIVE LEAD TIME

MANUFACTURING/ REPAIR/OVERHAUL TIME

“AS IS” ENVIRONMENT

- DIGITAL PRODUCT DATA
- ELECTRONIC:
  - ORDERING
  - CONFIRM
  - FUNDING

- DIGITAL PRODUCT DATA
- RESOURCE SCHEDULING
- EXPERT SYSTEMS
- J.I.T. MATERIAL
- PAPERLESS ENVIRONMENT

- DIGITAL PRODUCT DATA
- MODULAR FIXTURES
- IN PROCESS Q.C.
- PAPERLESS SHOP
- SHOP CONTROL

“TO BE” ENVIRONMENT

FCIM IS . . .

. . . THE INTEGRATION OF EQUIPMENT, SOFTWARE, COMMUNICATIONS, HUMAN RESOURCES, AND BUSINESS PRACTICES TO REDUCE THE CYCLE TIME FOR THE ACQUISITION, REPAIR AND OVERHAUL OF PARTS FOR DoD WEAPONS SYSTEMS.

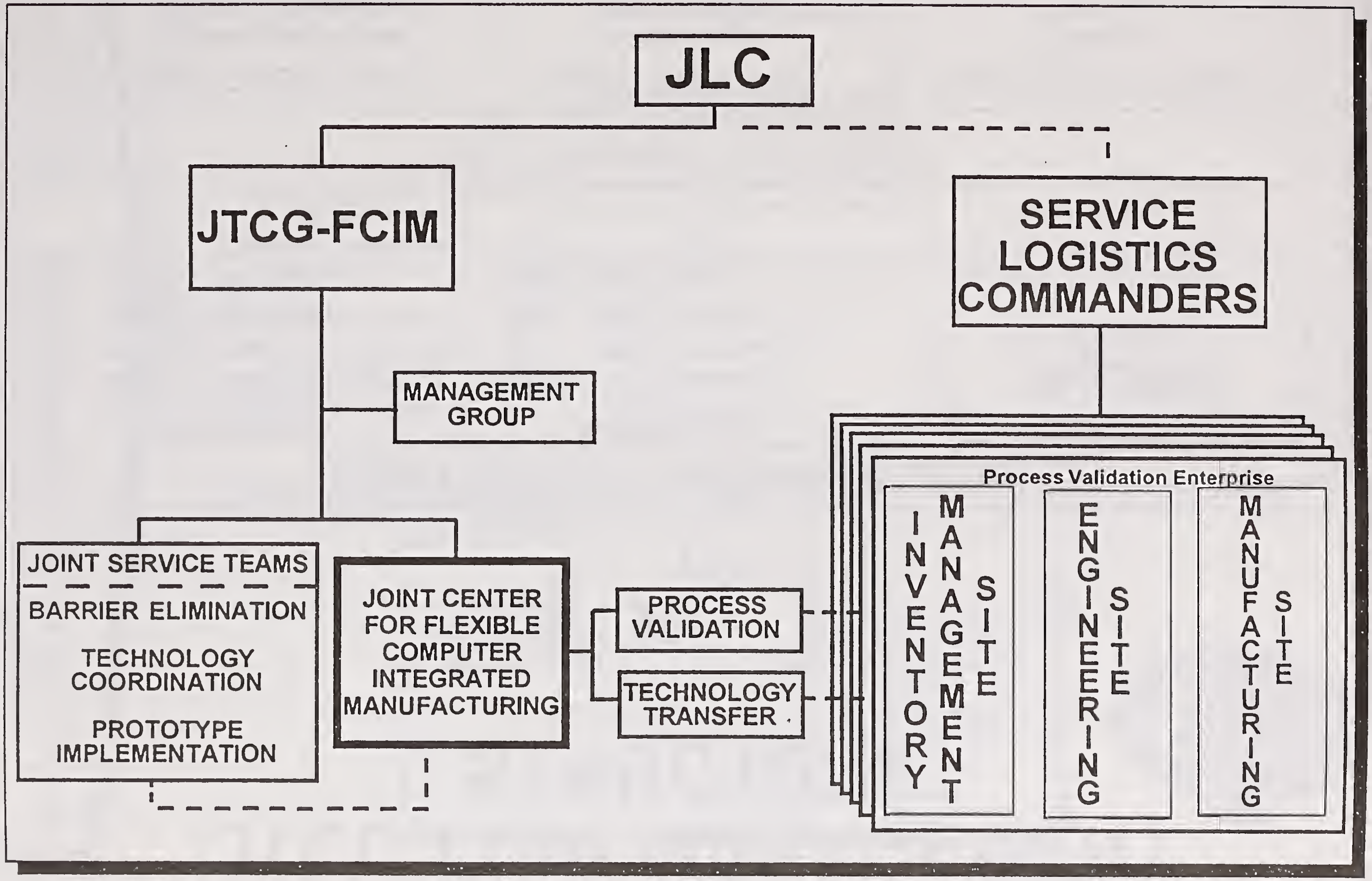
...SPONSORED BY JOINT LOGISTICS COMMANDERS AND ENCOMPASSES THE TOTAL PARTS ACQUISITION ENTERPRISE: INVENTORY CONTROL POINT, ENGINEERING ACTIVITY, AND REPAIR / OVERHAUL / MANUFACTURING ACTIVITY.

ORGANIZATION

AND

PARTICIPANTS

JOINT FCIM: A WORKING ORGANIZATION



JLC

JTCG-FCIM

SERVICE LOGISTICS COMMANDERS

MANAGEMENT GROUP

JOINT SERVICE TEAMS

BARRIER ELIMINATION

TECHNOLOGY COORDINATION

PROTOTYPE IMPLEMENTATION

JOINT CENTER FOR FLEXIBLE COMPUTER INTEGRATED MANUFACTURING

PROCESS VALIDATION

TECHNOLOGY TRANSFER

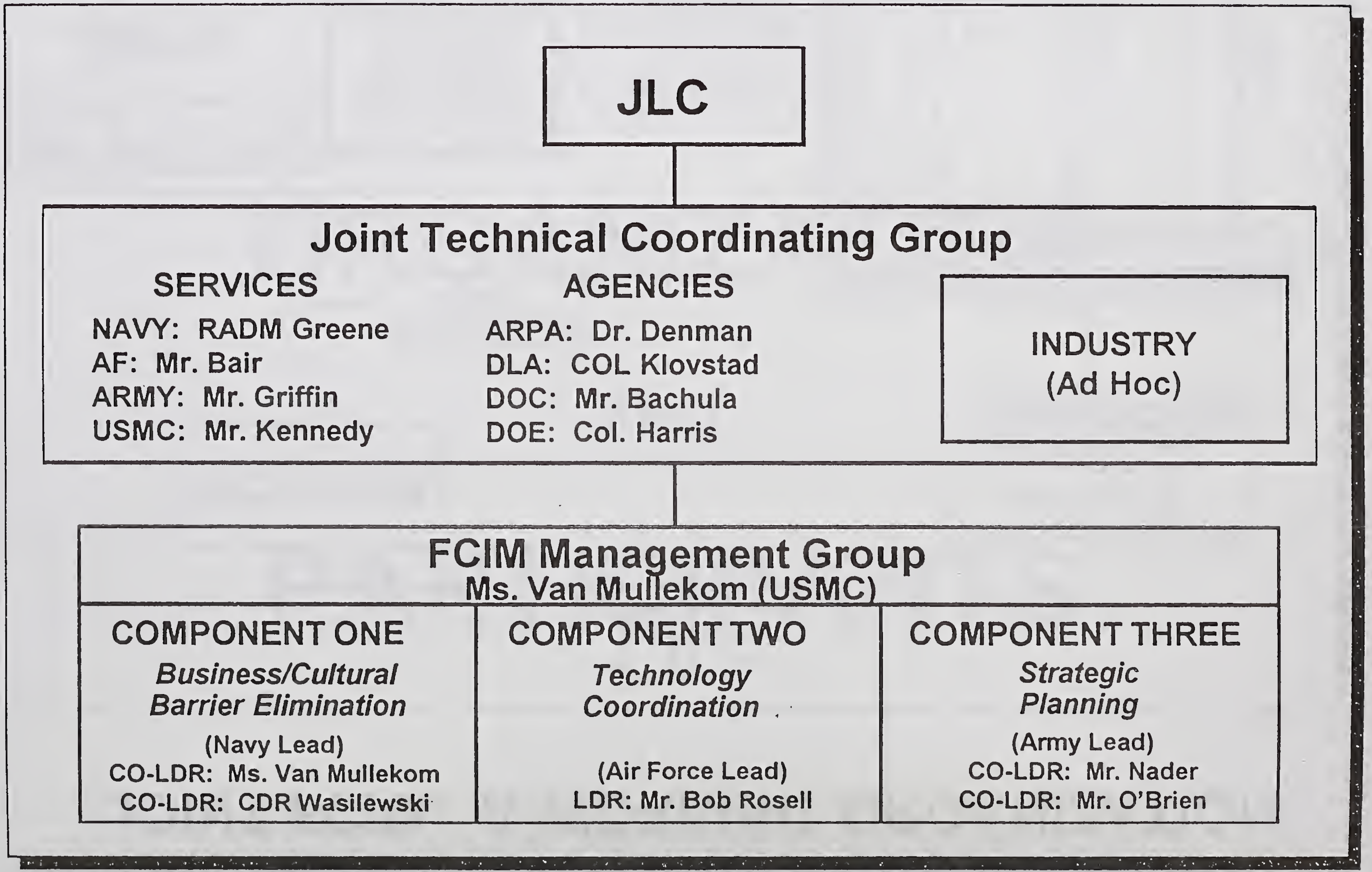
Process Validation Enterprise

INVENTORY MANAGEMENT SITE

ENGINEERING SITE

MANUFACTURING SITE

JTCG-FCIM MANAGEMENT STRUCTURE



JLC

Joint Technical Coordinating Group

SERVICES

NAVY: RADM Greene
AF: Mr. Bair
ARMY: Mr. Griffin
USMC: Mr. Kennedy

AGENCIES

ARPA: Dr. Denman
DLA: COL Klovstad
DOC: Mr. Bachula
DOE: Col. Harris

INDUSTRY
(Ad Hoc)

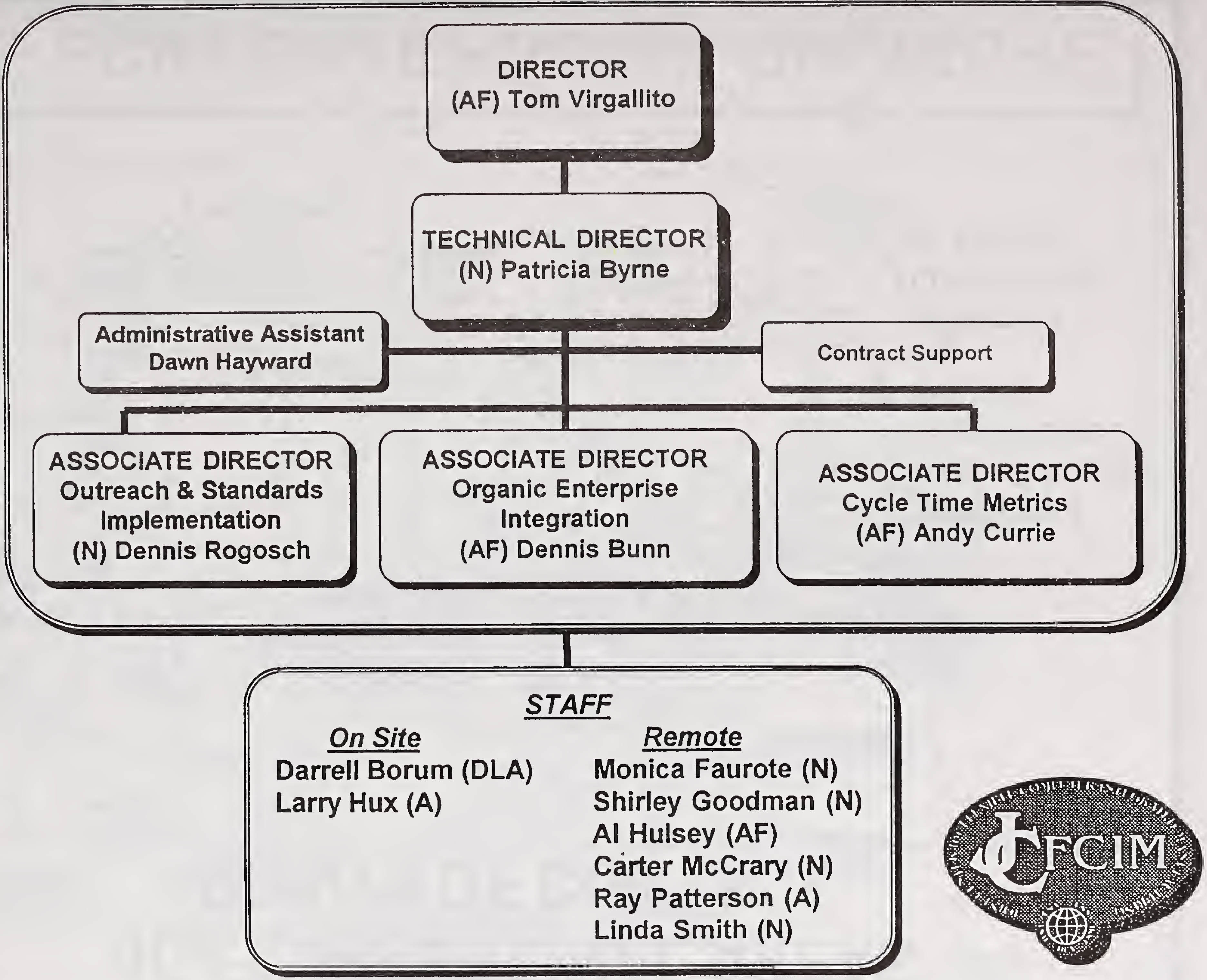
FCIM Management Group
Ms. Van Mullekom (USMC)

COMPONENT ONE
Business/Cultural Barrier Elimination
(Navy Lead)
CO-LDR: Ms. Van Mullekom
CO-LDR: CDR Wasilewski

COMPONENT TWO
Technology Coordination
(Air Force Lead)
LDR: Mr. Bob Rosell

COMPONENT THREE
Strategic Planning
(Army Lead)
CO-LDR: Mr. Nader
CO-LDR: Mr. O'Brien

JC FCIM ORGANIZATION



DIRECTOR
(AF) Tom Virgallito

TECHNICAL DIRECTOR
(N) Patricia Byrne

Administrative Assistant
Dawn Hayward

Contract Support

ASSOCIATE DIRECTOR
Outreach & Standards Implementation
(N) Dennis Rogosch

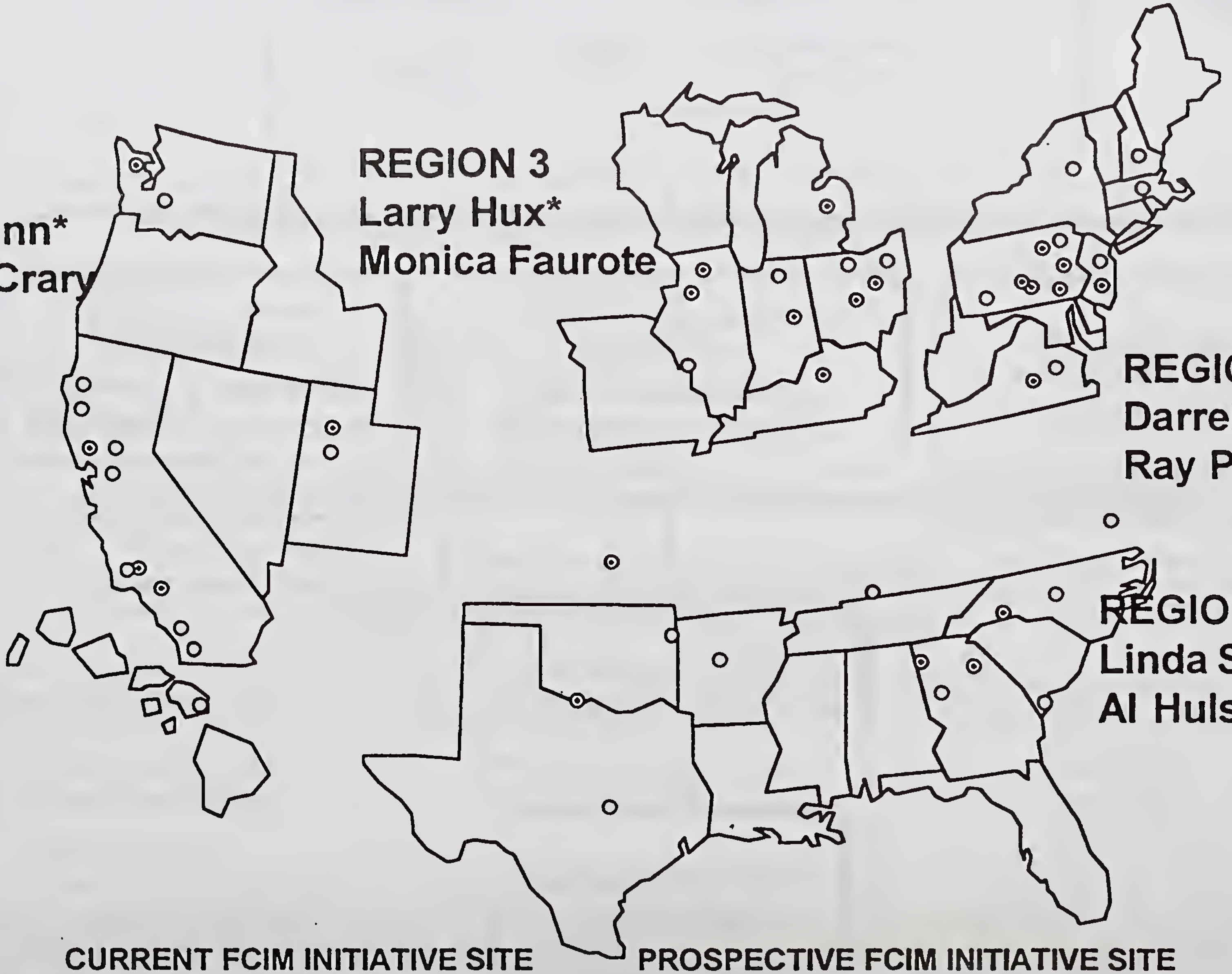
ASSOCIATE DIRECTOR
Organic Enterprise Integration
(AF) Dennis Bunn

ASSOCIATE DIRECTOR
Cycle Time Metrics
(AF) Andy Currie

STAFF

On Site	***Remote***
Darrell Borum (DLA)	Monica Faurote (N)
Larry Hux (A)	Shirley Goodman (N)
	Al Hulsey (AF)
	Carter McCrary (N)
	Ray Patterson (A)
	Linda Smith (N)

JC-FCIM REGIONAL AREAS POINTS OF CONTACT



REGION 1
Dennis Bunn*
Carter McCrary

REGION 3
Larry Hux*
Monica Faurote

REGION 4
Darrell Borum*
Ray Patterson

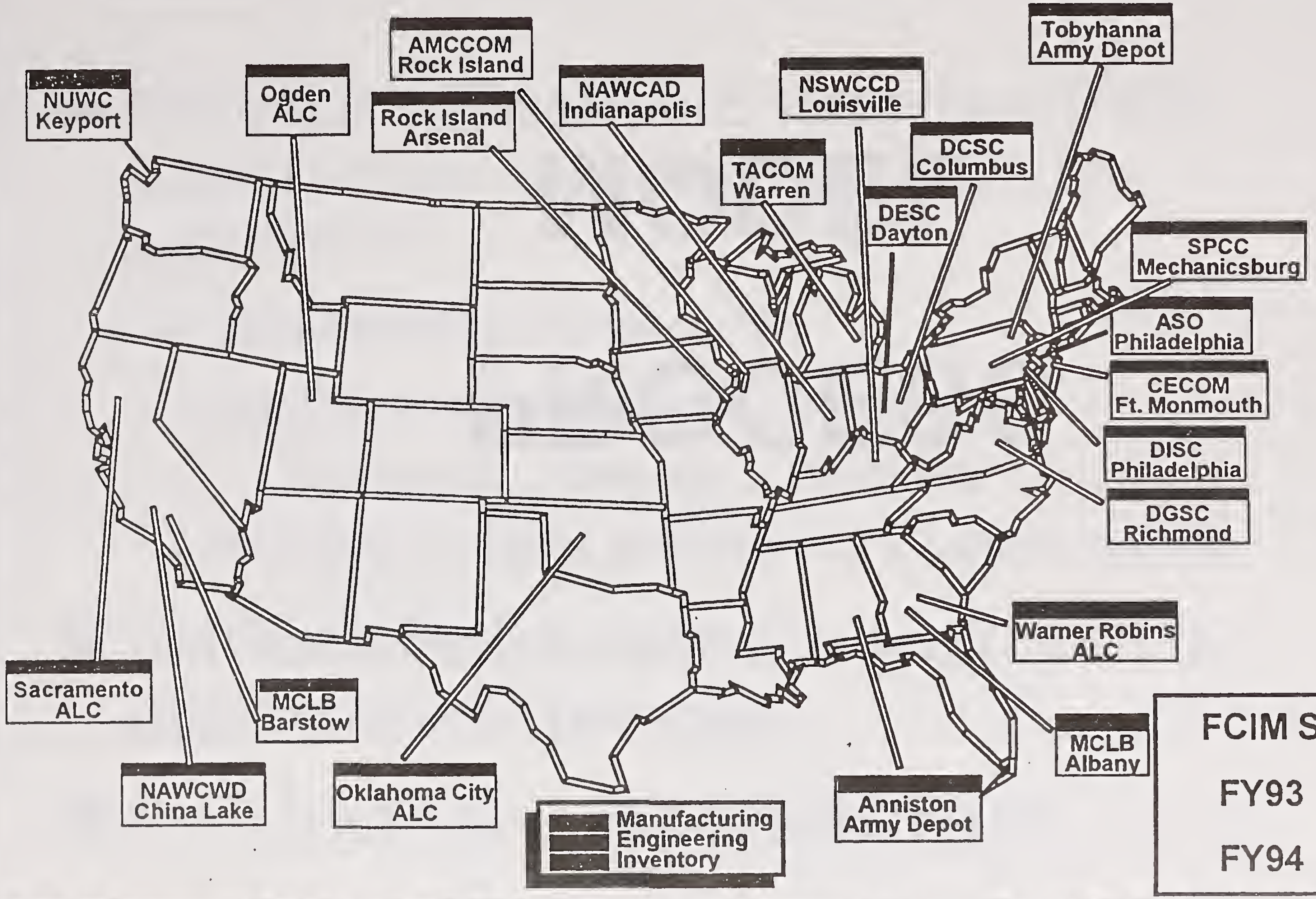
REGION 2
Linda Smith*
Al Hulsey

⊙ CURRENT FCIM INITIATIVE SITE

○ PROSPECTIVE FCIM INITIATIVE SITE

*Prime POC

THE FCIM ENTERPRISE UNIVERSE



FCIM SITES

FY93 = 22

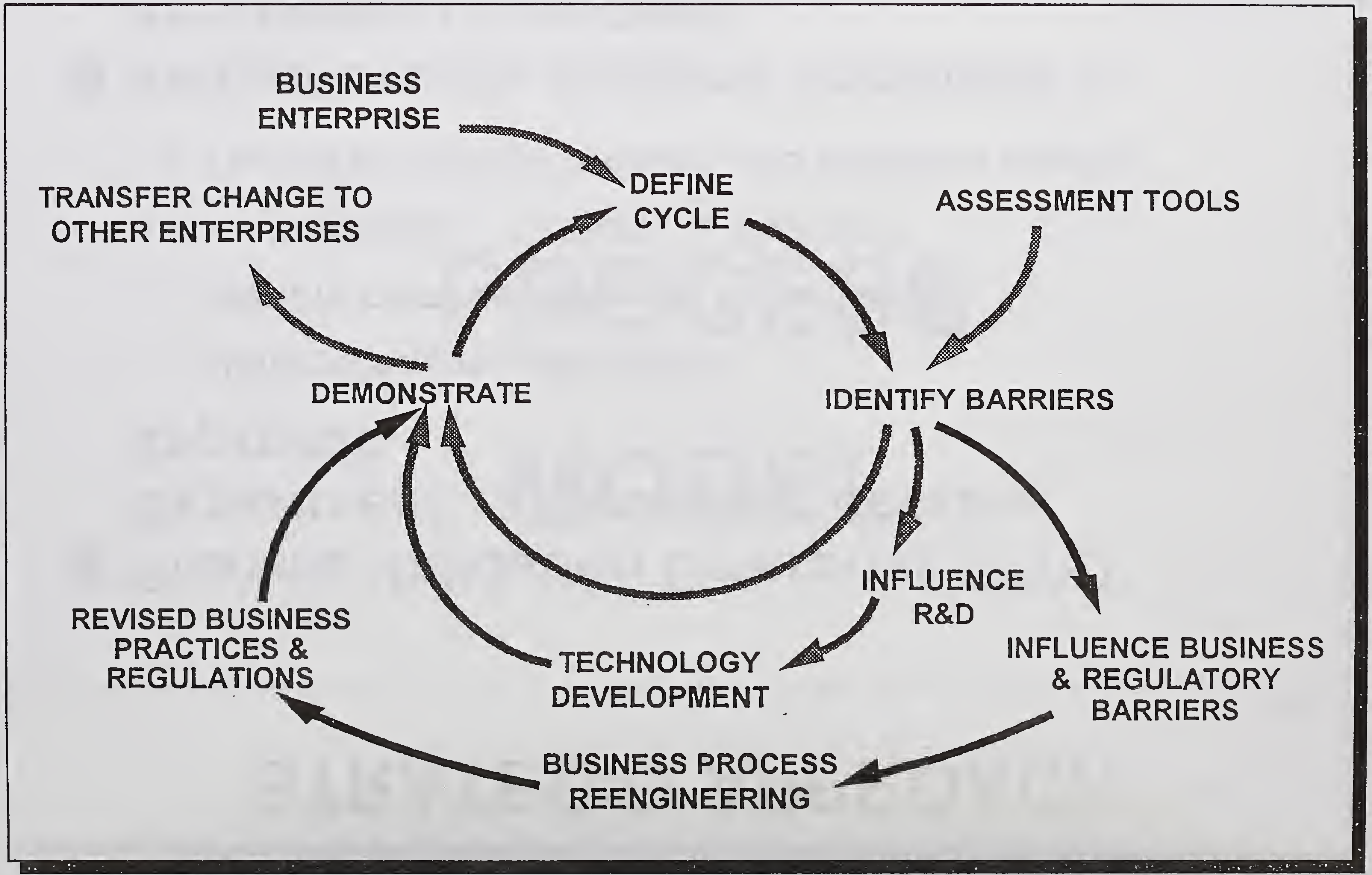
FY94 = 50

PROCESS
MODEL

STRATEGIC APPROACH

- Process Validation Enterprise (PVE) Experiment ... Three step iterative approach
  - Define/Measure total cycle
  - Identify barriers and work for removal
    - Technical ... Cultural ... Business
  - Prototype revised process and measure results
- Institutionalize systems approach to improvement process
- Document and export changes

FCIM EXPERIMENT CYCLE



BUSINESS ENTERPRISE

TRANSFER CHANGE TO OTHER ENTERPRISES

DEFINE CYCLE

ASSESSMENT TOOLS

DEMONSTRATE

IDENTIFY BARRIERS

INFLUENCE R&D

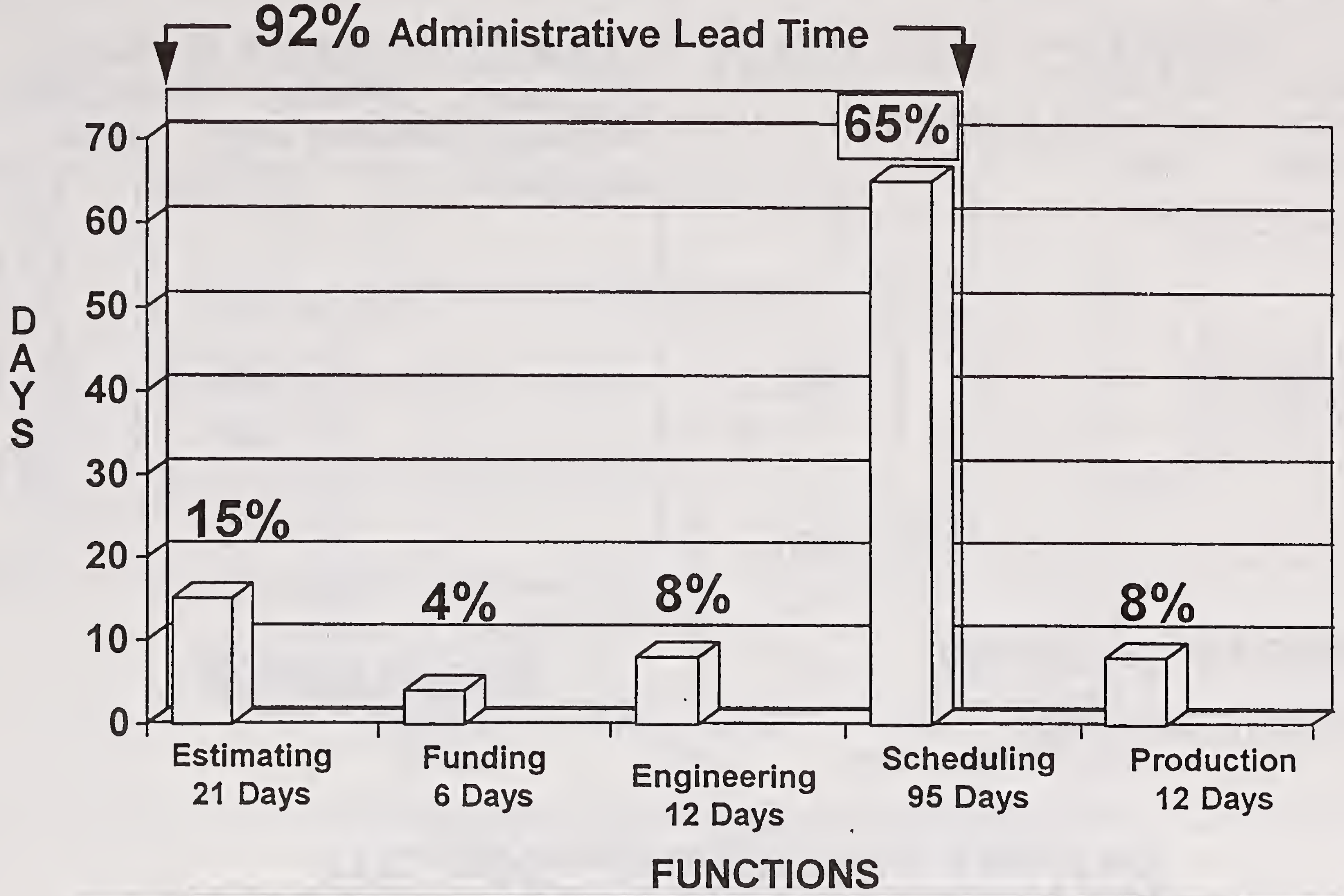
REVISED BUSINESS PRACTICES & REGULATIONS

TECHNOLOGY DEVELOPMENT

INFLUENCE BUSINESS & REGULATORY BARRIERS

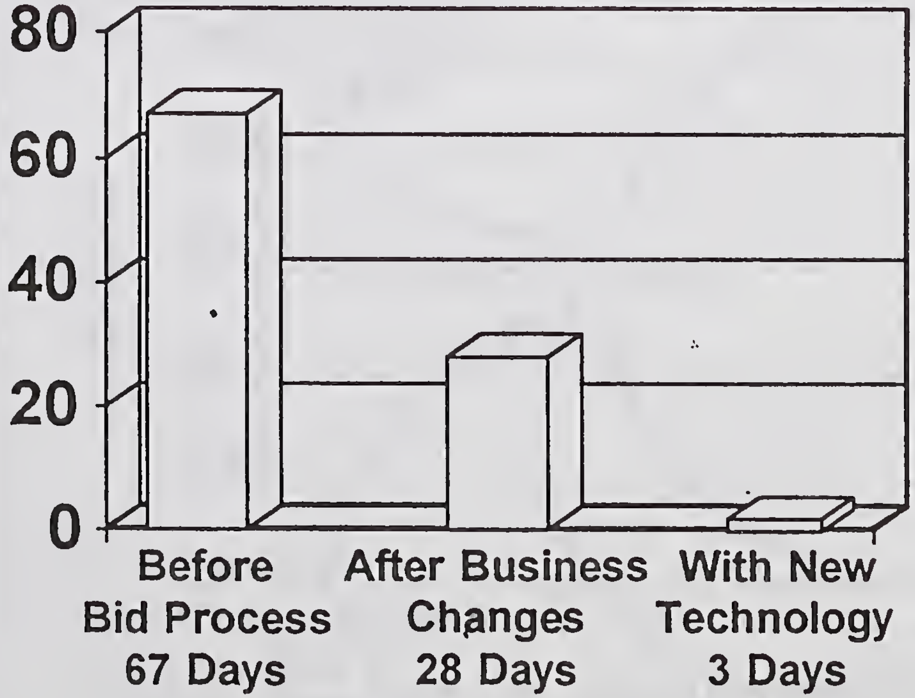
BUSINESS PROCESS REENGINEERING

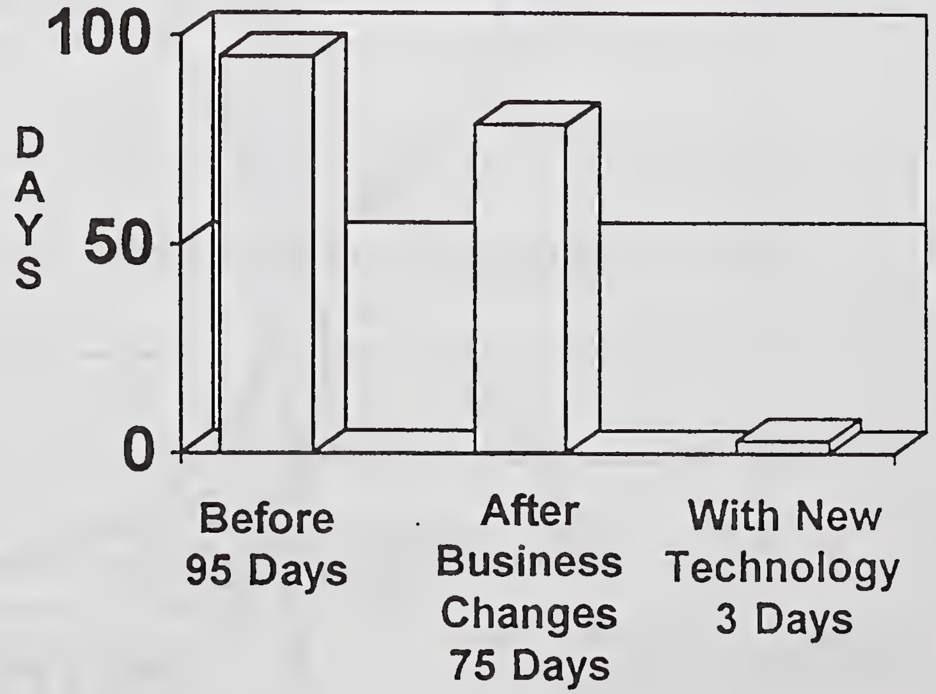
ADMINISTRATIVE TIME DRIVES CYCLE TIME



EFFORTS ARE FOCUSED ON THE 92%

TECHNOLOGICAL ADVANCES BUILD UPON BUSINESS PROCESS RE-ENGINEERING GAINS


Bid Process


Scheduling: Material Availability

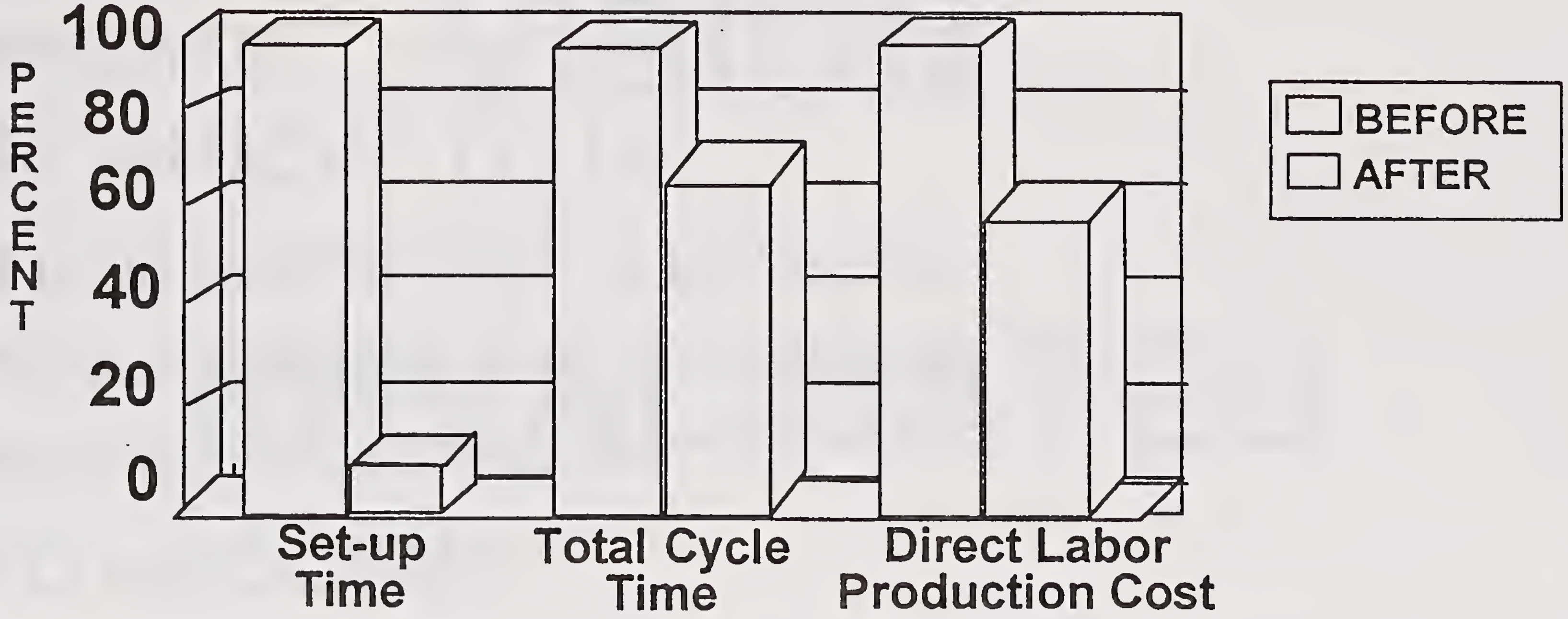
BUSINESS PROCESSES FIRST

SET-UP TIME REDUCTION PROJECT

NAVAL SURFACE WARFARE CENTER

CRANE DIVISION, LOUISVILLE

PERCENTAGE REDUCTION



INITIAL INVESTMENT RECOUPED AFTER PRODUCING JUST FOUR PARTS

SMALL INVESTMENT, RAPID PAYBACK

OTHER PROCESS CHANGE EXAMPLES

- BID PROCESS
  - Parallel vs Sequential
  - EDI (Electronic Data Interchange)
  - ROM (Rough Order of Magnitude)
- TECHNICAL DATA
  - NEDALS
  - Reverse Engineering Capabilities
  - CAD Conferencing (Computer-aided Design)
- MATERIAL AVAILABILITY
  - BPA (Blanket Purchase Agreement)
  - EDI
  - Bank Card

VISION

REVALIDATED

FCIM IS . . .

- ✯ A Joint initiative
- ✯ The virtual enterprise in action
- ✯ Working to improve the acquisition process
- ✯ Grass roots
- ✯ Initially limited to no bid / non-responsive bid / critical readiness items
- ✯ A success story

FCIM IS AN INTEGRATED APPROACH TO PROCESS IMPROVEMENT WHERE IT COUNTS: IN THE FIELD

FCIM STRATEGIC VISION REVALIDATED

- Military activities / DLA understand each other's capabilities and are communicating - BECOME AN EDUCATED BUYER / SELLER
- Time compression → reduces cost
- Foster convergence of defense and commercial processes
- Take maximum advantage of NATIONAL capital investments

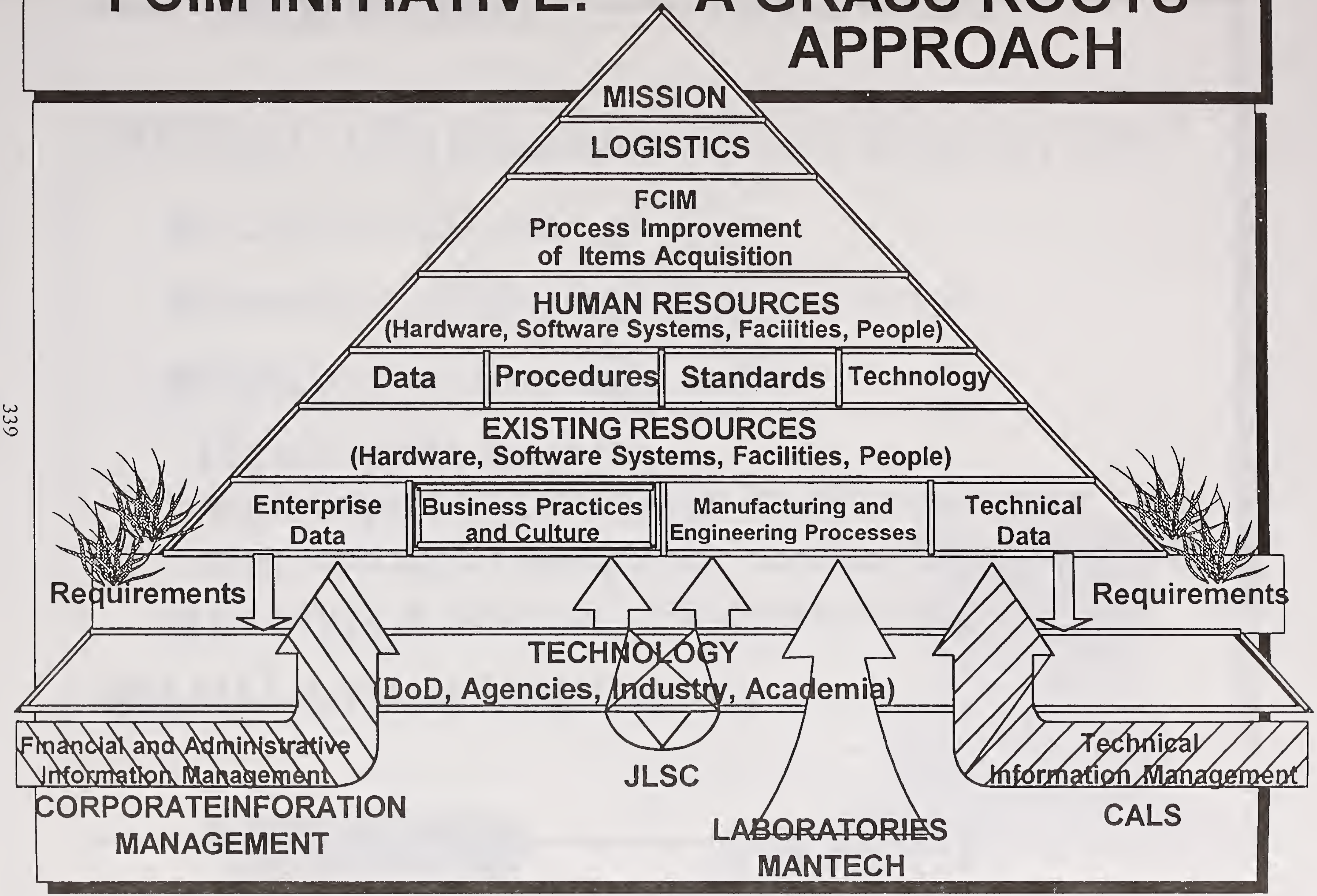
FCIM - A MECHANISM FOR STIMULATING AN EFFICIENT INDUSTRIAL BASE

FUNCTIONAL BOUNDARIES

INTERFACES

RELATIONSHIPS

FCIM INITIATIVE: A GRASS ROOTS APPROACH



MISSION

LOGISTICS

FCIM
Process Improvement
of Items Acquisition

HUMAN RESOURCES
(Hardware, Software Systems, Faciiities, People)

Data | Procedures | Standards | Technology

EXISTING RESOURCES
(Hardware, Software Systems, Facilities, People)

Enterprise Data | Business Practices and Culture | Manufacturing and Engineering Processes | Technical Data

Requirements

Requirements

TECHNOLOGY
(DoD, Agencies, Industry, Academia)

Financial and Administrative Information Management

CORPORATEINFORATION
MANAGEMENT

JLSC

LABORATORIES
MANTECH

Technical Information Management

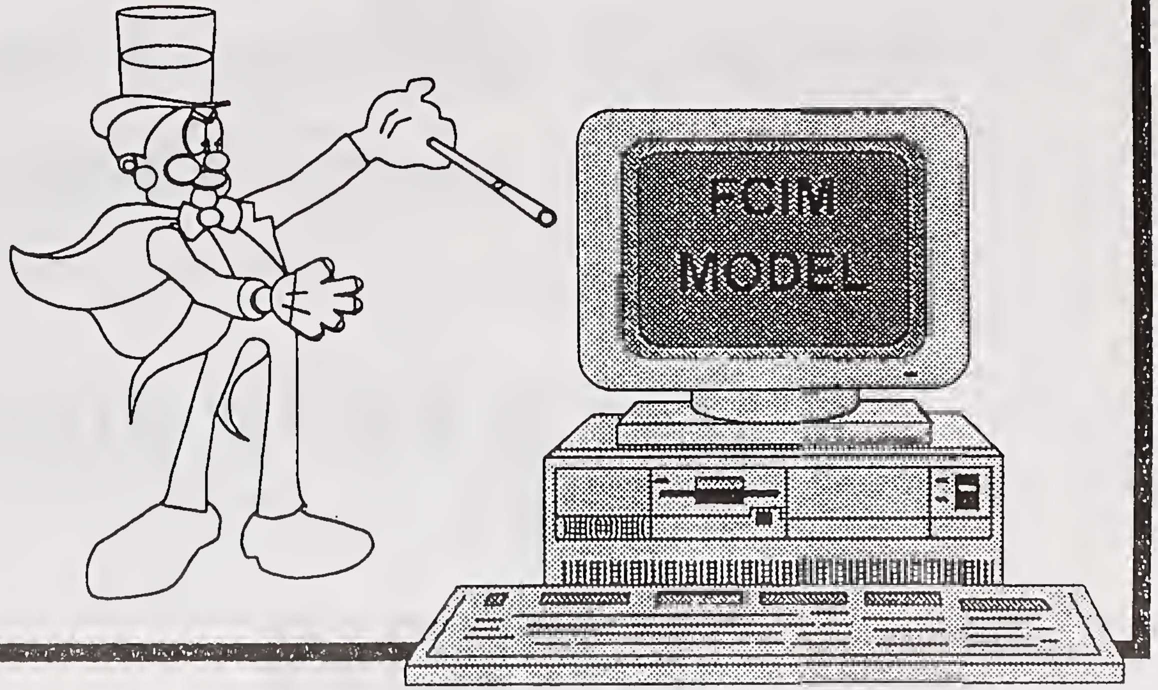
CALS

MODEL

- Why build a model?
  - Provide a tool to clearly articulate FCIM and identify interfaces, overlaps, and gaps with related initiatives, programs, and technology efforts

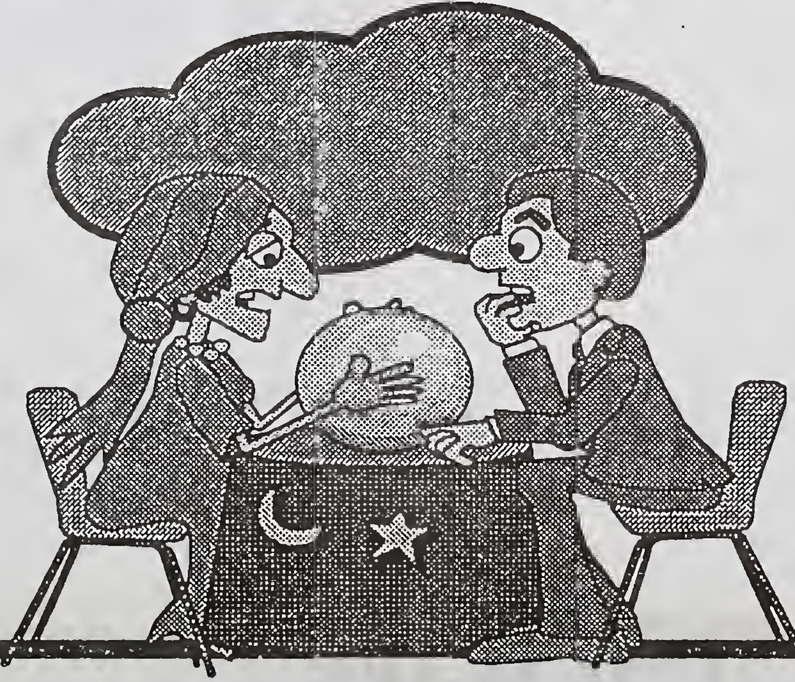
MODEL

- What information does it provide?
  - FCIM functions
  - Relationships and dependencies
  - Related technology areas



MODEL

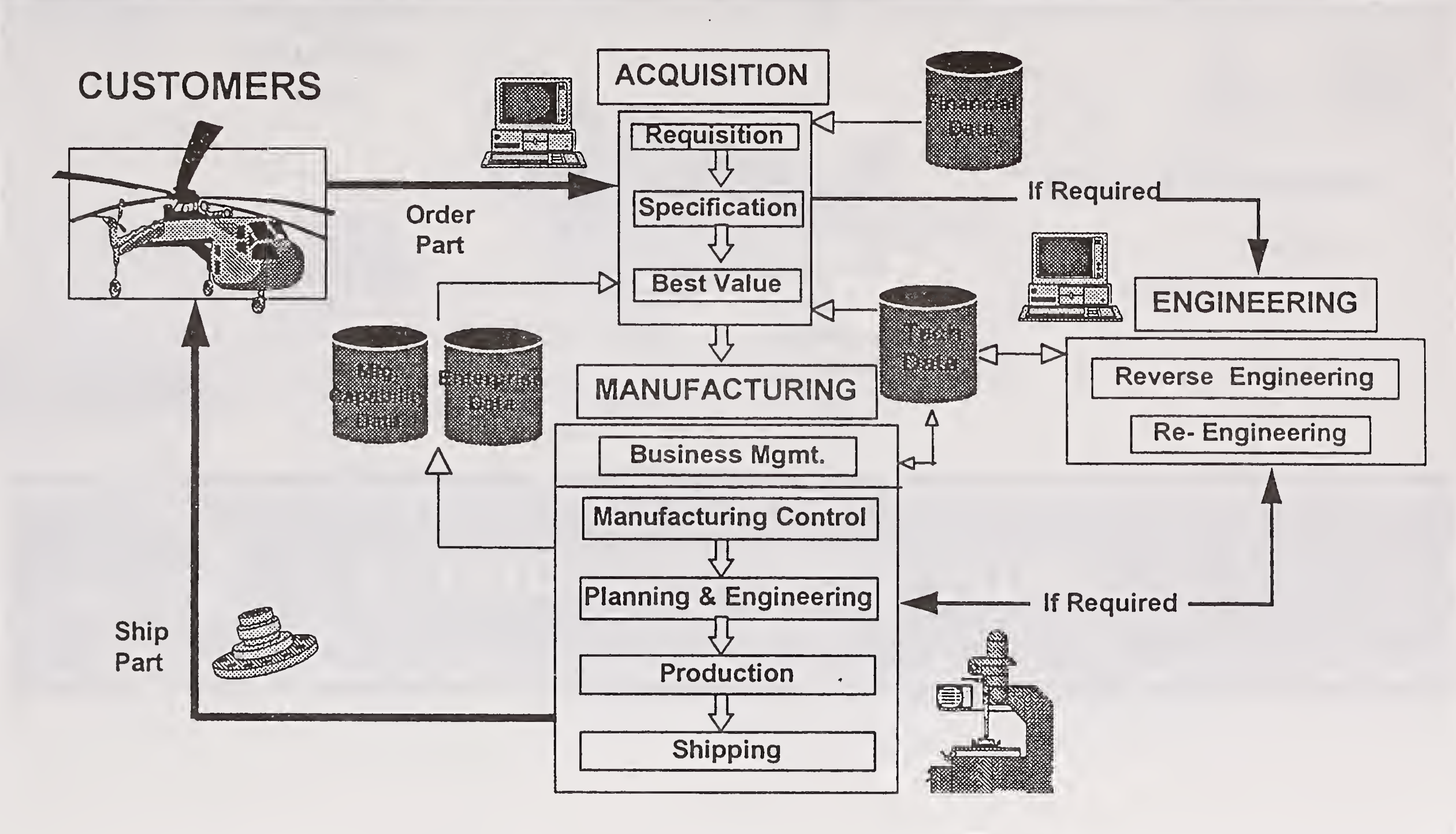
- What information does it not provide?
  - Timing of technology efforts
  - Potential success or maturity of efforts
  - Detail sufficient to identify duplication



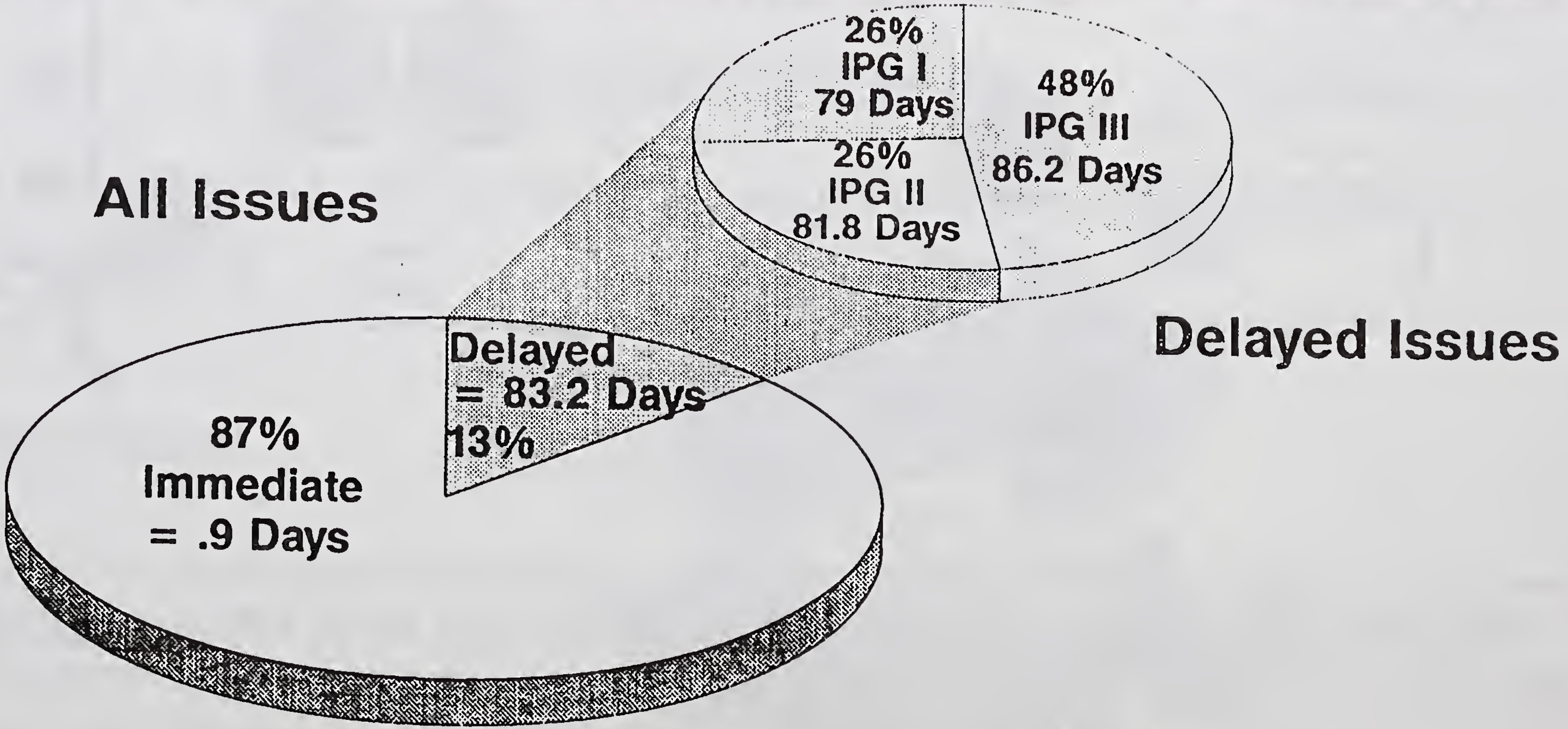
FCIM

MODEL

FCIM - Flexible Computer Integrated Manufacturing



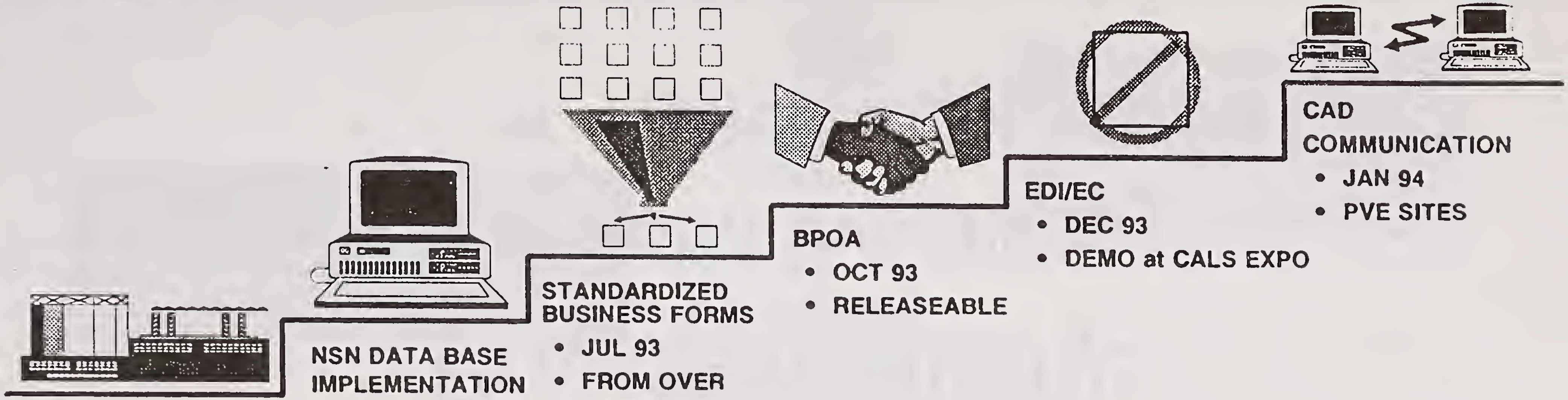
Customer Wait Time



Total Avg. Wait Time = 11.5 Days

FY 93

Technology Interface With Services



IDENTIFY ORGANIC MANUFACTURERS
- MAR 93
- OVER 40 SITES IDENTIFIED

NSN DATA BASE IMPLEMENTATION
- JUN 93
- OVER 100,000 NSN's ID

STANDARDIZED BUSINESS FORMS
- JUL 93
- FROM OVER 12 TO 3

BPOA
- OCT 93
- RELEASEABLE

EDI/EC
- DEC 93
- DEMO at CALS EXPO

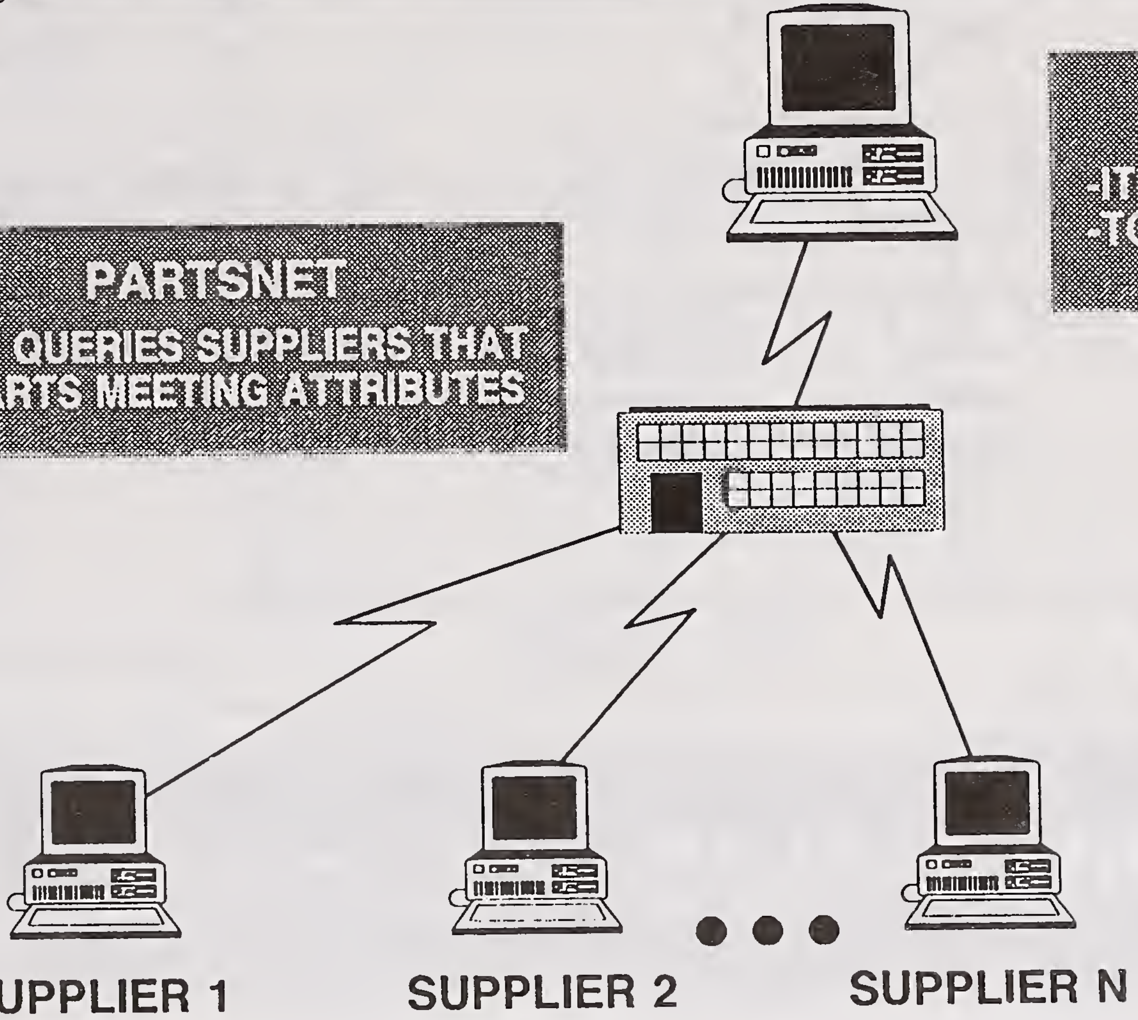
CAD COMMUNICATION
- JAN 94
- PVE SITES

DLA FCIM

Private Industry:

- ➡ Joint Initiatives
- ➡ Technology Export

Mid Term Approach



USER

-ITEM P/Ns OR ATTRIBUTES
-TO PARTSNET SERVER

PARTSNET

-SERVER QUERIES SUPPLIERS THAT HAVE PARTS MEETING ATTRIBUTES

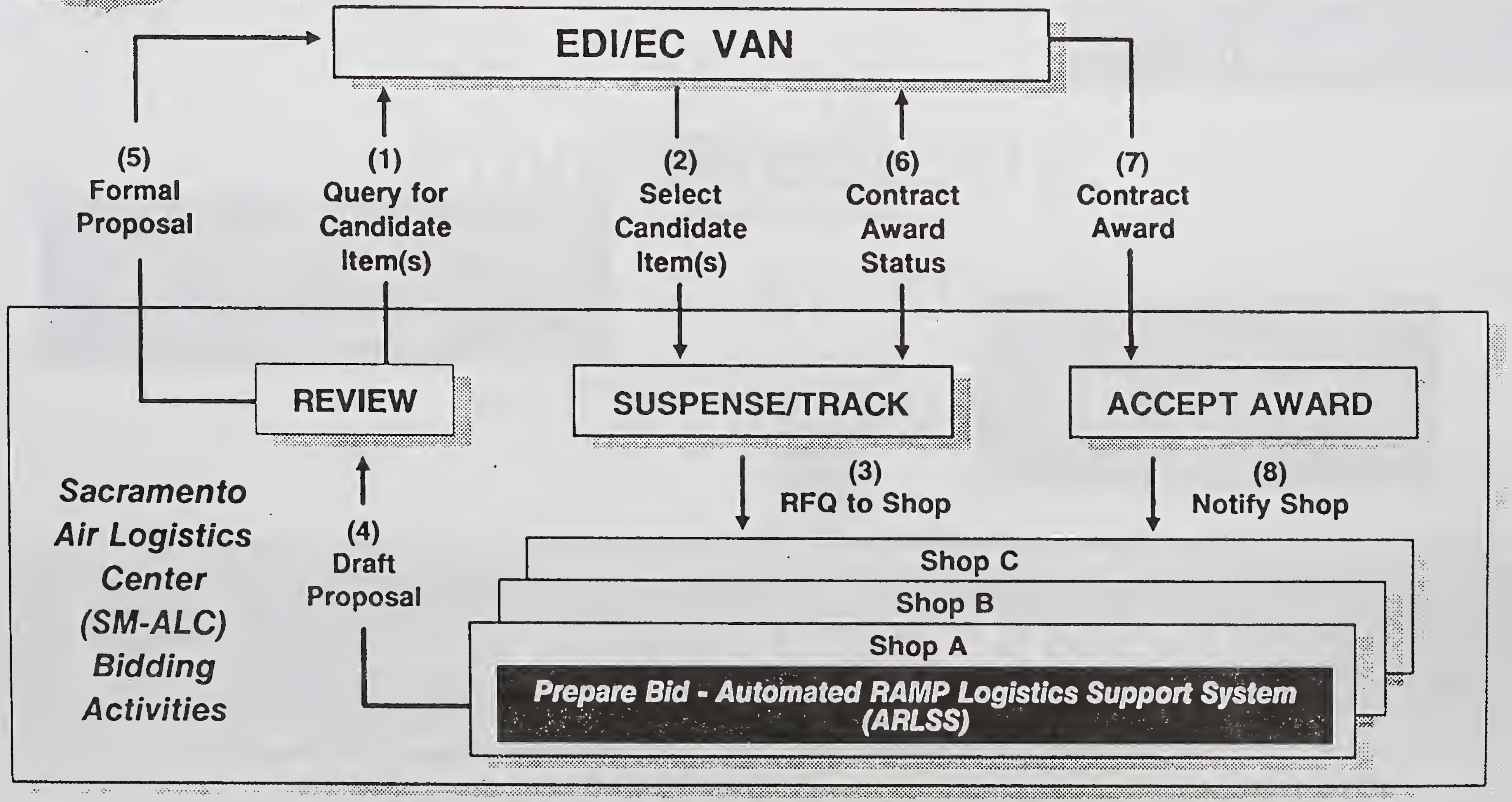
SUPPLIER

-SUPPLIERS "RESPOND" TO QUERIES WITH PRICE AND LEADTIME INFORMATION

TECHNOLOGY EXPORT

Smart Bid

TECHNOLOGY EXPORT



EDI/EC VAN

(5) Formal Proposal

(1) Query for Candidate Item(s)

(2) Select Candidate Item(s)

(6) Contract Award Status

(7) Contract Award

REVIEW

SUSPENSE/TRACK

ACCEPT AWARD

(3) RFQ to Shop

(8) Notify Shop

(4) Draft Proposal

Shop C

Shop B

Shop A

Prepare Bid - Automated RAMP Logistics Support System (ARLSS)

Sacramento Air Logistics Center (SM-ALC) Bidding Activities

FCIM

MANUFACTURING TECHNOLOGY NEEDS AND ISSUES CONFERENCE
28 APRIL

PAM GAUDIOSE
U.S. ARMY DEPOT SYSTEM COMMAND

Chart 1


Cooperative Engineering and Maufacturing Teams
Partners: Government/Government/Industry
ARMY
NAVY
MARINES
Indusrty
DLA
USAF
Engineering
Manufacturing
Inventory Management
Standard Interface
Common Data

Chart 2

FCIM Contracting LINC

Purpose: Test Concept of EDI/CALS Technology to support full acquisition process

Participants:

- Tobyhanna Army Depot
- CALS Shared Resource Center
- Northhampton Community College
- Northeastern Pennsylvania Technology Council
- Bloomsburg University
- 7 Small Manufacturers

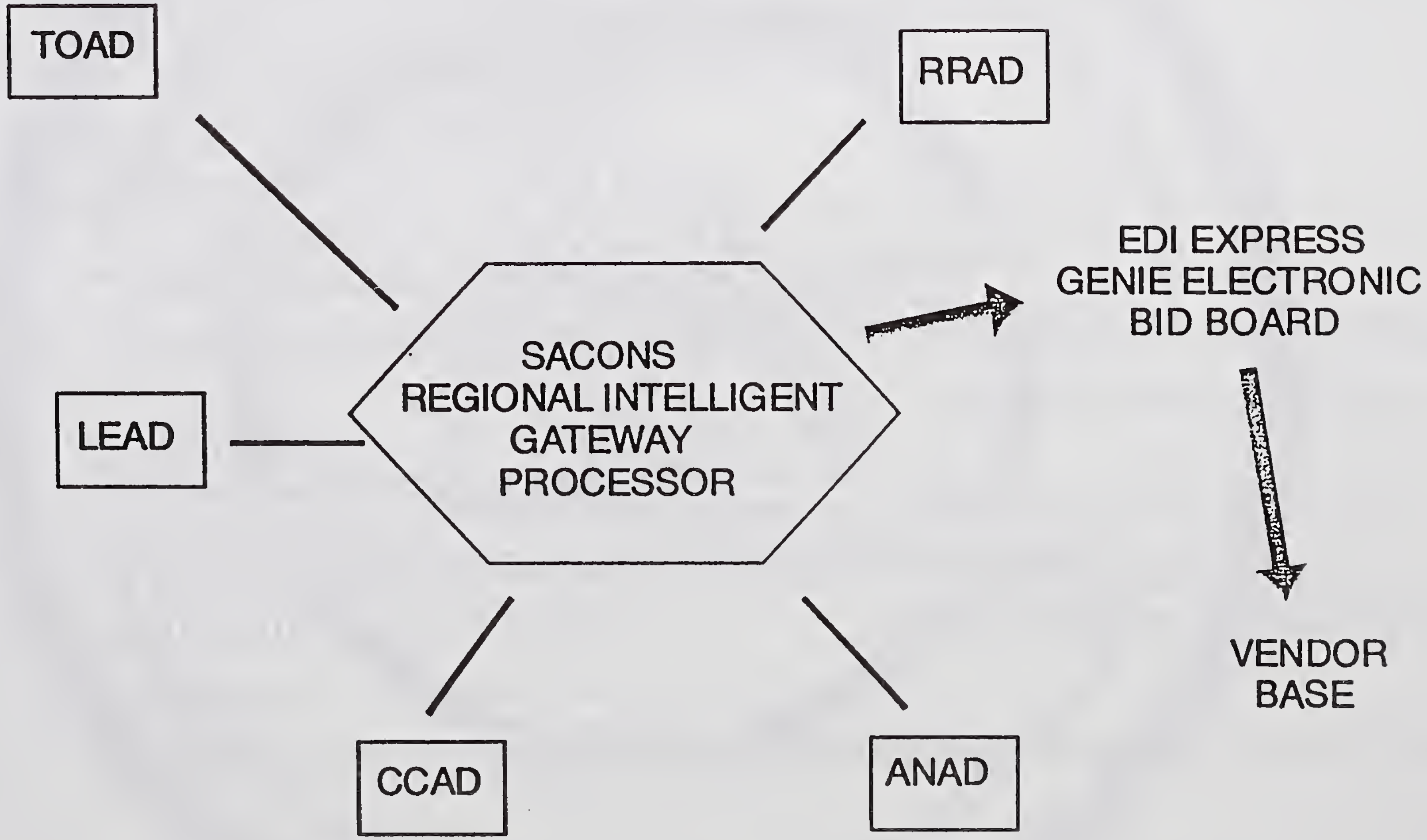
Description: Complete procurement action for a mechanical part requirement totally through an electronic medium

Acquisition Documents

840 Request for Quotation
841 Technical Specification
843 Response to Request for Quotation
850 Purchase Order
856 Shipping Notice/Manifest
810 Invoice

Chart 3

SAACONS - EDI

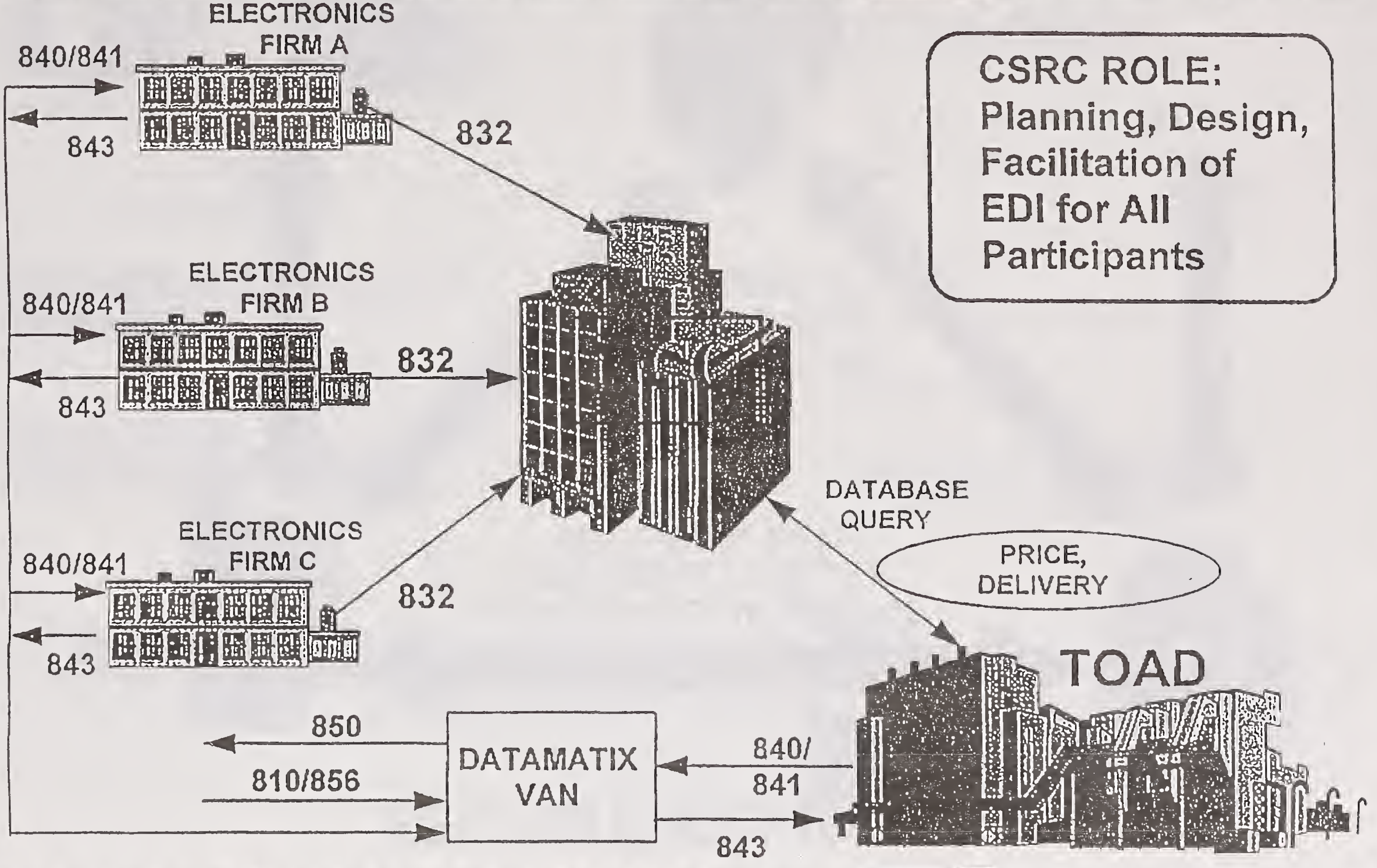


25 K & BELOW PROCUREMENTS

Chart 4

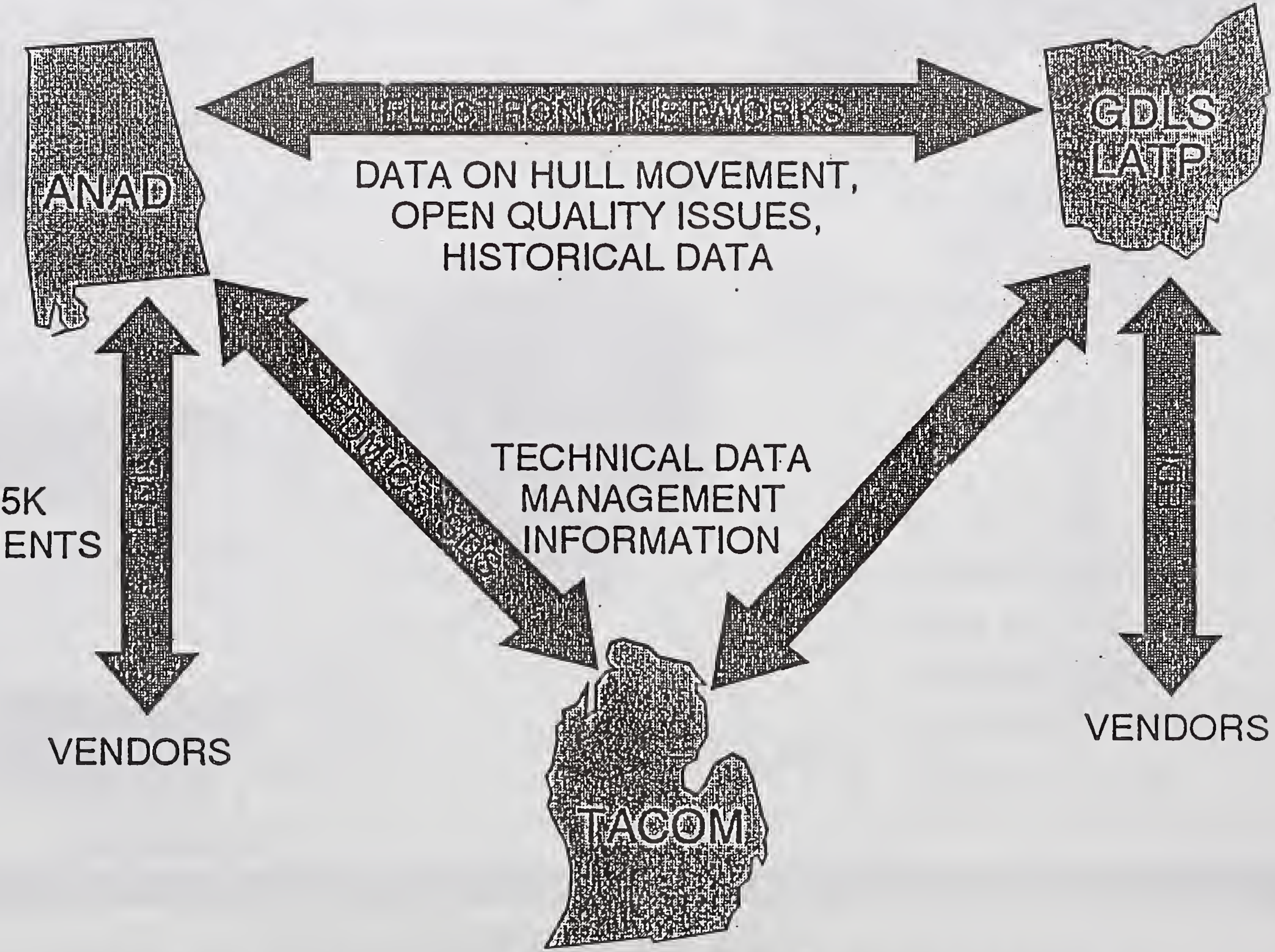
AGILE SUPPLIER BASE PROJECT

CSRC ROLE:
Planning, Design,
Facilitation of
EDI for All
Participants



CALS Shared Resource Center

SECTOR ROUND TABLE



DATA ON HULL MOVEMENT,
OPEN QUALITY ISSUES,
HISTORICAL DATA

UNDER 25K
PROCUREMENTS

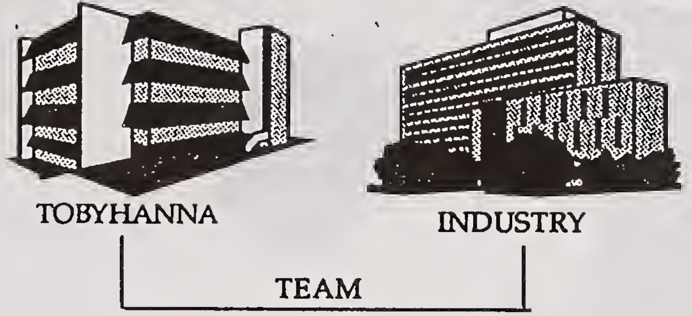
TECHNICAL DATA
MANAGEMENT
INFORMATION

VENDORS

VENDORS

Chart 6

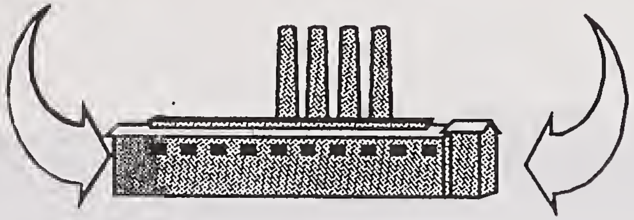
A Partnership for Defense



CAPABILITIES

MATCHING COMPLIMENTARY
CAPABILITIES

NEW BODY OF
CORPORATE KNOWLEDGE



CONSORTIA

PRODUCTIVITY
CENTER-NAVY

RIA - IOWA, ILL

ANAD- N.E. ALABAMA

TOAD- N.E. PA.

LEAD- PA. W.V., VA., MD.
(IN DEVELOPMENT)

Chart 7

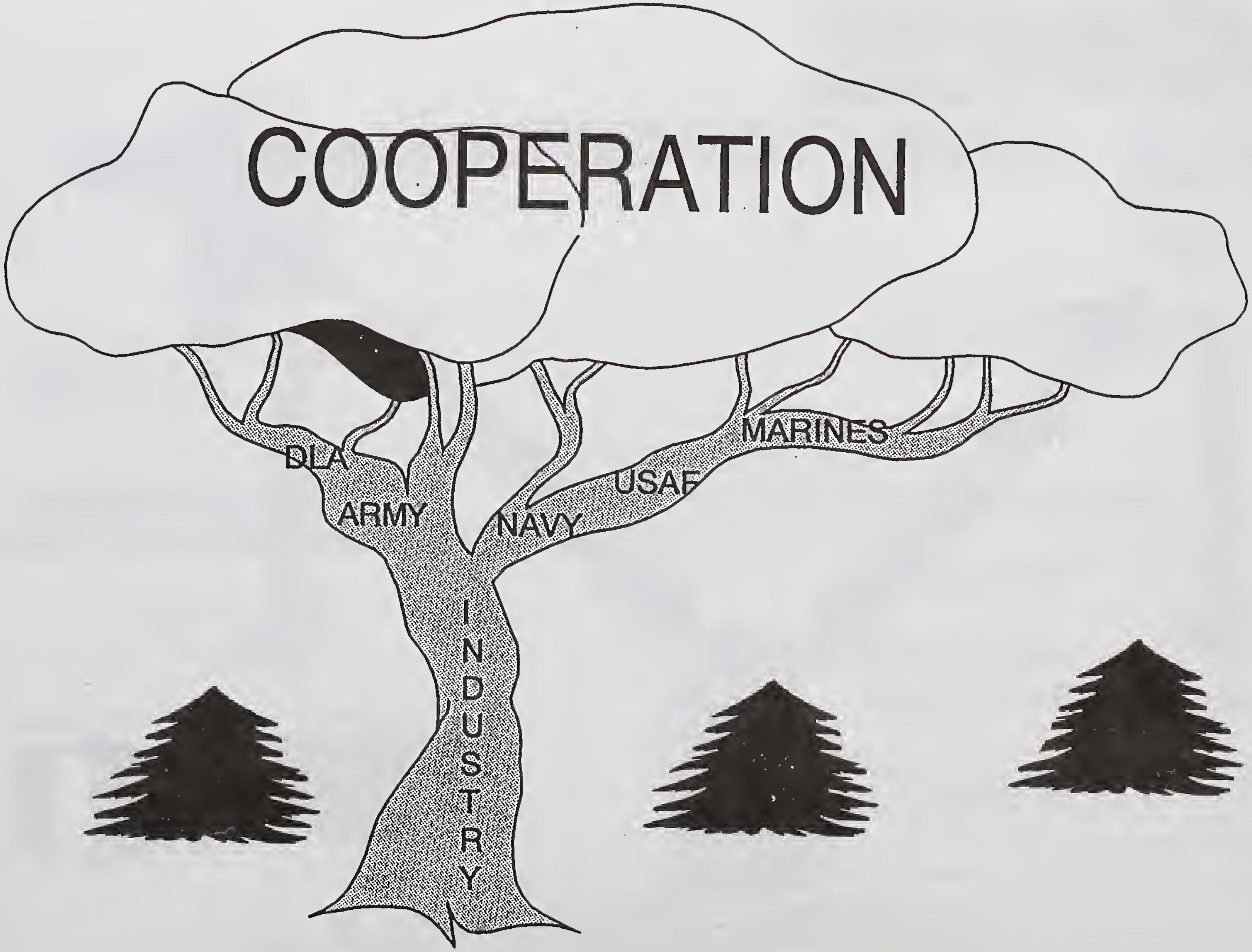


Chart 8

Partnerships

An FCIM Perspective

Dennis K. Rogosch

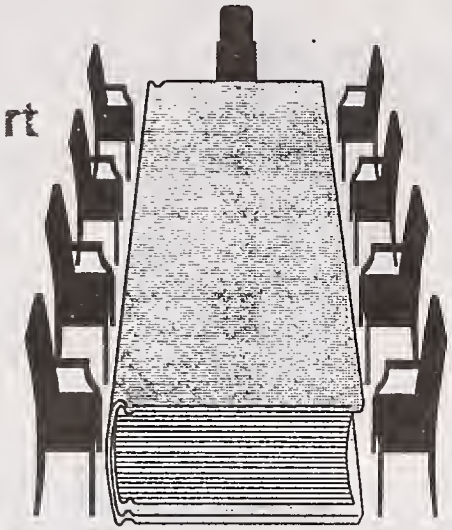
COOPERATION + COMMON SENSE = GOOD BUSINESS

Outline for Success

- Identify the players
- Agree on a Concept of Operation
- Understand the requirements
- Educate (Rapid Prototype) if necessary
- Remove barriers to doing good business
- Drive the solutions

What do I mean?

- Identify the Players
  - Partners know no boundaries both vertically and horizontally
- Agree on Process
  - What you're going to do determines the business sense
- Understand Requirements
  - Don't come with the answer begging a question
- Rapid Prototype
  - Partners are always right but not always smart
- Remove Barriers
  - Good solutions are often regulated out
- Drive the Solutions
  - Implement - Implement - Implement
  - Drive the standards and technology



Foster Balanced Industrial Base

- Prototype Two Dual-use facilities
  - Government and industry
- Establish Consortia Between Sites
  - DoC - Technology Administration, Minority Business Administration, Economic Development Administration, Small Business Administration
  - DoE - federal labs, academia
  - Existing Consortia - Manufacturing Assistance Centers, MTCs, Government Reinvention Sites, Advanced Technology Centers, etc.

- Establish DoD Links
  - Weapons System Program Offices, Operational Sites (Ships, planes, bases, etc.)

21st Century Manufacturing

JUST IN TIME INFORMATION SUPERHIGHWAY

PROCESS IMPROVEMENT *ENTERPRISE INTEGRATION*

TQM *ELECTRONIC COMMERCE* EDI

Implement Standards

SUPPLIER INTEGRATION *PROCESS SIMPLIFICATION*

QUALITY FUNCTIONAL DEPLOYMENT

Teaming/Partnering

Design for Future

LEAN/AGILE PRODUCTION

CONCURRENT ENGINEERING

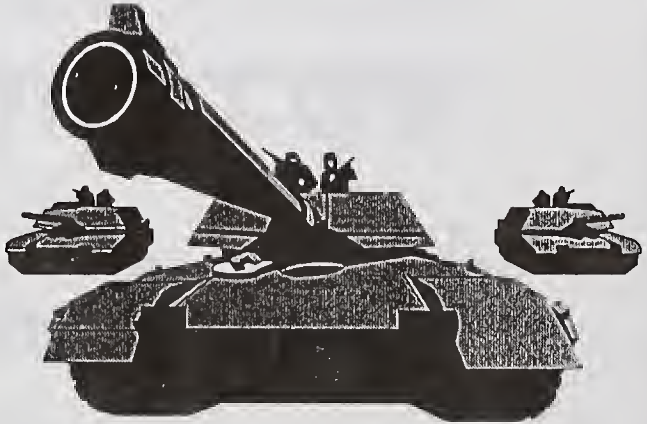
ISLANDS OF AUTOMATION

Standard Parts Virtual Enterprise

PRODUCT LIFE CYCLE MANAGEMENT

Models

- Midwest Flood Recovery
- Industry Round Tables (M1/A2)
- FCIM Teaching Factories
- Advanced Weapons Systems
- National Initiative for Product Data Exchange



Appendix K
Manufacturing Extension Partnership (MEP) Tutorial

Manufacturing Extension Partnership

Presented at
Manufacturing Technology Needs and Issues Workshop
Thursday April 28, 1994

Ron Hira
Regional Manager
NIST Manufacturing Extension Partnership

NIST

Smaller Manufacturers are Important

- There are 370,000 manufacturing firms with under 500 employees
- Smaller firms make up 98% of all manufacturing establishments
- Smaller firms contribute more than half the value-added in manufacturing in the U.S.
- Smaller firms account for 75% of new jobs in manufacturing
- Smaller firms employ 65% of all manufacturing employees (over 8 million jobs)
- Smaller firms supply many of the components used by larger firms

NIST

Objective

- *Help small and medium sized manufacturers become more competitive.*

NIST

Barriers Faced by Smaller Manufacturers

- Lack of awareness of changing technology, production techniques, and business management practices
- Difficulty in finding high-quality, unbiased information, advice, and assistance
- Isolation of smaller manufacturers, which have too few opportunities for interaction with other companies in similar situations
- Regulatory environment which creates a disproportionate burden
- Difficulty of obtaining operating capital and investment funds for modernization

From Learning to Change: Opportunities to Improve the Performance of Smaller Manufacturers, National Academy Press, 1993

Density of Small Manufacturers in the U.S.

NIST

Meeting the Objective

- Assist small and medium sized manufacturers
  - Implement appropriate advanced technology and techniques - core
  - Adopt best manufacturing and management practices - core
  - Adopt modern workforce training and organization approaches - essential related services
- Provide a nationwide system for manufacturing modernization, building on existing organizations, resources, and experience.

NIST

Key Elements

- Manufacturing Extension Centers
  - Manufacturing Technology Centers (MTCs)
  - Manufacturing Outreach Centers (MOCs)
- State Technology Extension Program (STEP)
- LINKS

NIST

Present Manufacturing Extension Centers

- 16 MTC sized centers (9 new ones)
- 19 MOC sized centers

NIST

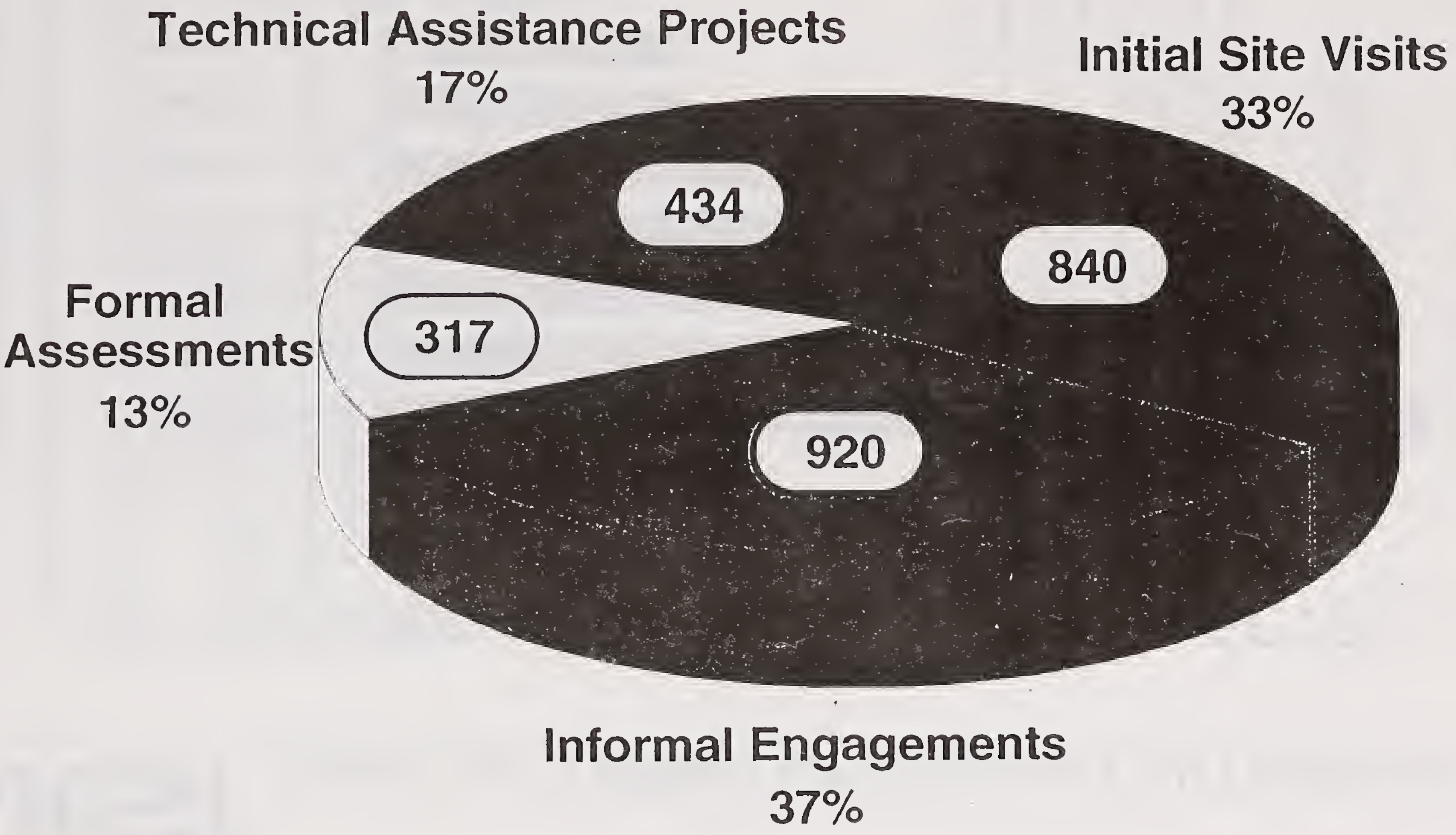
What Extension Centers Do

- Core - need substantial in-house expertise
  - Assessment of company needs
  - Help companies undertake fundamental reshaping
  - Provide technical expertise - field engineers and consultants
  - Integrate service delivery
  - Projects
  - Demonstration and selection of S/W, H/W, training, etc.
  - Links to technology developers (labs, univs)

MEP EXTENSION CENTERS

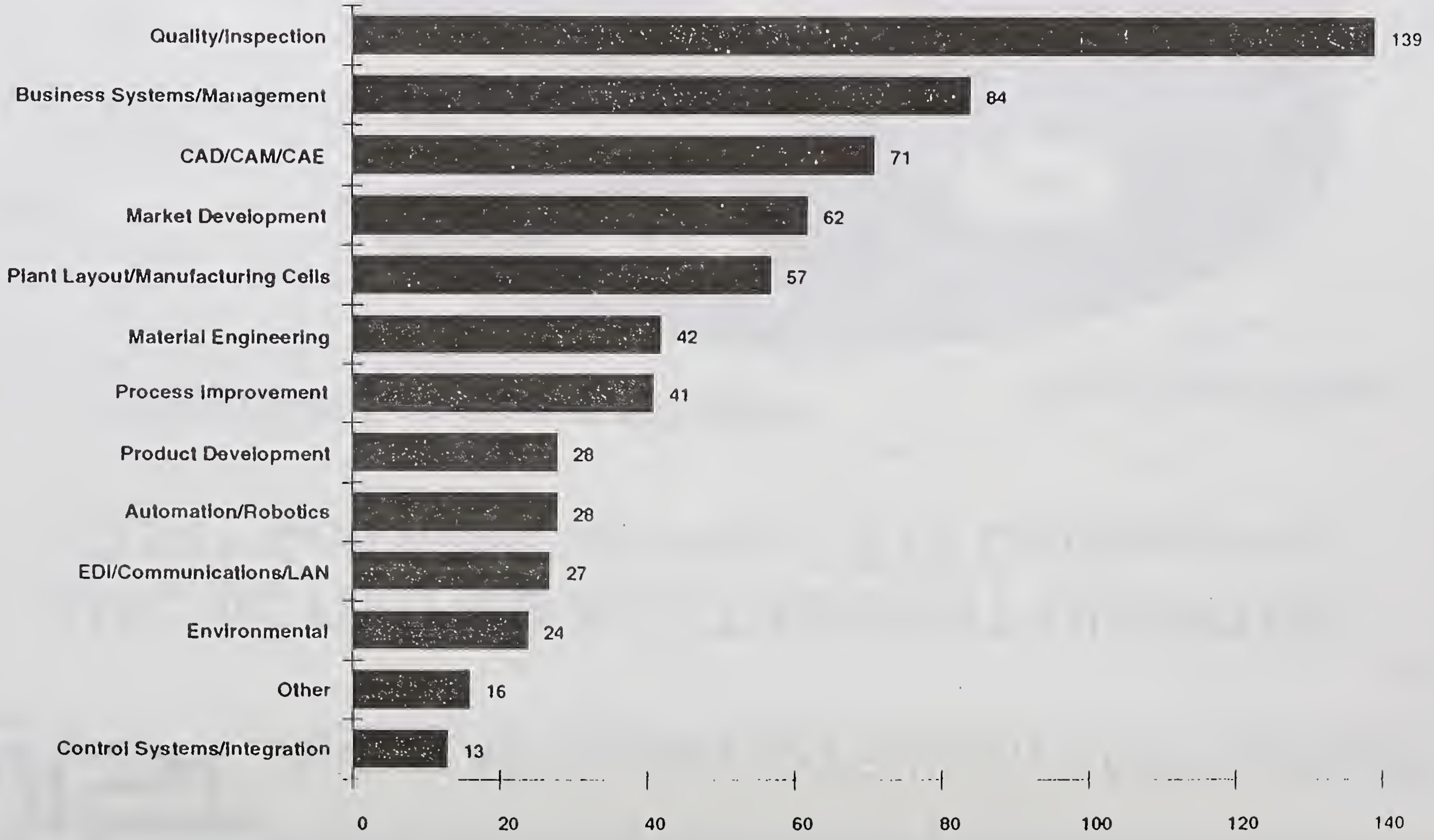
NIST MANUFACTURING EXTENSION PARTNERSHIP

MTC ACTIVITIES MOST RECENT QUARTER
(2,511 Activities Serving 1,613 Companies)



NIST MANUFACTURING EXTENSION PARTNERSHIP

632 TECHNICAL ASSISTANCE PROJECTS
(Most Recent Quarter)



NIST

What Extension Centers Do

- Essential Related Services - need strong linkages to others; MEP money used only for links, catalyzing and kick-off
  - Workforce training and workplace organization
  - Human resources issues
  - Business system development
  - Marketing
  - Financing

NIST

Extension Center Funding and Structure

- MTCs -- Grow to ~30 over 4 years
  - Serves region with 6,000 - 8,000 manufacturers
  - Total budget $6 million, half Federal (declining to 1/3)
  - Substantial technical and management resources
- MOCs -- Grow to ~70 over 4 years
  - Serves region with 600-800 manufacturers
  - Total budget $1 million, half Federal (declining to 1/3)
- Strong local ties, links to state infrastructure
- User fees vary by center and service delivered

NIST State Technology Extension Program (STEP) is an Agent of Change for State Industrial Extension Services

- Funding and providing technical support for planning.
- Providing continuing support for state-based implementations in sparse states.
- Helps build links among states and between states and federal technology sources

NIST

LINKS- the National Infrastructure

- information infrastructure - communications, access to information
- evaluation
- field agent training
- tool development
- linkages with other national organizations

NIST

Linkages

- There are Federal, state, local, private resources and programs in place which relate to the mission
- Establish linkages with existing resources and programs
- Don't duplicate existing resources
- Don't clash with existing programs

NIST

Illustrations of Linkages

- National Laboratories as technology resources
- Department of Labor for workforce training
- Environmental Protection Agency
- National Coalition of Advanced Technology Centers
- National Technology Transfer Center
- Small Business Administration for financing and business planning
- National Tooling and Machining Association
- Electric Power Research Institute
- Technology Reinvestment Project (TRP)

NIST

What the MEP Program Does

- Help potential proposers develop their plans
- Select winners in a fully competitive process
- Help winners develop
- Shape a national system, viewed from the federal level
- Provide vision for MEP entities in the field
- Provide services, such as evaluation, information infrastructure
- Evaluate, force change, terminate
- Serve as a source of expertise, a national resource.

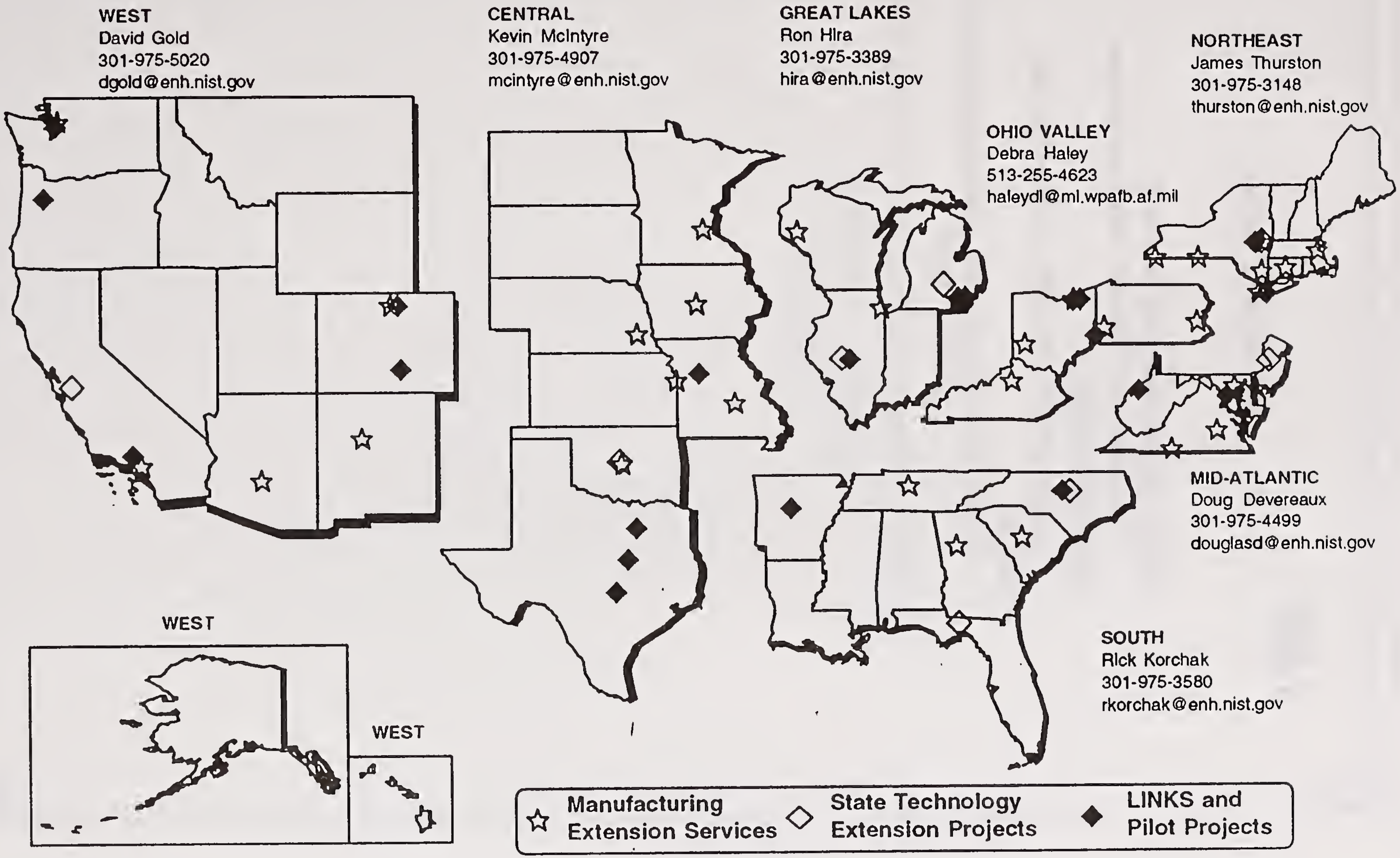
NIST

Vision for MEP

- By 1997 there will be manufacturing extension services within the reach of essentially all of the 370,000 smaller manufacturers
- Nantionwide electronic network services will provide filtered access to technology sources and essential related services - first through field agents, then directly to companies
- Smaller manufacturers will be active in electronic commerce
- The Federal program for service delivery will be coherent and focused, with appropriate linkages
- There will be a uniform system for effectively measuring performance of extension service providers
- The national manufacturing extension system will evolve, grow, and change its mix of services as we learn, as the capabilities of the extension system develop, and as companies progress

NIST MANUFACTURING EXTENSION PARTNERSHIP

MANAGEMENT REGIONS



NIST

Points of Contact

Quality, Evaluation and Training
- – Ruth Haines 301-975-6454, ruth@micf.nist.gov

Outreach/Linkages
- – Gale Morse 301-975-4520, gale@micf.nist.gov

LINKS
- – Ron Parsons 301-975-5302, rparsons@micf.nist.gov

Appendix L

Manufacturing Science and Technology (MS&T) Program

Tutorial

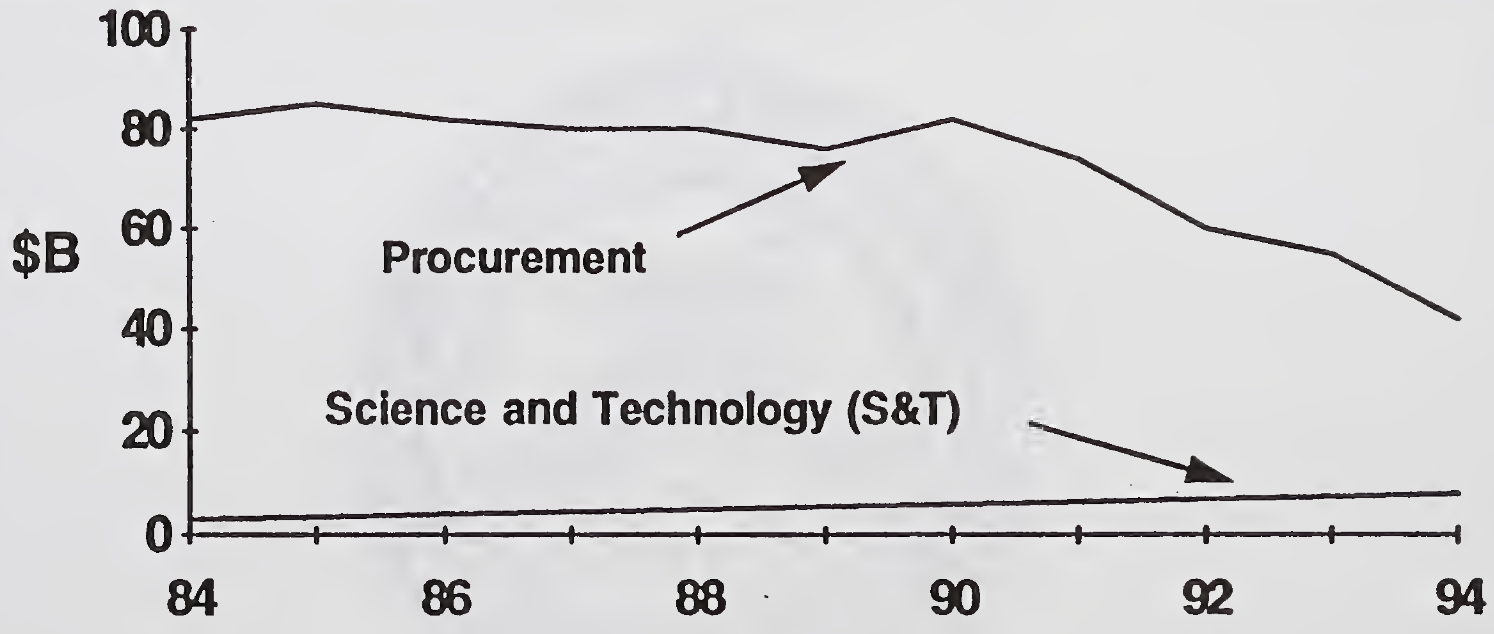
Manufacturing Science & Technology

DEPARTMENT OF DEFENSE
UNITED STATES OF AMERICA

Dan Cundiff
DDR&E
(703) 614-0205

MS&T

Affordability - More Important Than Ever



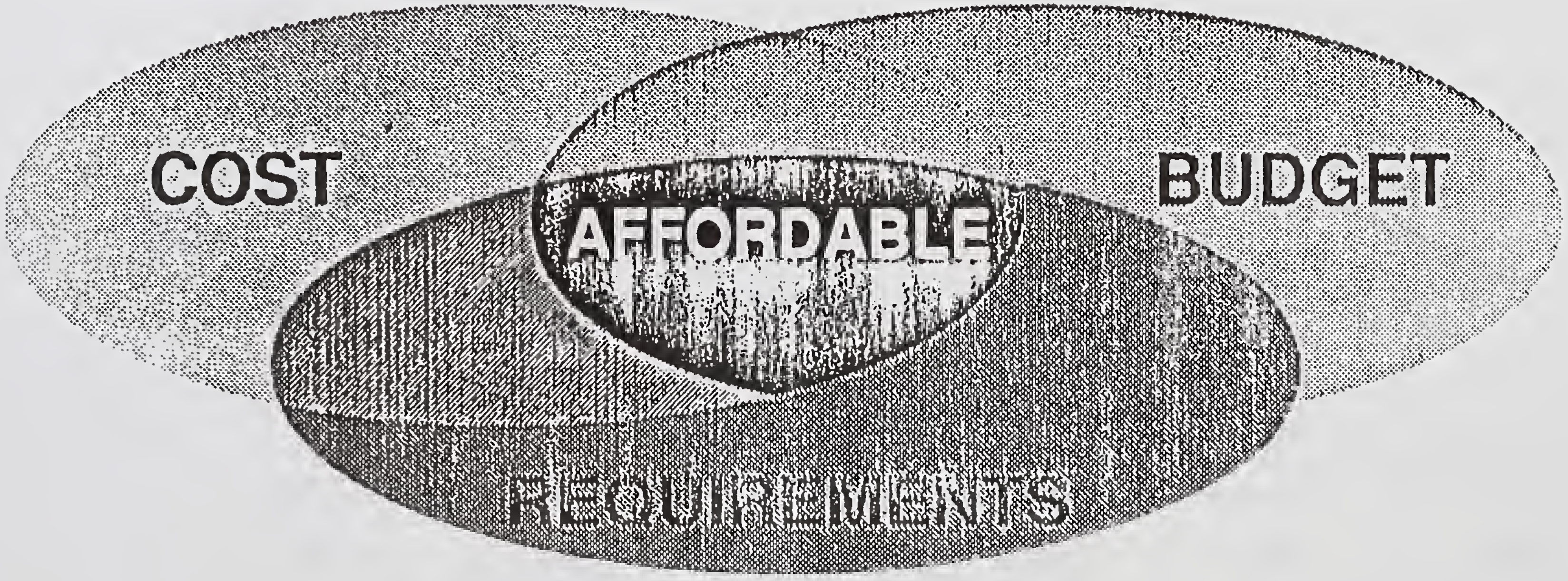
DoD Strategy

- Invest in Technology to:
  - Make future defense systems affordable
  - Maintain a responsive industrial base

S&T Vision

Develop and transition superior technology to enable affordable, decisive military capability and to enhance economic security

Affordability Definition



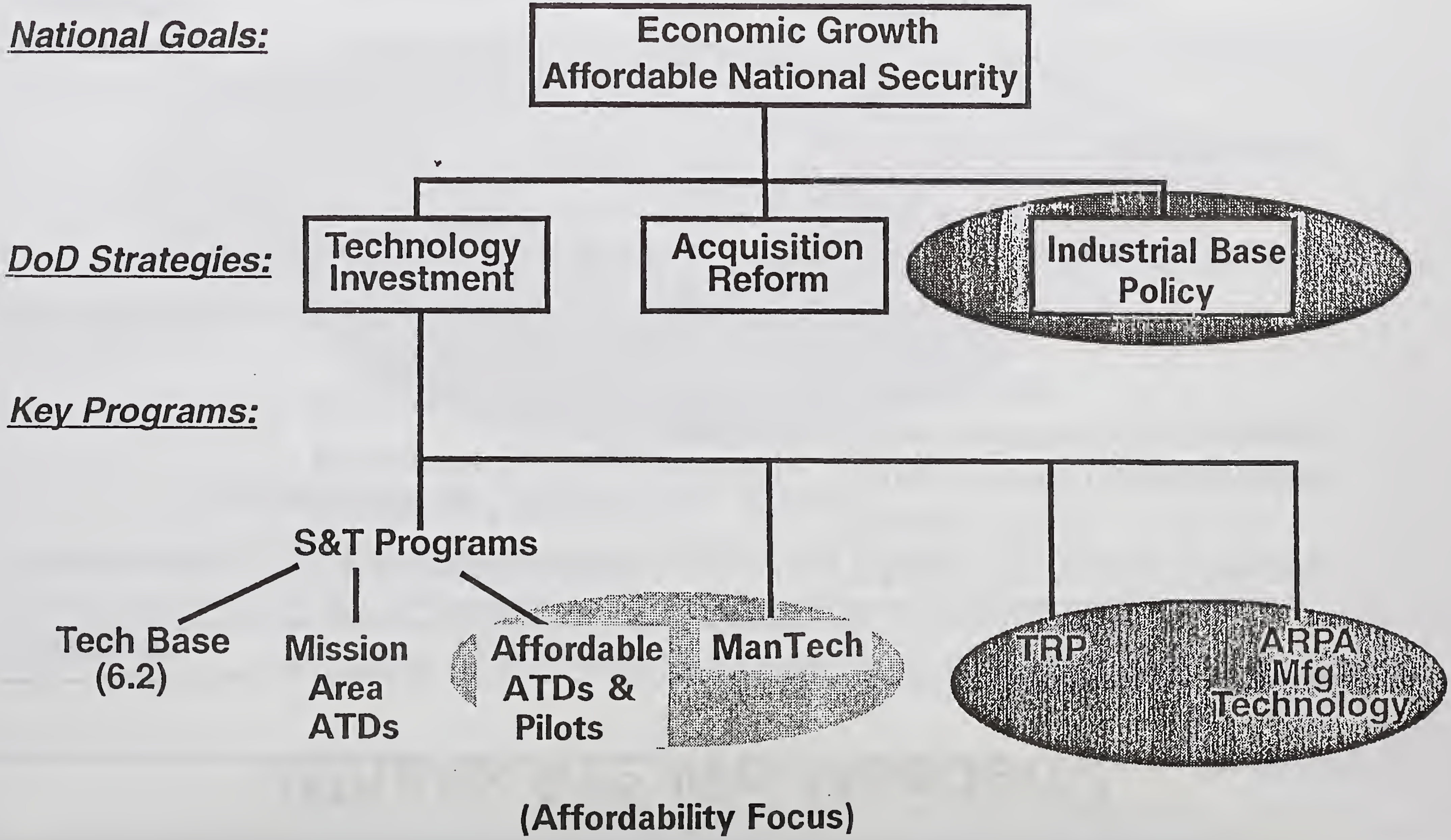
A technology is "affordable" when:

- It is within an acceptable cost range,
- It does not exceed the customer's budget, and
- It meets or exceeds the customer's requirements.

Where Are We Headed?

Capability	Today	Future
Engineering	• Sequential design • Minimum focus on producibility, supportability • Incompatible design tools	• Integrated Product/ Process Design (IPPD) • Multi-function design teams • Interoperable tools, models, simulations
Manufacturing	• "Mass Production" Paradigm • Dedicated DoD Lines	• Lean, Agile manufacturing • Flexible systems to decouple cost from quantity • DoD access to commercial lines
Information Integration	• High factory overhead • Slow paper-based processes	• Intra-company integration to attack overhead • Inter-company electronic exchange of engr data • Electronic commerce

Strategies for Affordable Defense



National Goals:

Economic Growth
Affordable National Security

DoD Strategies:

Technology Investment

Acquisition Reform

Industrial Base Policy

Key Programs:

S&T Programs

Tech Base (6.2)

Mission Area ATDs

Affordable ATDs & Pilots

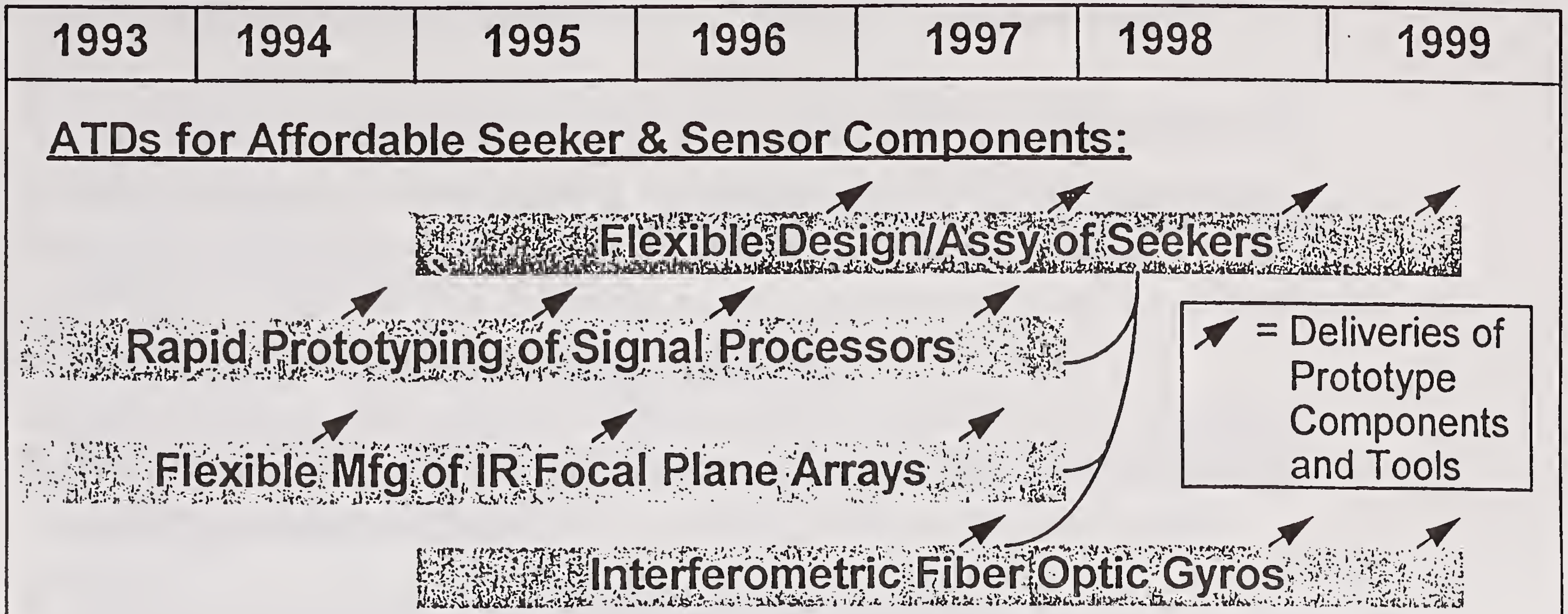
ManTech

TRP

ARPA Mfg Technology

(Affordability Focus)

ATDs



Expected Results

- New Benchmarks for Cost, Time, Quality
- IPPD Design Tools
- Advanced Mfg Processes
- Factory Control Systems
- Pilot Multi-use Factories
- Models & Simulations
- Affordable Subsystems

Thrust 7 ATD Descriptions

- **FDAMMS:** Develop advanced manufacturing technology to demonstrate the ability to substantially reduce acquisition cost and schedule of high performance, electro-mechanical assemblies through integrated product/process design and flexible manufacturing, with initial application to missile/munition seekers.
- **IFOG:** Develop advanced manufacturing technology and infrastructure to produce large volume, low cost fiber optic gyroscopes for affordable, high precision weapon and platform guidance and navigation and commercial applications.
- **RASSP:** Improve the process by which complex digital systems, particularly embedded signal processors, are designed, manufactured, upgraded and supported. to provide affordable embedded signal processors for a wide range of dual-use systems that are state-of-the-art when fielded
- **IRFPA-FM:** Develop low volume, flexible manufacturing capabilities to produce affordable, SOTA Infrared Focal Plane Arrays for advanced sensor systems including missile seekers.

MS&T Program

- Customer driven
- Factory focused across product life cycle
- Pervasive - results applicable to more than one factory/system
- Diverse technology areas
- Feasibility previously demonstrated, little "high risk R&D"
- Emphasis is on implementation & development
- Formal joint planning/execution
- Strong industry & Congressional support

History

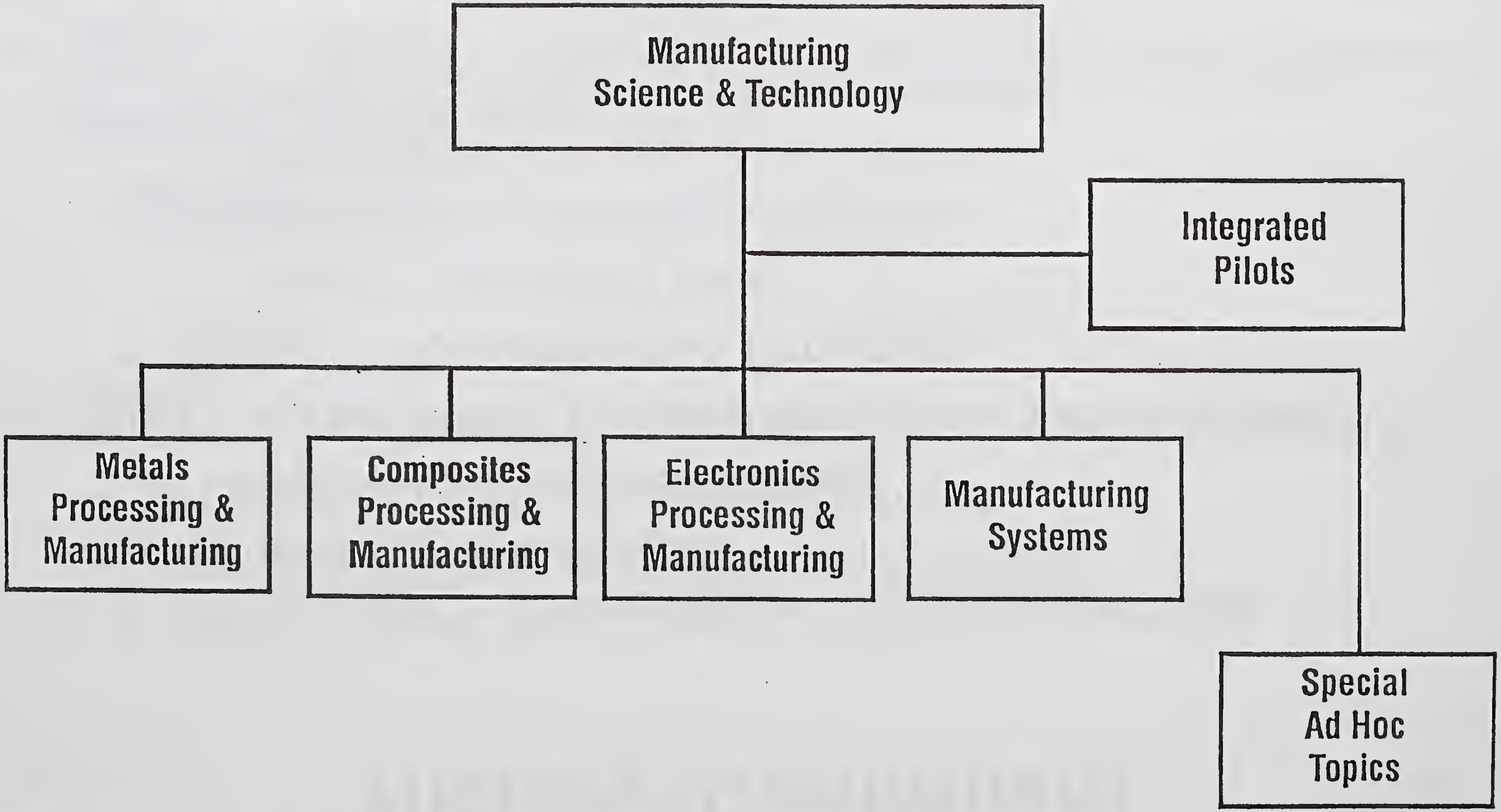
- 1960s - 1990s: Solid Record of Solving Generic Factory Floor Problems
  - Reduced Costs, Improved Quality

- 1991: Congress Increased ManTech Funding
  - To Stimulate Industrial Competitiveness
  - To Bolster Regional Economic Development

History (Continued)

- 1992 - 1993: President's Budgets Did Not Extend The Increases
  - Congress Increased Earmarking
  - Dec 92: USD(A) Assigned ManTech to DDR&E (Thrust 7)
- Today: Consolidated Program
  - DDR&E: Oversight & Policy
  - Services/DLA: Planning & Execution
  - Manufacturing Reliance Panel chartered
  - Defense Manufacturing Council chartered

MS&T Taxonomy



Manufacturing Science & Technology

Integrated Pilots

Metals Processing & Manufacturing

Composites Processing & Manufacturing

Electronics Processing & Manufacturing

Manufacturing Systems

Special Ad Hoc Topics

MANUFACTURING SCIENCE & TECHNOLOGY TAXONOMY

Metals Processing And Manufacturing Addresses Accurate And Repeatable Processing Of Metals And Other Materials That Use The Same Processes Including Forming, Consolidation, Mass Change (Addition Or Reduction), Joining, Metrology, And The Intelligence Required To Model, Simulate And Control The Shop Floor Processes.

Composites Processing And Manufacturing Addresses The Area Of Composite Material Applications Including Polymer Matrix Composites, Metal Matrix Composites, Carbon-Carbon Matrix Composites, Ceramic Matrix Composites, And Other Materials That Use Similar Processes. The Technical Issues Will Emphasize Tooling, Fabrication, And Assembly Relevant To Implementing Improved Process Simulation And Modeling Leading To Significant Cost Reduction.

Electronics Processing And Manufacturing Addresses The Materials, Equipment, Assembly, Test And Inspection Processes Needed In Electronics Applications And Assures The Performance, Ruggedness, Reliability, And Quality For Form, Fit, And Function Of The Products In The Field. New Electronics Materials, Components, And Subsystems Emerging From The Technology Base Developments Are Included For Demonstrations.

Optics Automation & Management (OPTICAM)

Problem:

- High cost of precision optics
- Long cycle time
- Declining industrial base

Application:

- All direct view and electro-optical fire control systems
- Commercial products, e.g., binoculars, endoscopes

Approach:

- Establish FCIM capability
- Based on an integrated CNC machine environment
- Use deterministic processes

Accomplishments:

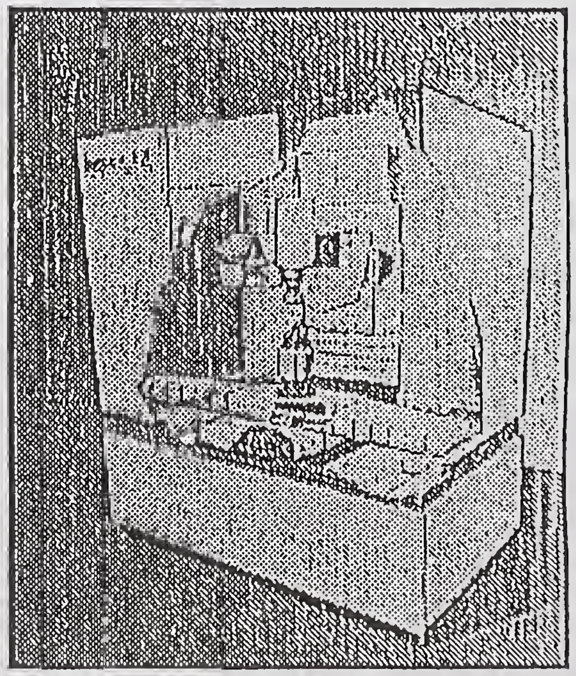
- OPTICAM system established
- Three CNC machines constructed and commercialized

Implementation:

- Spherical module installed by TI
  — IR lenses for AAWS-M missile
- 24 additional suppliers expected to facilitize by 1996

Benefits:

- 20% cost reduction/part (est. $10M/year savings)
- Cycle time reduced from 6 weeks to 2 days
- Factor of 10 improvement in dimensional tolerances
- Elimination of toxic solvents



Investment:

- $4.9M (Army)
- $2.0M (OSD)
- $8.3M (Matching Funds)

Period of Performance:

- Jul 90 – Mar 93

Performing Activity:

- Center for Optics Manufacturing Rochester, NY

MS&T

Advanced Fiber Placement

Problem:
- High costs associated with hand layup

Application:
- F/A-18E/F skins and inlet ducts
- AX low observable inlet ducts
- Other next generation aircraft

Approach:
- Automated fiber (prepreg tow) placement

Accomplishments:
- Proof-of-concept articles fabricated and tested
- F/A-18 inlet duct mandrels fabricated
- Drafts of material and process specs completed
- Structural equivalency panels fabricated
- Baseline design requirements established

Implementation:
- F/A-18E/F EMD aircraft
- F/A-18E/F production aircraft
- AX aircraft

Benefits:
- 25% reduction in component cost
- Reduced cycle time

Investment:
- $6M (Navy)

Period of performance:
- Oct 91 - Apr 94

Performing activities:
- Great Lakes Composites Consortium
- McDonnell Douglas
- Northrop
- Hercules
- Grumman
- Rockwell International
- Cincinnati Milacron

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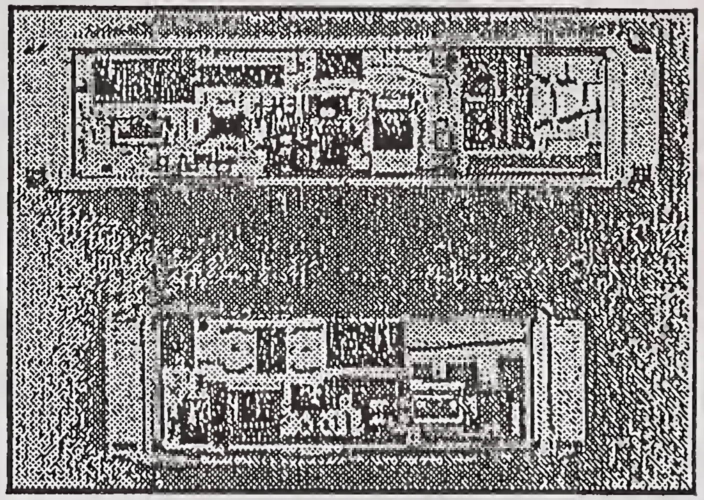
Thrust 7: Technology for Affordability

Transmit / Receive (T/R) Modules



Problem:

- Major cost driver of next generation radars
  - — Large quantities required
  - — Unit cost of $8,000

Application:

- Airborne, ground-based, and space-based radars
- Automotive anti-collision systems

Approach:

- Dual award to major radar manufacturers
- Demonstrate large-scale producibility

Accomplishments:

- Test time reduced from 8 hours to 30 minutes
- Parts count reduced from 135 to 35
- Interconnects reduced from 800 to 300
- GaAs chip cost reduced by factor of 3 to 4

Implementation:

- F-22 active element phased array radar
- Hughes-Delco object detection system

Benefits:

- Module costs reduced from $8,000 to $400
- Increased reliability (125,000 hours MTBF)
- Large quantity producibility

Investment:

- $18.9M (AF)
- $2.0M (Navy)
- $1.1M (F-22 SPO)

Period of performance:

- Apr 89 - Feb 94

Performing activities:

- TI /Westinghouse
  Dallas, TX
- Hughes Aircraft
  El Segundo, CA

MS&T

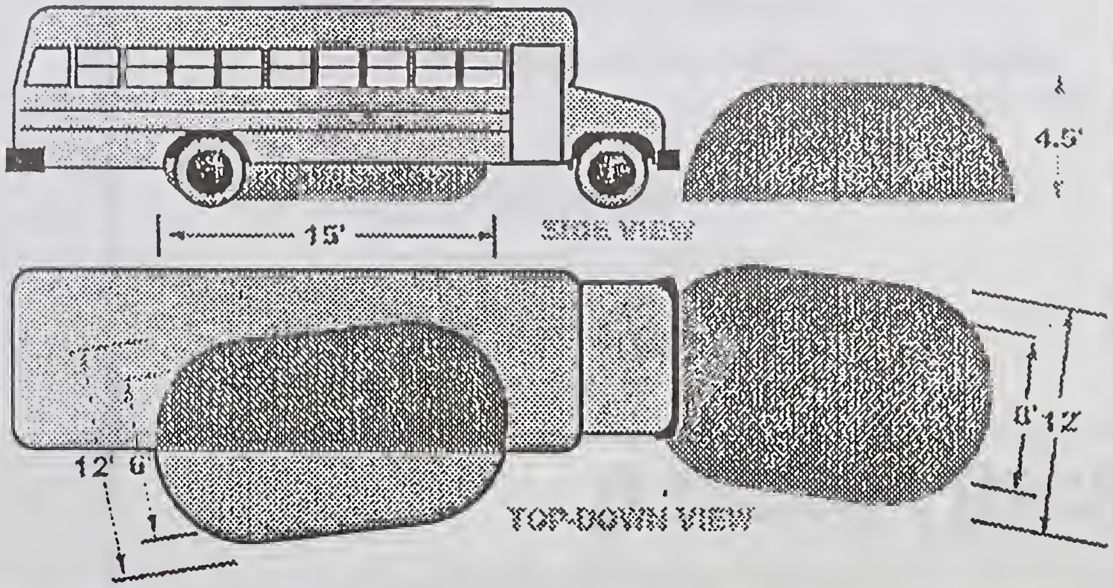
Dual Use Manufacturing — HE Microwave

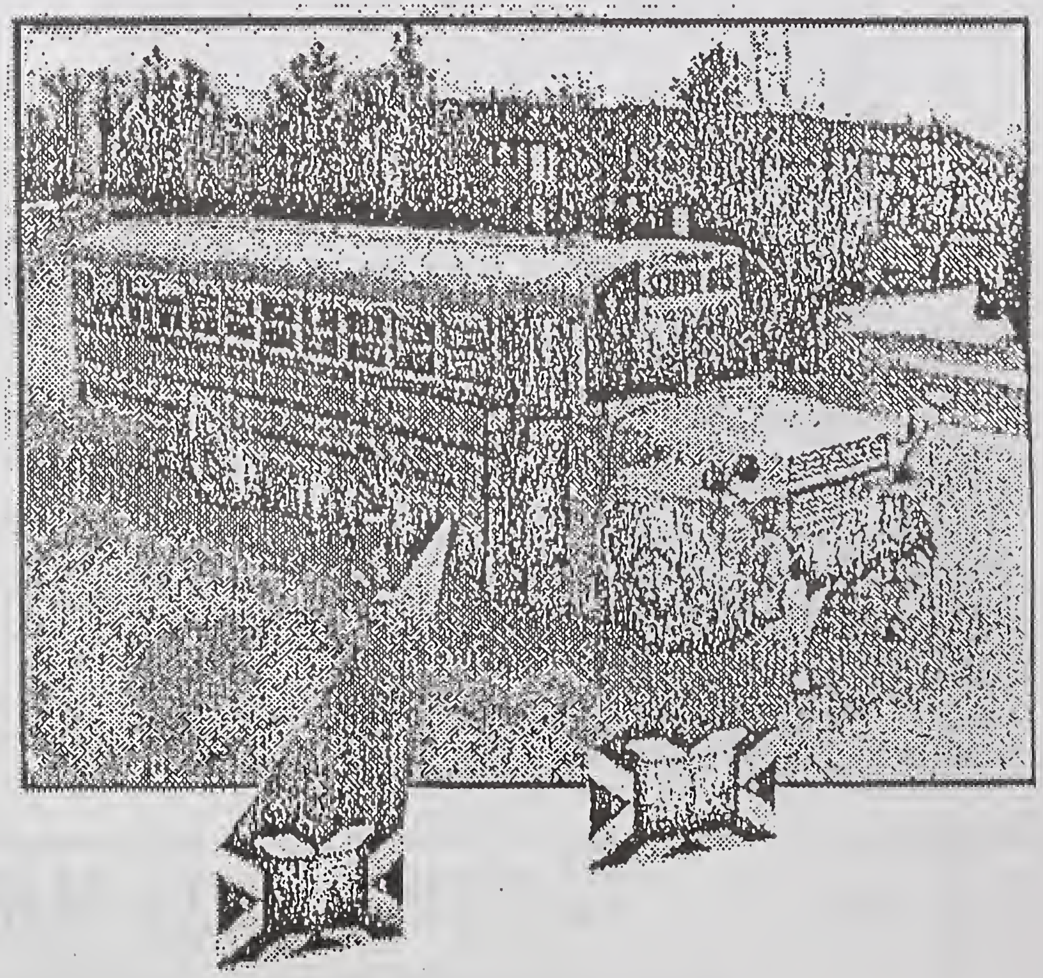
Phased Array X-Band Radar Modules And Near Object Detection System Modules

Delco Electronics
FOREWARN™
OBJECT DETECTION SYSTEMS

Delco Electronics

DETECTION AREAS:
FOREWARN 2-SENSOR SYSTEM



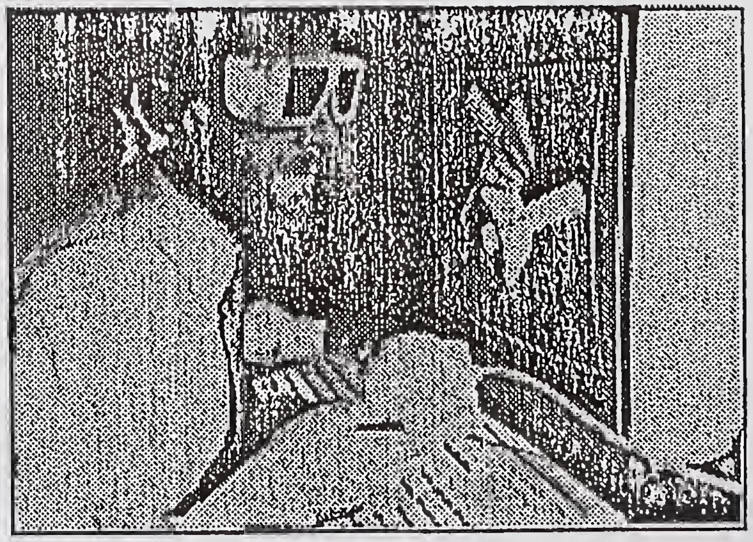


MS&T

Manufacturing Systems

- ***Strategic Theme:***
  - Aggresively Attack Above-The-Shop-Floor Manufacturing Support Costs
- **Technical Themes:**
  - Networked Data Exchange Among Primes And Suppliers
  - Data Bases To Support Design-To-Cost And Design For Manufacturability / Assembly
  - Virtual Manufacturing Simulation For Pre- Hardware Validation Of Processes

Automated Airframe Assembly Program (AAAP)



Problem:

- High cost of airframe production
- Lack of integration of the production environment

Application:

- Airframe assembly industry sector
- Primes, subs, vendors

Approach:

- Develop technologies in support of automated assembly
- Focus on above-the-shop-floor processes
- Emphasis on a modular, open architecture
- Based on national standards

Accomplishments:

- Assembly modeling
- Communications technology
- Generative assembly planning
- Dynamic shop-floor scheduling
- Feature-based modeling

Implementation:

- Commercial products include:
  - Oracle "Version 7"
  - Simgraphics assembly modeling – F/A-18

Benefits:

- New approaches to airframe assembly
- Reduced factory costs
- Shortened cycle times

Investment:

- $17M (AF)

Period of Performance:

- Jul 86 – Oct 91

Performing Activity:

- Northrop Corporation
  Hawthorne, CA

MS&T

Integrated Pilots

Strategic Theme:

- Closely Couple The Integration Of Advances From MS&T Initiatives to Weapon System Programs .. And Link With New Or Alternative Manufacturing And Business Methods

Technical Themes:

- Impact System Cost Reduction And Lower Risk For Technology Insertion
- Models For Near-Term Affordability Demos
- Demonstrate The Benefits Of Changes To DoD Procurement Practices
- Implementation Of Commercial Processes

Special Ad Hoc Topics

Topics having a very narrow or unique technology requirement but which have a general interest of the ManTech community.

- Centers of Excellence/Consortia
- Munitions Affordability

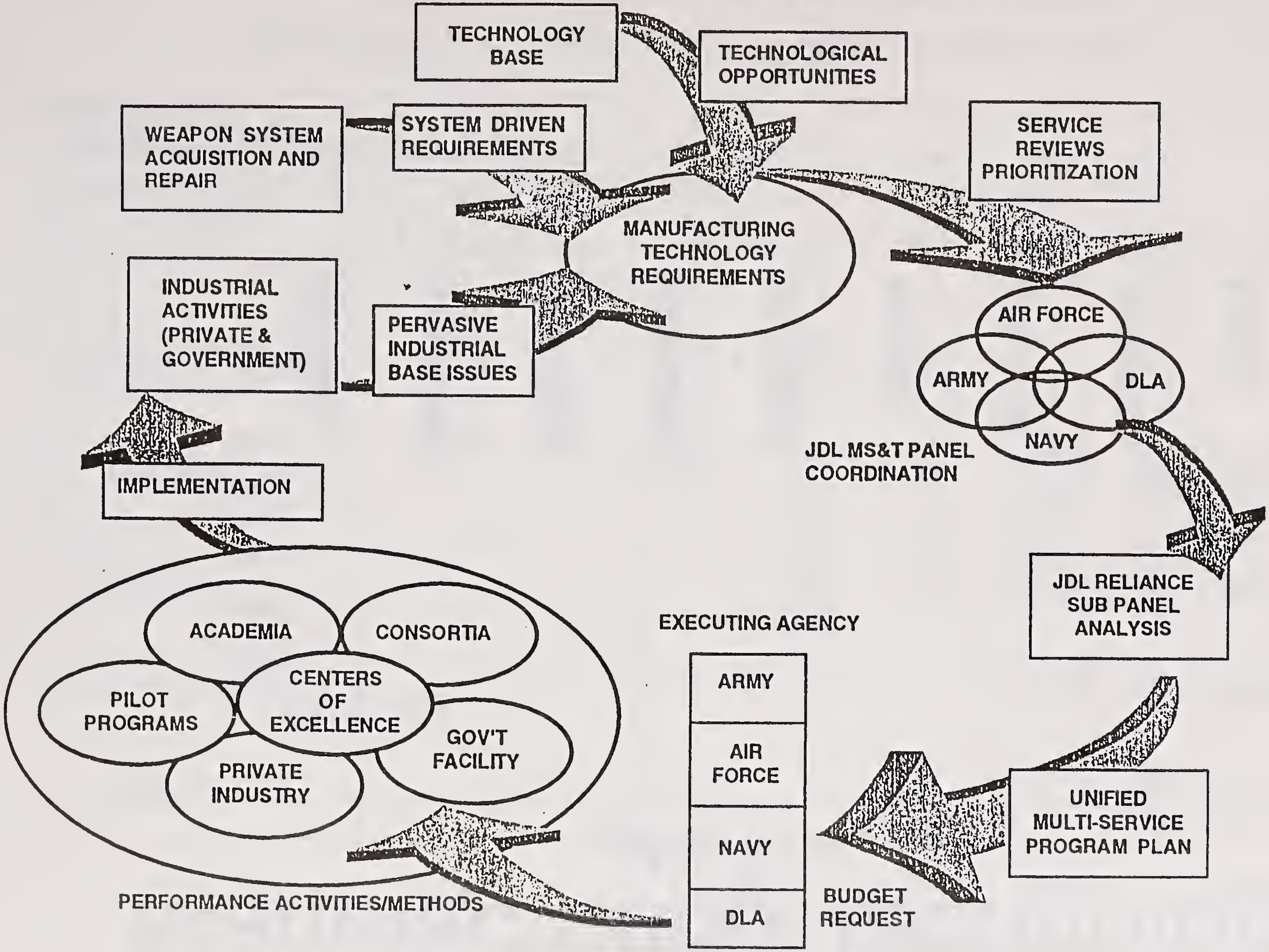
MS&T Regional Centers

		FY 94 ($M)
Army		
• Environmental Center	Johnstown, PA	20.0
• Instrumented Factory for Gears (INFAC)	Chicago, IL	4.7
Navy		
• Nat'l COE in Metalworking	Johnstown, PA	40.0
• Great Lakes Composites Consortium	Kenosha, WI	7.0
• Electronics Mfg Productivity Facility	Indianapolis, IN	11.0
• Advanced Mfg Research Facility	NIST, MD	6.0
• Nat'l Center for Adv. Gear Mfg	Penn State, PA	8.0
• Mfg Producibility Center	Louisville, KY	5.0
Air Force		
• Nat'l Center for Mfg Sciences	Ann Arbor, MI	40.0
Defense Logistics Agency		
• Food Processing Center	Rutgers U., NJ	0.7
• Apparel Demonstration Centers	Various Universities	7.5

MS&T Taxonomy Enhances Jointness

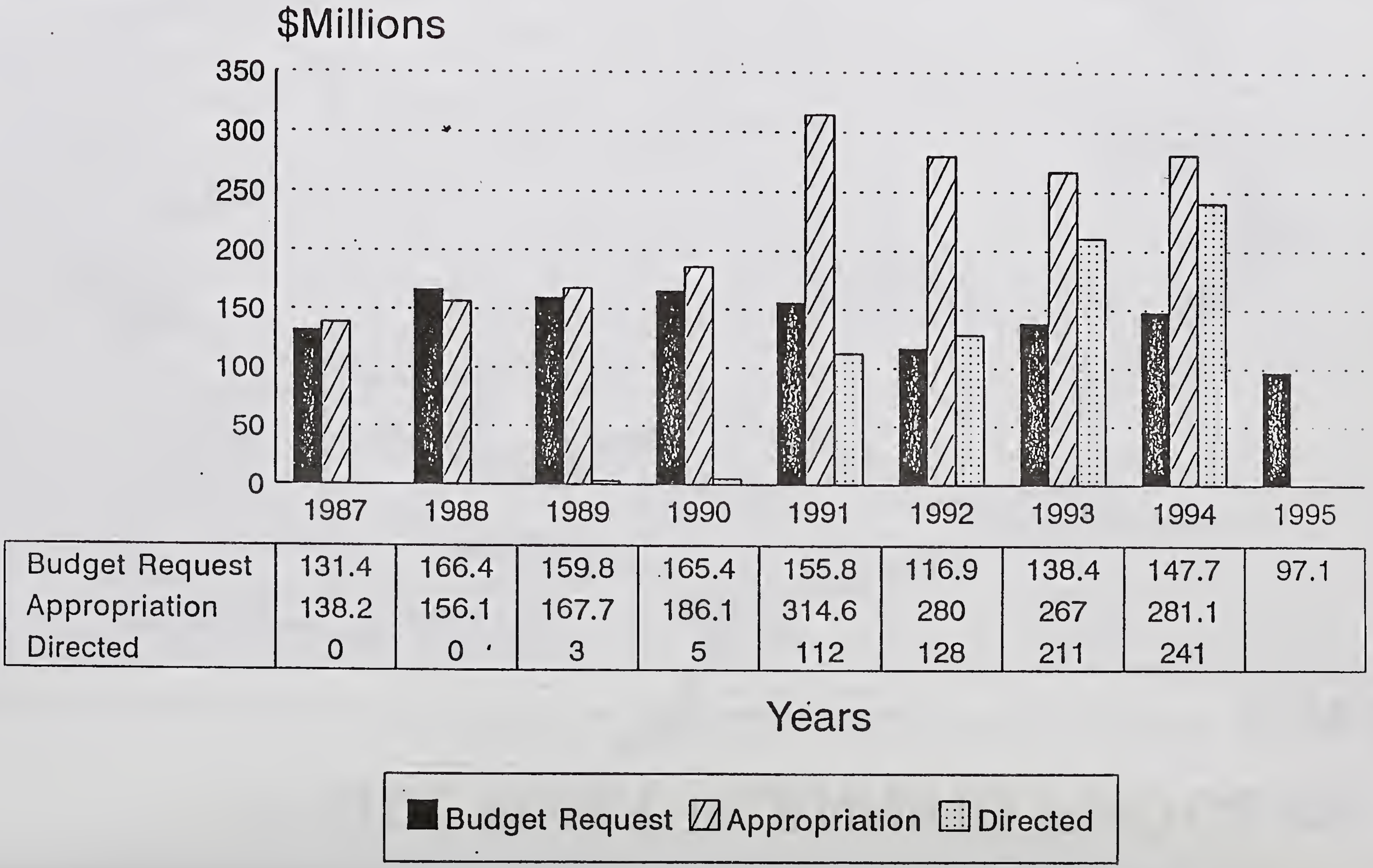
	Existing	Potential
Planning	• Subcommittee Process • MTAG Conference • Specific Projects — Navy Centers — Ductile Iron — Soldering — Optics	• Projects Linked To Joint Requirements • Nat'l Defense Mfg Conf • Subpanel Workshops • Navy Joining Center • Pilot Demonstrations • Mfg Science Strategy
Execution	• Next Gen Controller • Advanced Gun Barrel • Solder Inspection • T/R Modules • Thermo-Electric Coolers • Paint Stripping	• Virtual Manufacturing • IP/PD Tools • Composites • Integrated Pilots • Sustainment • Manufacturing Science • Technology Deployment

JDL MS&T PLANNING PROCESS



Manufacturing Technology

(ManTech)



	1987	1988	1989	1990	1991	1992	1993	1994	1995
Budget Request	131.4	166.4	159.8	165.4	155.8	116.9	138.4	147.7	97.1
Appropriation	138.2	156.1	167.7	186.1	314.6	280	267	281.1	
Directed	0	0	3	5	112	128	211	241	

Manufacturing Technology

The Problem: Appropriated But Unauthorized

[Earmarks]

FY94	Budget	Authorization	Appropriation
OSD/DDR&E	147.7	112.5 [3.0]	
Army			43.2 [28.2]
Navy			142.2 [140.2]
Air Force			73.8 [54.8]
DLA			21.9 [17.5]
Total	147.7	112.5 [3.0]	281.1 [240.7]

FY94 BUDGET FOR MS&T

Request
($147.7M)

- DDR&E MS&T Pgm
- Service Planning/Execution
- Distribution
  - $112M On-going
  - 30M Centers/Congr Interest
- $5.7M New Start

Authorization
($112.5M)

- DDR&E ManTech Pgm
- Distribute per DDR&E Direction
- Distribution
  - Ongoing Pgms/Center
  - $3M for Navy RAMP
- Encourage Cost Sharing
- Competitive Awards

Appropriation
($281.1M)

- Services/DLA ManTech Pgm (Zero for DDR&E MS&T)
- 85% Earmarked-36 Projects
- Distribution
  - Army: $43.2M
  - Navy: $142.2M
  - AF: $73.8M
  - DLA: $21.9M
- Statutory: $40M for NCMS

FY94 ManTech Budget

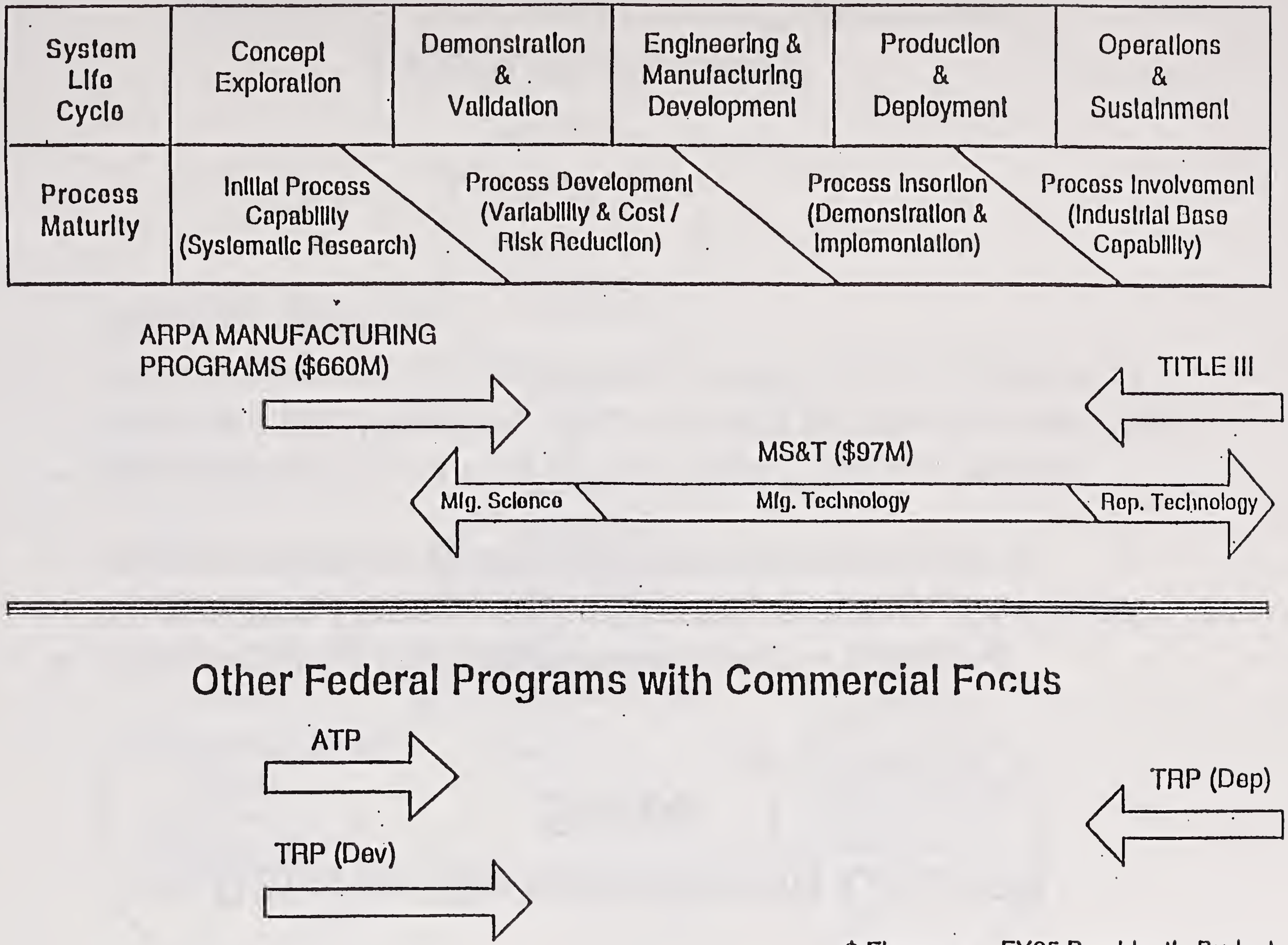
Status of Funding Release

Activity	Jan94	Apr94	Uncommitted
Army	21.0	7.0	15.2
Navy	36.0	45.5	60.7
Air Force	44.5	28.3	1.0
DLA	5.0	7.6	9.3
DoD Total	106.5	88.4	86.2

FY95 PRESIDENTS BUDGET
$97M

Integrated Pilots	15.5
Mil Prod From Commercial Lines	
Commercial Mil Integ-Composite	
Lean Aircraft Initiative	
Composites	22.1
GLCC	
Low Cost Structures	
Broadgoods Fab Cell	
Electronics	22.6
Optics	
Tactical Grade Gyro	
EMPF	
Seekers	
Metals	10.1
Welded Ti Structures	
Joining Center	
Powder Metal	
Metalworking Center	(20.0)
Mfg Systems	7.8
Virtual Testing	
Production Engineering Tools	
AMRF	
Other Topics	18.9
Energetics	
Shipbuilding Center	
Program Support	
Environmental Center	(13.8)
TOTAL	97.0

MS&T Fills a Critical Gap in the Defense Program



System Life Cycle

Concept Exploration

Demonstration & Validation

Engineering & Manufacturing Development

Production & Deployment

Operations & Sustainment

Process Maturity

Initial Process Capability (Systematic Research)

Process Development (Variability & Cost / Risk Reduction)

Process Insertion (Demonstration & Implementation)

Process Involvement (Industrial Base Capability)

ARPA MANUFACTURING PROGRAMS ($660M)

TITLE III

MS&T ($97M)

Other Federal Programs with Commercial Focus

$ Figures are FY95 President's Budget

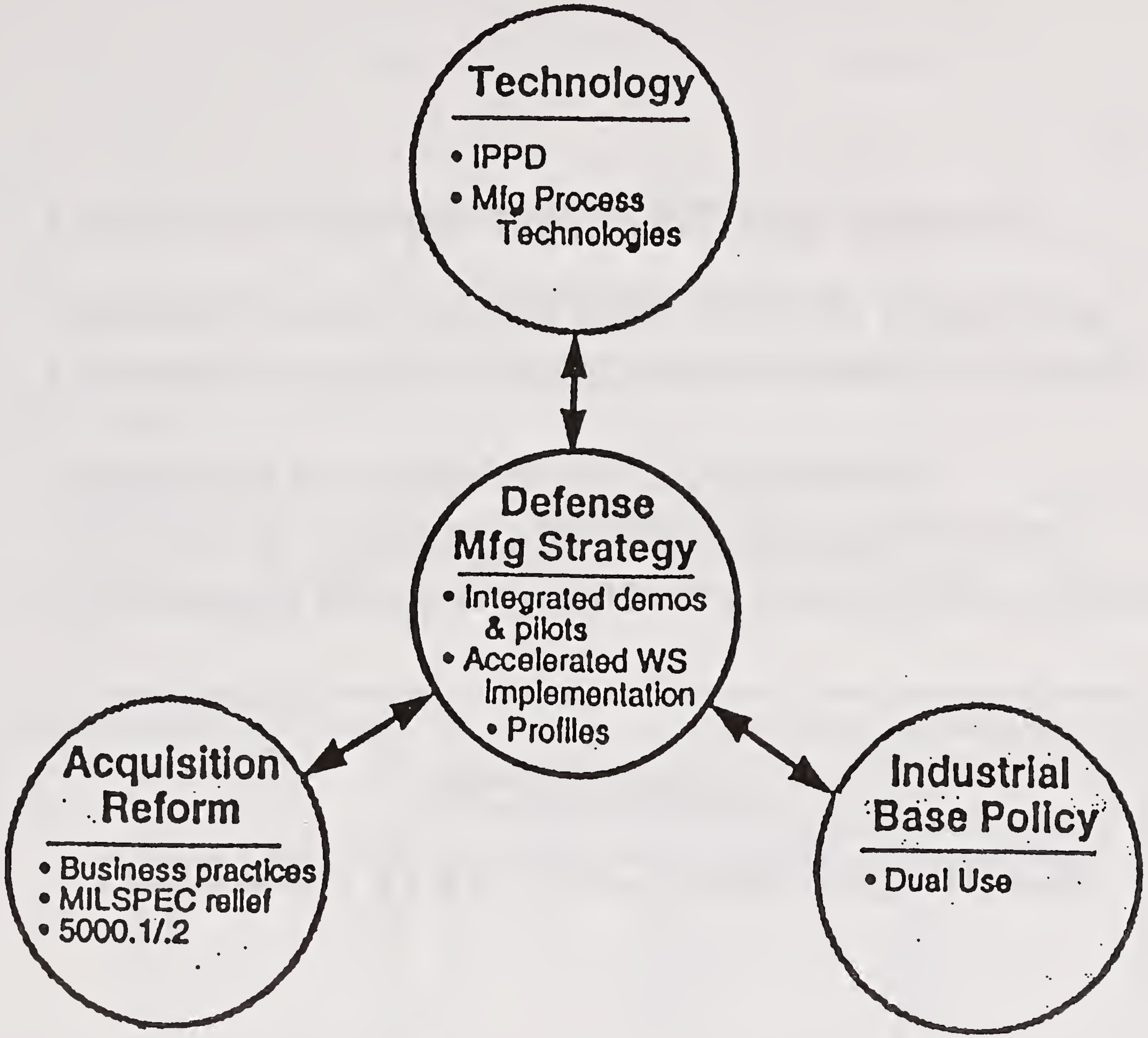
Defense Manufacturing Council

Scope

- *Cross-cutting manufacturing issues* -- affecting Acquisition Reform, Industrial Base Policy, S&T, and implementation in acquisition/support programs

- *Manufacturing* is used in the “Big M” sense, which includes all of the DoD and industry processes required for development, production and life cycle support of defense systems.

Defense Manufacturing Council
Integrating Role



Technology

- IPPD
- Mfg Process Technologies

Defense Mfg Strategy

- Integrated demos & pilots
- Accelerated WS Implementation
- Profiles

Acquisition Reform

- Business practices
- MILSPEC relief
- 5000.1/.2

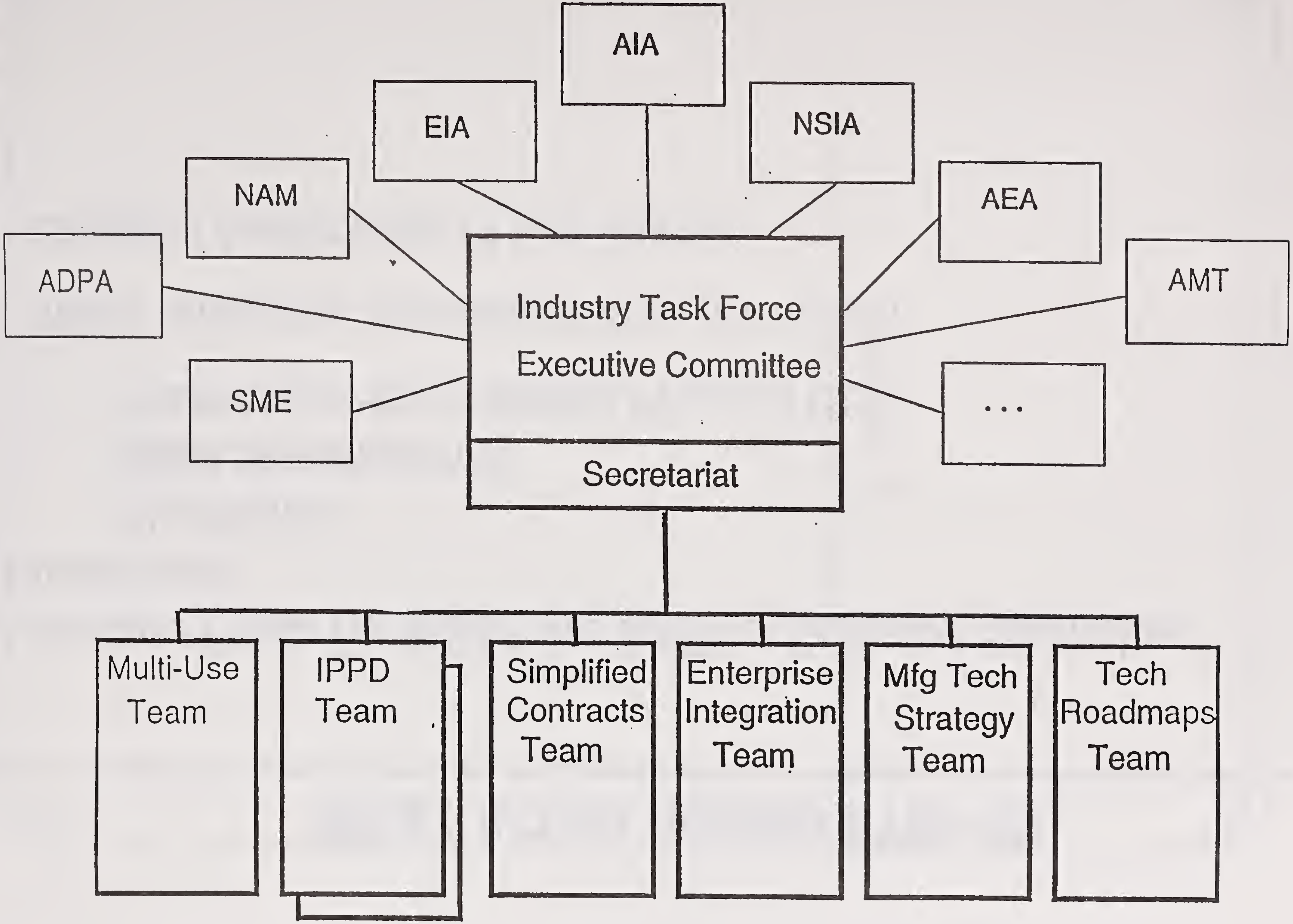
Industrial Base Policy

- Dual Use

Defense Manufacturing Council
Objectives

- Accelerate implementation of Acquisition Reform, Science & Technology, and Industrial Base initiatives in weapon system programs
- Develop an integrated Defense Manufacturing Strategy, and identify resources to execute it
- Foster a supportive dialogue with industry

Industry Task Force on Affordability



ADPA

NAM

EIA

AIA

NSIA

AEA

AMT

SME

. . .

Industry Task Force
Executive Committee

Secretariat

Multi-Use Team

IPPD Team

Simplified Contracts Team

Enterprise Integration Team

Mfg Tech Strategy Team

Tech Roadmaps Team

MS&T Action Agenda FY94-95

- Leverage Points For MS&T And ARPA In Common Technology Investments
  - Electronics
  - Agile Manufacturing
  - Technology Reinvestment Project (TRP)
- MS&T Integrated Investment Plan (FY 95-99)
- Strategic Assessment Of Key Centers

Appendix M

Technology Reinvestment Project (TRP) Tutorial

Technology Reinvestment Project

Overview

Richard Flake
ARPA/TRP

Agenda

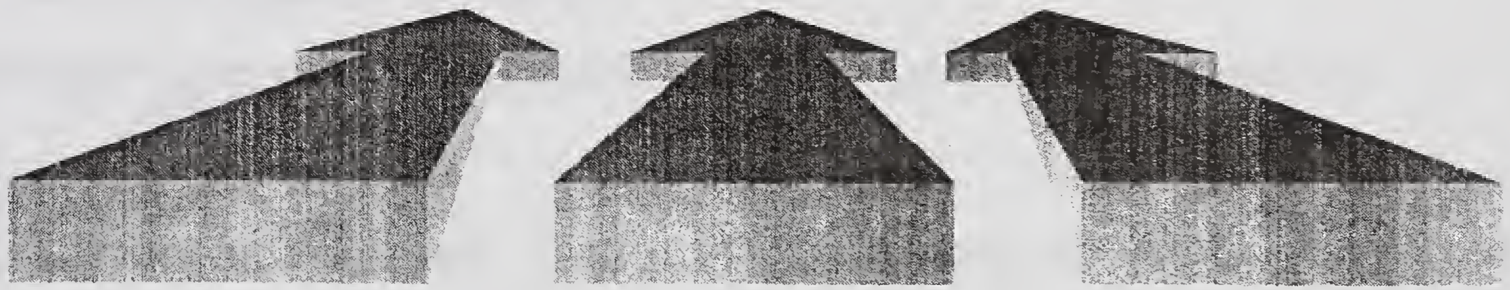
- Technology Reinvestment
- Overview of Technology Reinvestment Project
  - Background
  - Status
  - Future
- Q&A

Technology Reinvestment - DoD Perspective

- Department of Defense Remains Committed to Advanced Technical Capability
- Separate, Dedicated Defense Industry No Longer Possible
  - Declining Defense Budgets
  - Pacing Commercial Advancement
- Strong, Integrated Industrial Base Critical to Strong National Defense
  - Commercial Availability of Defense Technologies
  - Commercial Viability of Products/Processes Required for Defense

Technology Reinvestment

Stimulate the transition to a growing, <u>integrated</u>, national industrial capability which provides the most advanced, affordable, military systems and the most competitive commercial products



Technology Reinvestment Project

Technology Development

Technology Deployment

Manufacturing Education and Training

TECHNOLOGY REINVESTMENT PROJECT

Three Avenues of Attack

I. Technology Development

- Stimulate commercialization of dual-use technologies to foster integration of the defense and commercial industrial bases
  - » Pyrotechnic Actuated Vehicle Rescue Equipment
  - » Computer Aided Earth Moving with DP-GPS
- Provide for the national defense by promoting cutting-edge commercial and defense capabilities
  - » Dual-use Sensor Technology for Air TransportationSystemCapacity and Safety

II. Technology Deployment

- Assist new and established manufacturers to be globally competitive and achieve world-class standards
  - » Georgia Manufacturing Technology Extension Center
- Coordinate Federal, State, and local resources to improve and concentrate the flow of services to areas of opportunity
  - » Manufacturing Outreach System for Achieving International Competitiveness

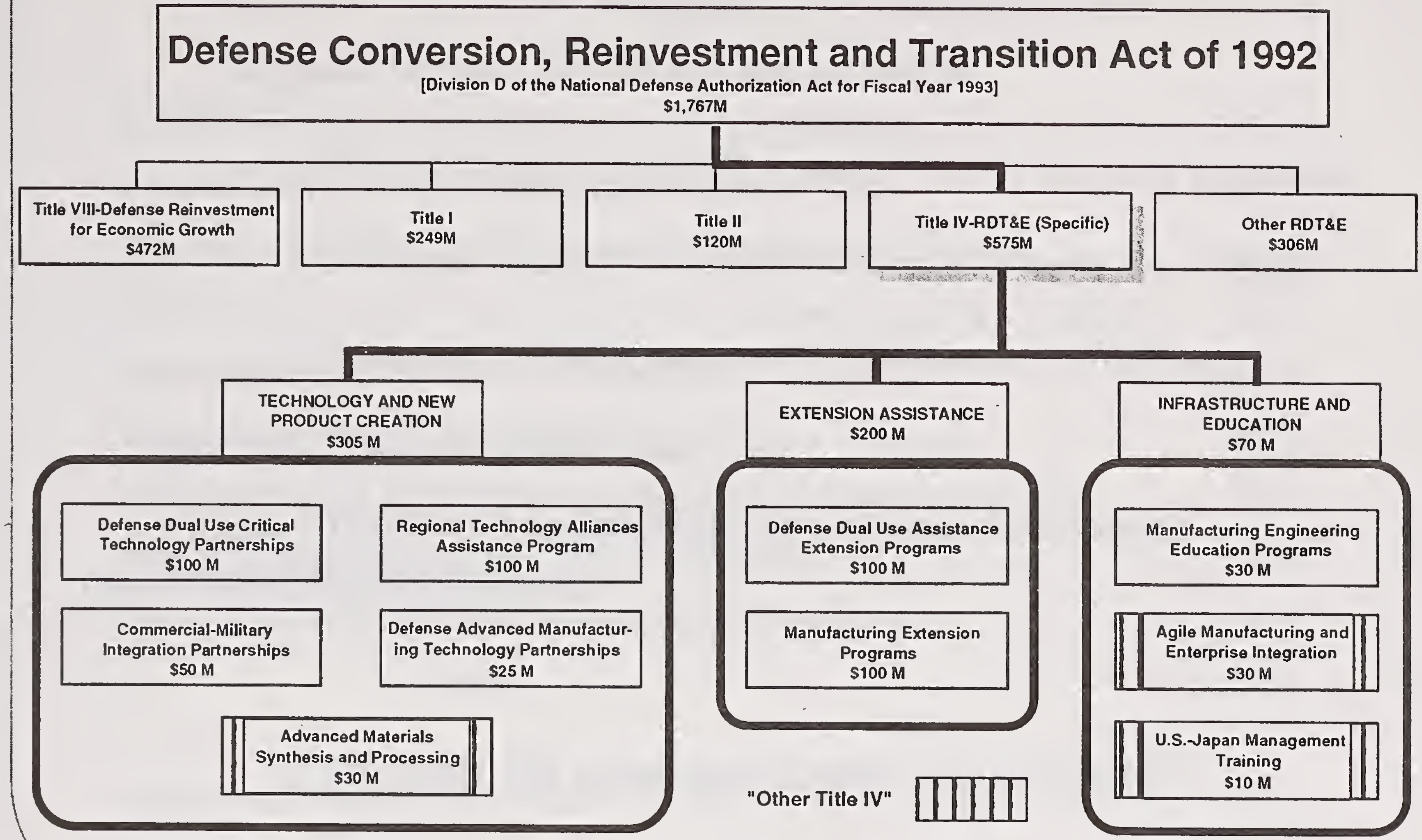
Three Avenues of Attack (continued)

III. Manufacturing Education and Training

- Reform manufacturing engineering education to build the high skills manufacturing work force of the future
  - Manufacturing Education for Product Realization: The ‘Realization’ Coalition
  - Southern California Coalition for Education in Manufacturing Engineering
- Retrain defense engineers and technicians so they can contribute to the commercial and defense industries of today
  - CSUF Integrated Environmental Training Program for Defense

TECHNOLOGY REINVESTMENT PROJECT

Defense Conversion, Reinvestment and Transition



Defense Conversion, Reinvestment and Transition Act of 1992
[Division D of the National Defense Authorization Act for Fiscal Year 1993]
$1,767M

Title VIII-Defense Reinvestment for Economic Growth
$472M

Title I
$249M

Title II
$120M

Title IV-RDT&E (Specific)
$575M

Other RDT&E
$306M

TECHNOLOGY AND NEW PRODUCT CREATION
$305 M

- Defense Dual Use Critical Technology Partnerships
$100 M
- Regional Technology Alliances Assistance Program
$100 M
- Commercial-Military Integration Partnerships
$50 M
- Defense Advanced Manufacturing Technology Partnerships
$25 M
- Advanced Materials Synthesis and Processing
$30 M

EXTENSION ASSISTANCE
$200 M

- Defense Dual Use Assistance Extension Programs
$100 M
- Manufacturing Extension Programs
$100 M

INFRASTRUCTURE AND EDUCATION
$70 M

- Manufacturing Engineering Education Programs
$30 M
- Agile Manufacturing and Enterprise Integration
$30 M
- U.S.-Japan Management Training
$10 M

"Other Title IV"

Technology Reinvestment—What It Is

Technology Reinvestment to:

(1) Focus on turning technologies into products/processes

(2) Create jobs in the long term

- Diversification from defense to commercial products
- Integration of defense and commercial production facilities
- Deployment of technology to and from commercial industries
- Development of dual-use technologies

TECHNOLOGY REINVESTMENT PROJECT

Fiscal Year 1993 Title IV Appropriations for TRP Programs ($ millions)

Defense Dual-Use Critical Technology Partnerships	$81.9
Commercial-Military Integration Partnerships	42.1
Regional Technology Alliances Assistance Program	90.5
Defense Advanced Manufacturing Technology Partnerships	23.5
Manufacturing Extension Programs	87.4
Defense Dual-Use Assistance Extension Program	90.8
Manufacturing Engineering Education: Grant Program	43.6*
Manufacturing Experts in the Classroom	4.6
Small Business Innovative Research Program	7.2
Total	$471.6

*Includes $20.1M of FY 1992 Funds

Common Requirements

Statutory Requirements Common to All TRP Programs

(1) Competitive Award

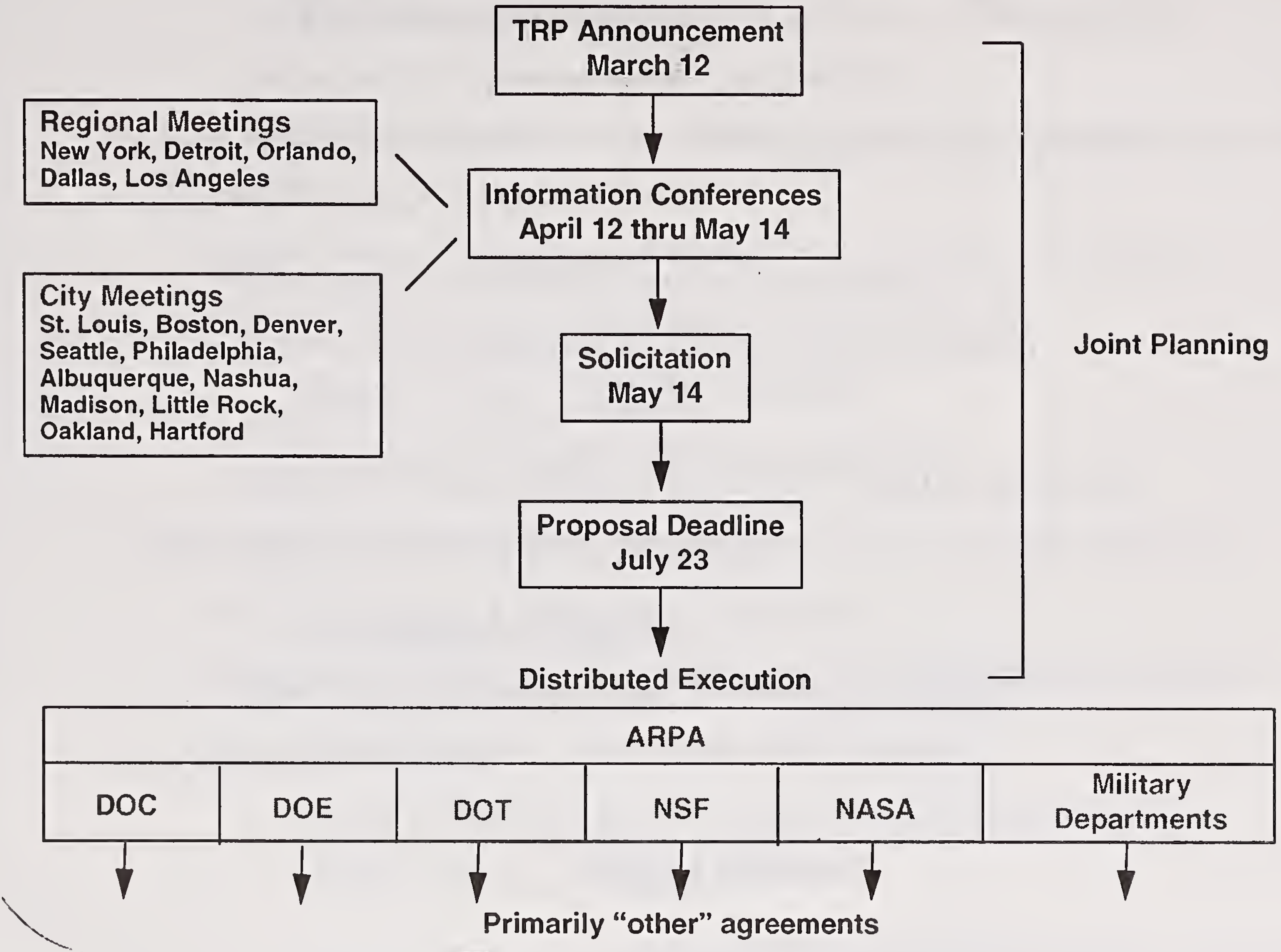
(2) Specific Participation (Emphasis on Partnerships)

(3) Cost Sharing of at Least Fifty Percent (50%)

(4) Defense Emphasis–10 U.S.C. § 2501

TECHNOLOGY REINVESTMENT PROJECT

Joint Agency Program



TRP Announcement
March 12

Regional Meetings
New York, Detroit, Orlando, Dallas, Los Angeles

Information Conferences
April 12 thru May 14

City Meetings
St. Louis, Boston, Denver, Seattle, Philadelphia, Albuquerque, Nashua, Madison, Little Rock, Oakland, Hartford

Solicitation
May 14

Proposal Deadline
July 23

Distributed Execution

Joint Planning

ARPA

DOC
DOE
DOT
NSF
NASA
Military Departments

Primarily “other” agreements

TECHNOLOGY REINVESTMENT PROJECT

TRP Update

- Oversubscribed!
  - Over 2800 Proposals Requesting $8.5 Billion
    - » $465 Million Available
- FY 1993 Competition Complete
  - Multi-tiered Interagency Evaluation (300 Evaluators)
  - Selection of 212 Proposals
  - Included $140 Million of FY 1994 TRP Funding
  - 153 SBIR Proposals Selected (>$14 Million)
- Diverse Array of Selections
  - 1631 Organizations, 46 States, District of Columbia, 6 Foreign
  - Defense and Non-Defense Contractors
  - Large Range of Award Value
  - Small Businesses, Universities Well Represented

TRP Development Winners -- Examples

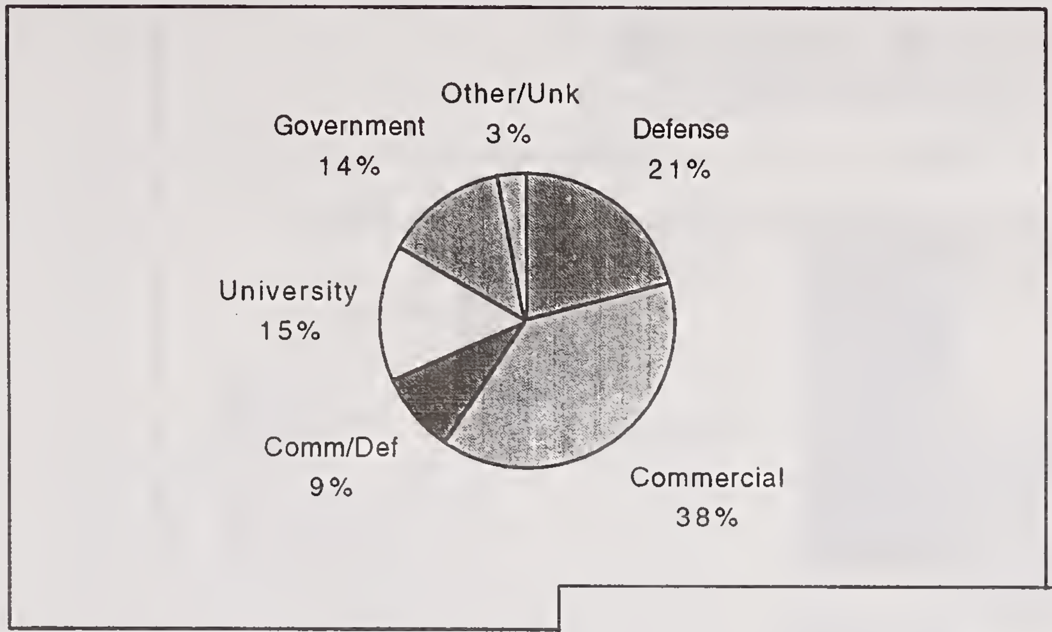
- Pyrotechnic Actuated Vehicle Rescue Equipment ($1.6 Million)
  - High Shears Tech Corp, City of Torrance (CA) Fire Depart
  - Use of Pyrotechnics for Power of "Jaws of Life"
    - » Single Person, Portable Operation
    - » Preserves U.S. Pyrotechnic Capability
- Advanced Composites for Bridge Renewal ($21 Million)
  - UC San Diego, J. Muller Int, Hercules ...
  - Polymer Composites for Bridge Construction/Rehabilitation
    - » High Strength , Corrosion Resistance ...
    - » Preservation of High Performance Composite Tech
    - » Mobile, Military Bridges

TRP Development Winners - Examples

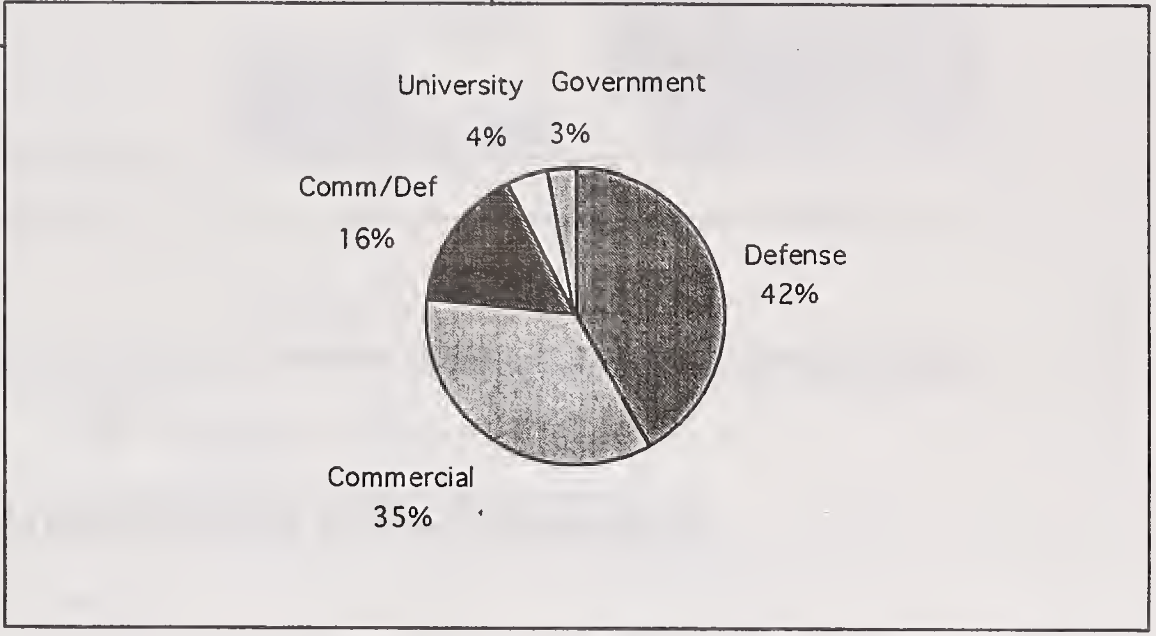
- Trauma Care Management System($15.1 Million)
  - **Rockwell Int, Texas Inst, AT&T Bell Labs, USC, ...**
  - **Monitoring, Diagnosis of Remote, Trauma Care**
    - » **Accident Sites**
    - » Battlefield Casualties
- Wearable Computer Systems ... Headmounted Displays ($5.1 Million)
  - Boeing Computer Services, Honeywell, Carnegie Mellon, ...
  - Superimposition of Images, Image Retrieval
    - » Manufacturing , Assembly, Maintenance, Training

TECHNOLOGY REINVESTMENT PROJECT

TRP Development Selections



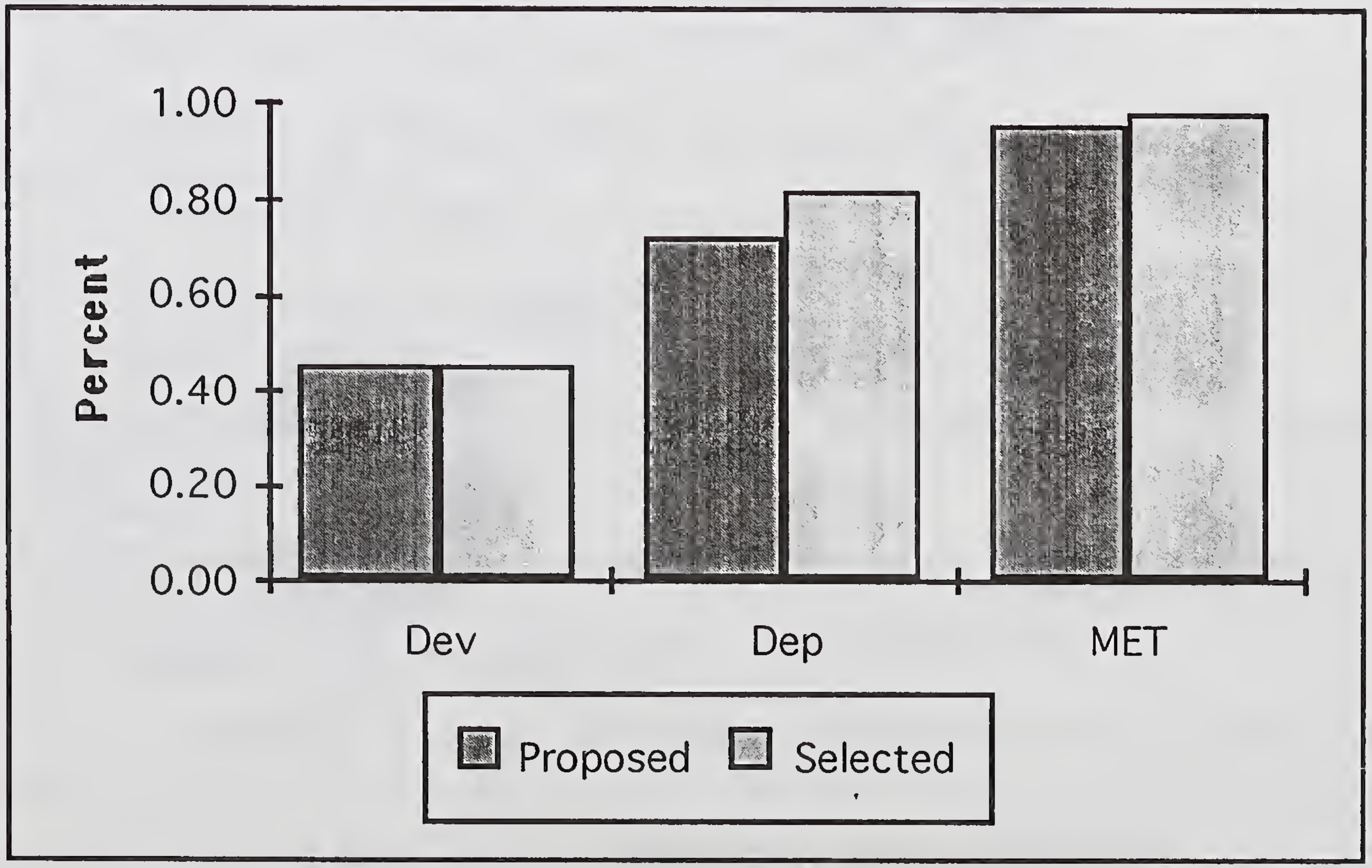
Participants



Lead Proposers

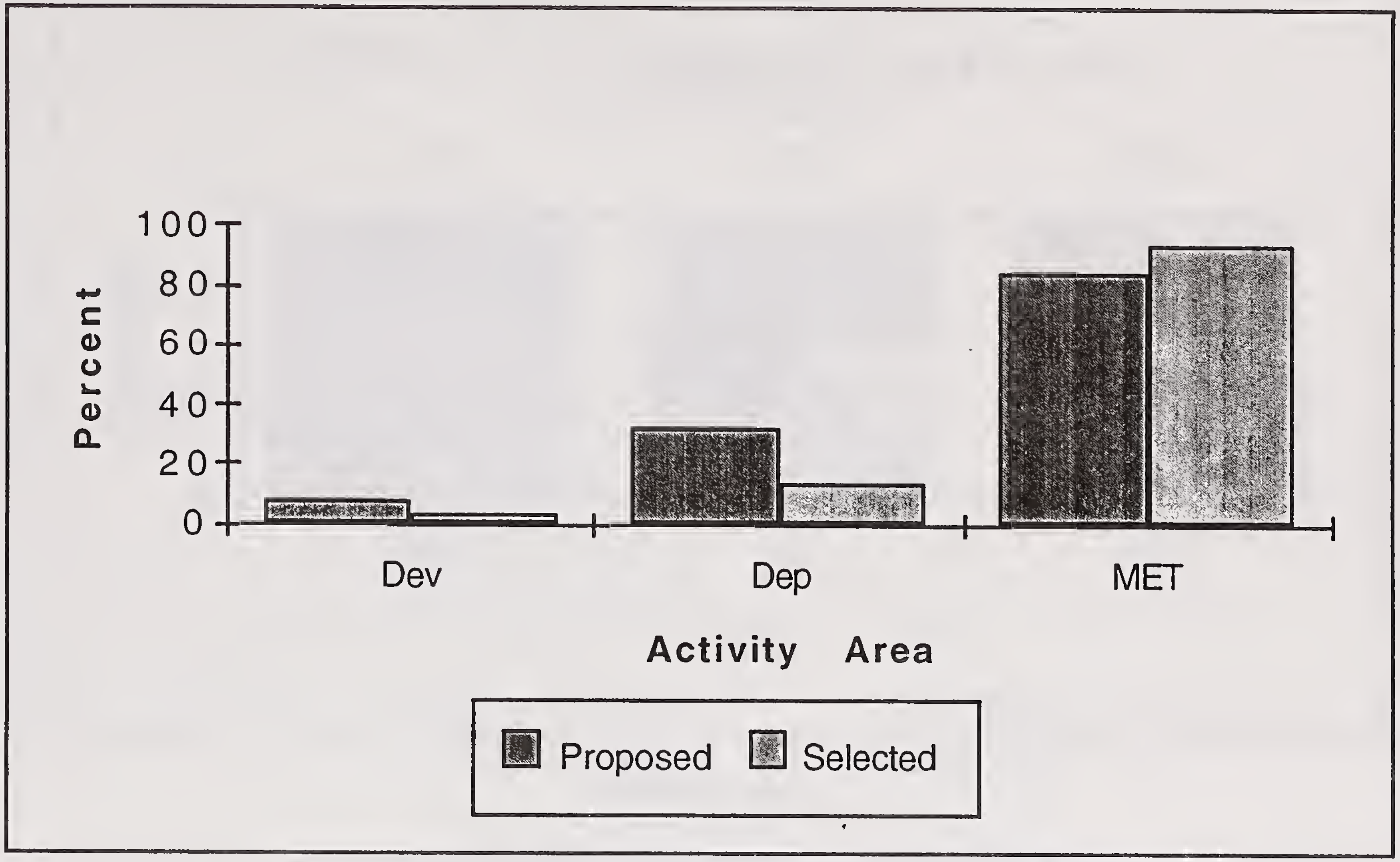
University Performance

Percent Proposals With at Least One Academic Institution



University Performance in TRP

Lead Proposer

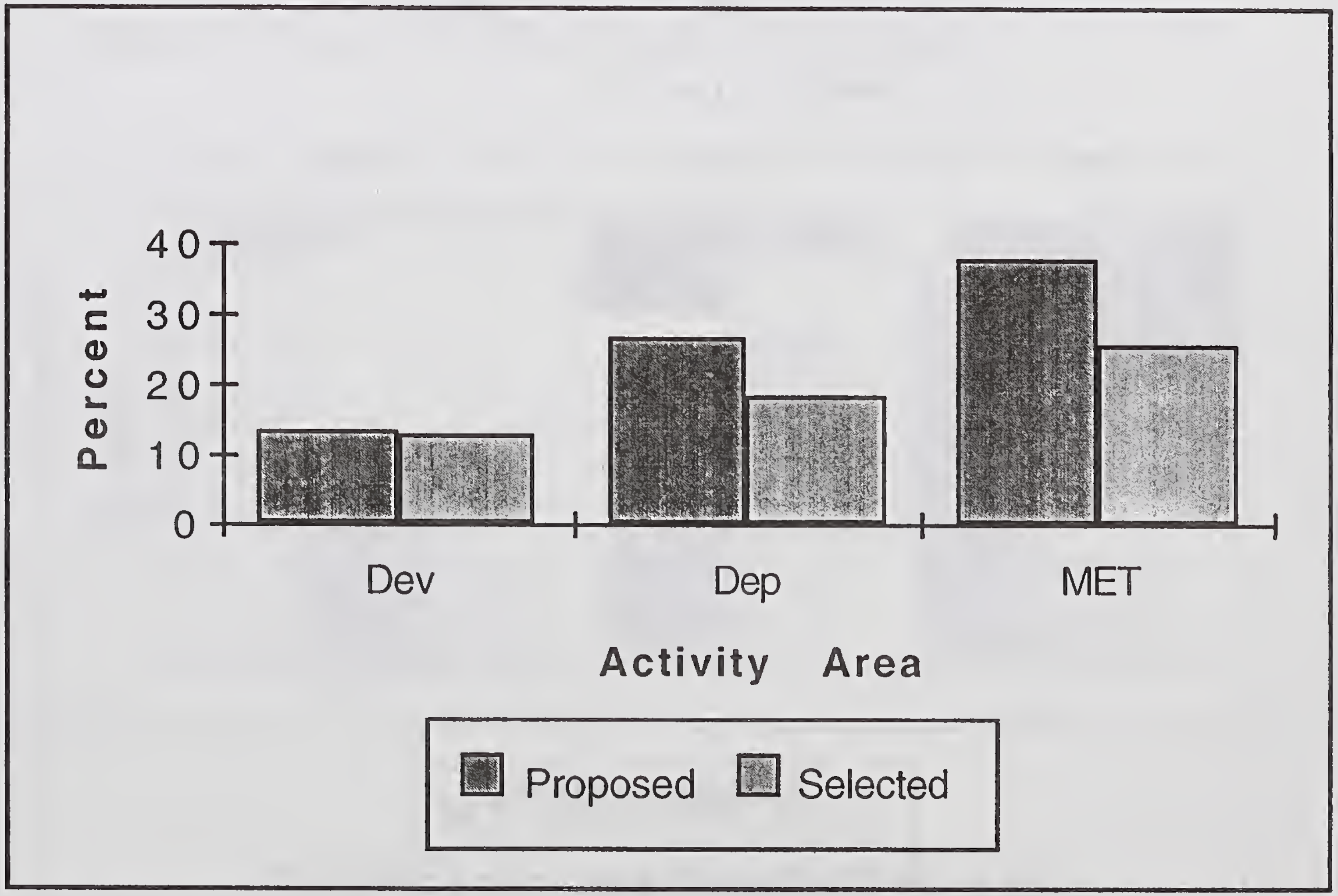


* Estimated using name search

TECHNOLOGY REINVESTMENT PROJECT

University Performance in TRP

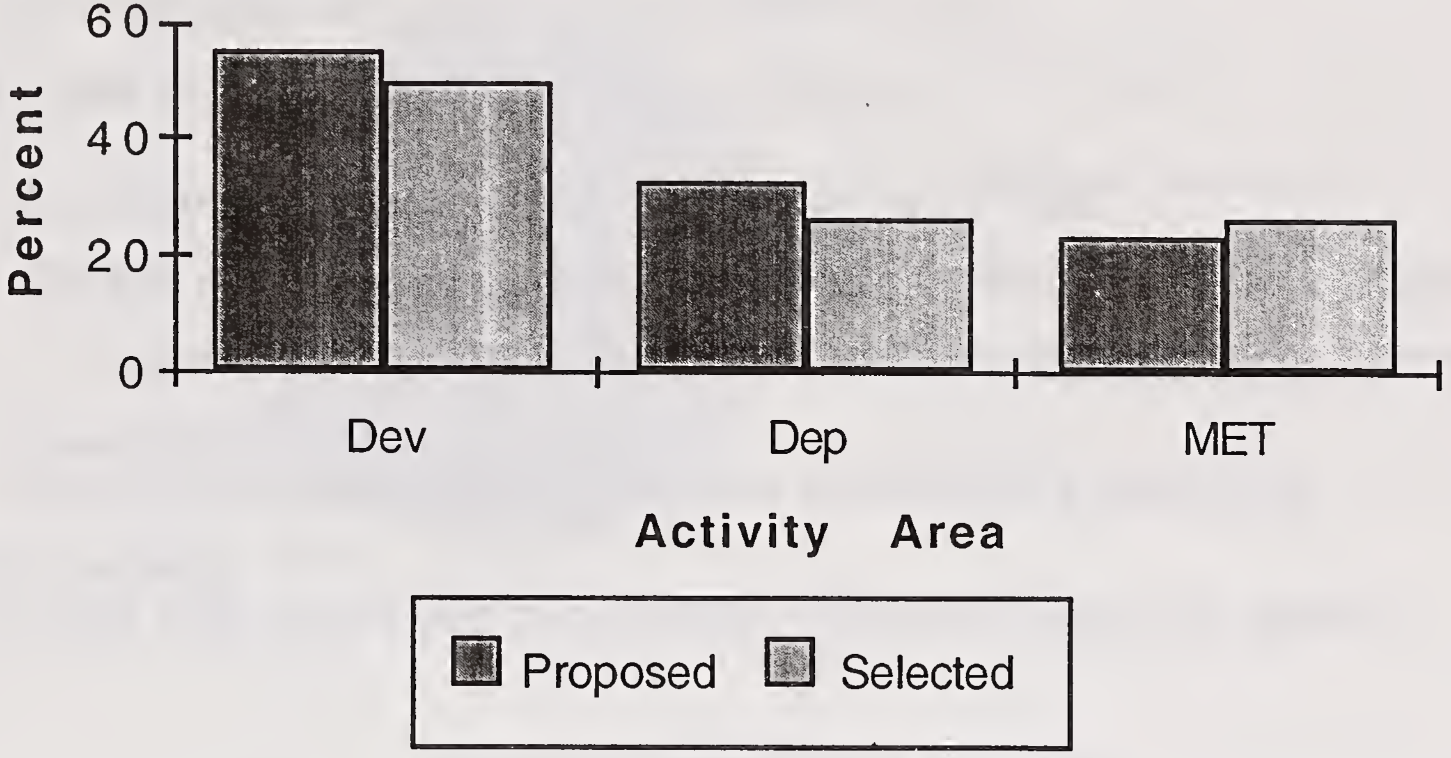
Participants



*** Estimated using name search**

Small Business in TRP

Percent of Proposals With at Least One Small Business

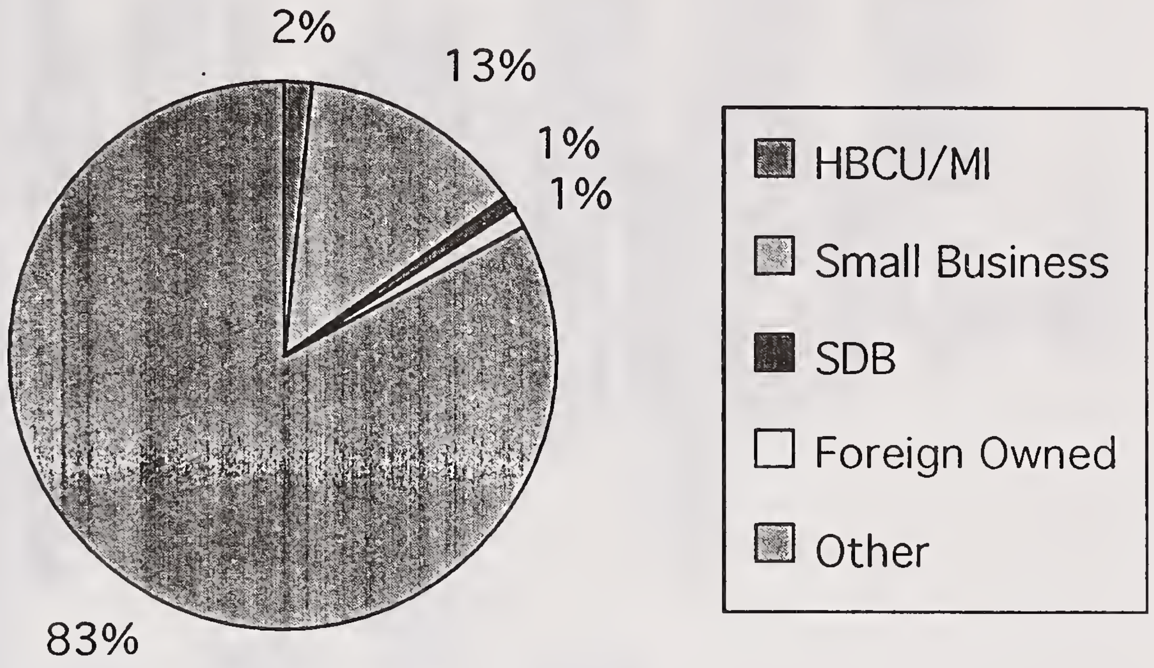


TECHNOLOGY REINVESTMENT PROJECT

Small Business in TRP

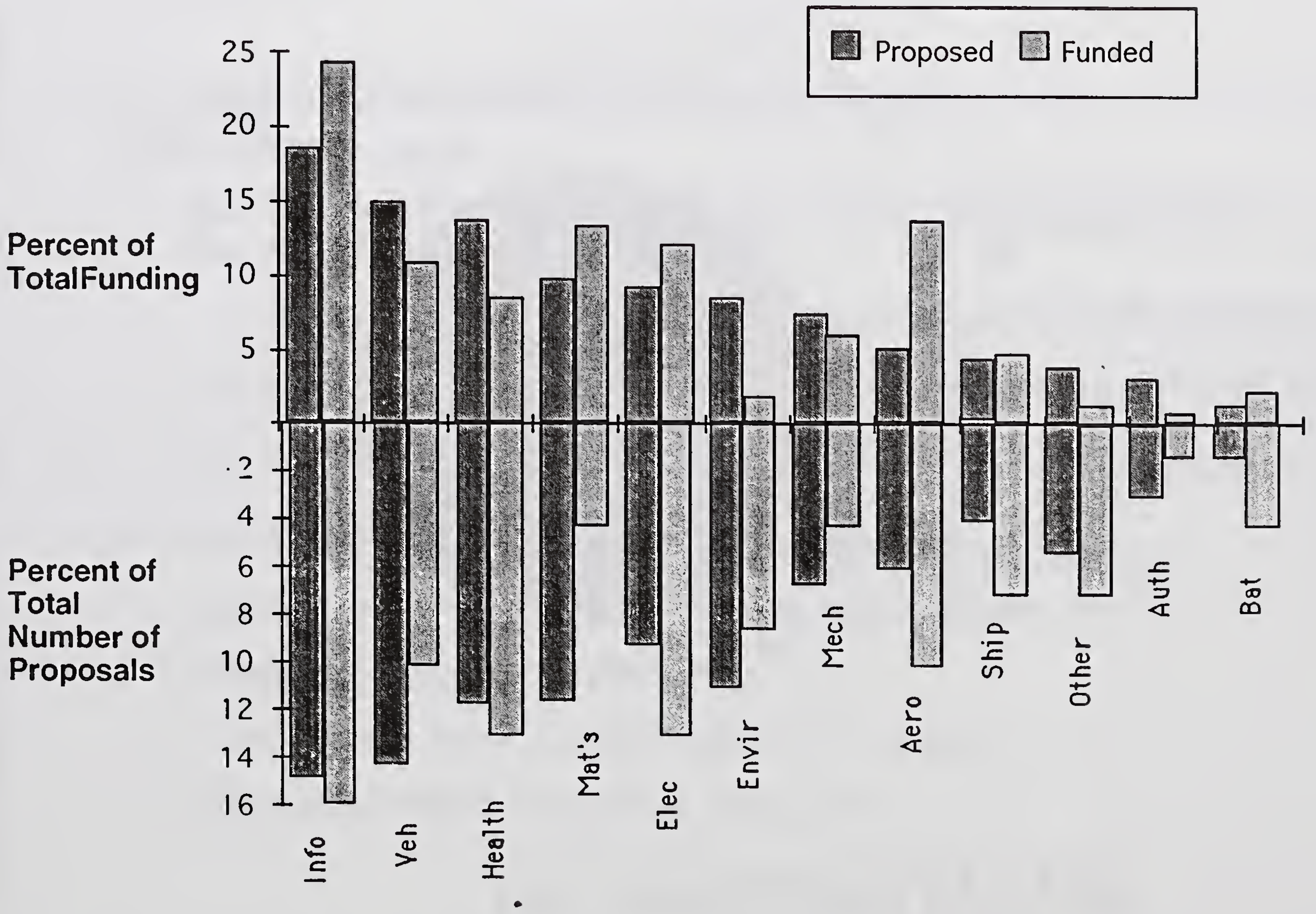
- FY 1993 TRP Provided Significant Opportunities for Small Businesses
  - Extensive Participation as a Team Member in Technology Development
    - » 50% of Winning Proposals Had At Least One Small Business
  - $210 M in Deployment/Extension Services Aimed at Small Business
  - $14 M in SBIR Awards to be Announced Shortly
- FY 1994 TRP Will Increase Opportunities
  - Use of SBIR and STTR as Non-Federal Match
  - Workshops to Foster Teaming
  - Considering Approaches to Entice Capital
  - New SBIR Effort (Including Phase II)

TRP Participants by Type

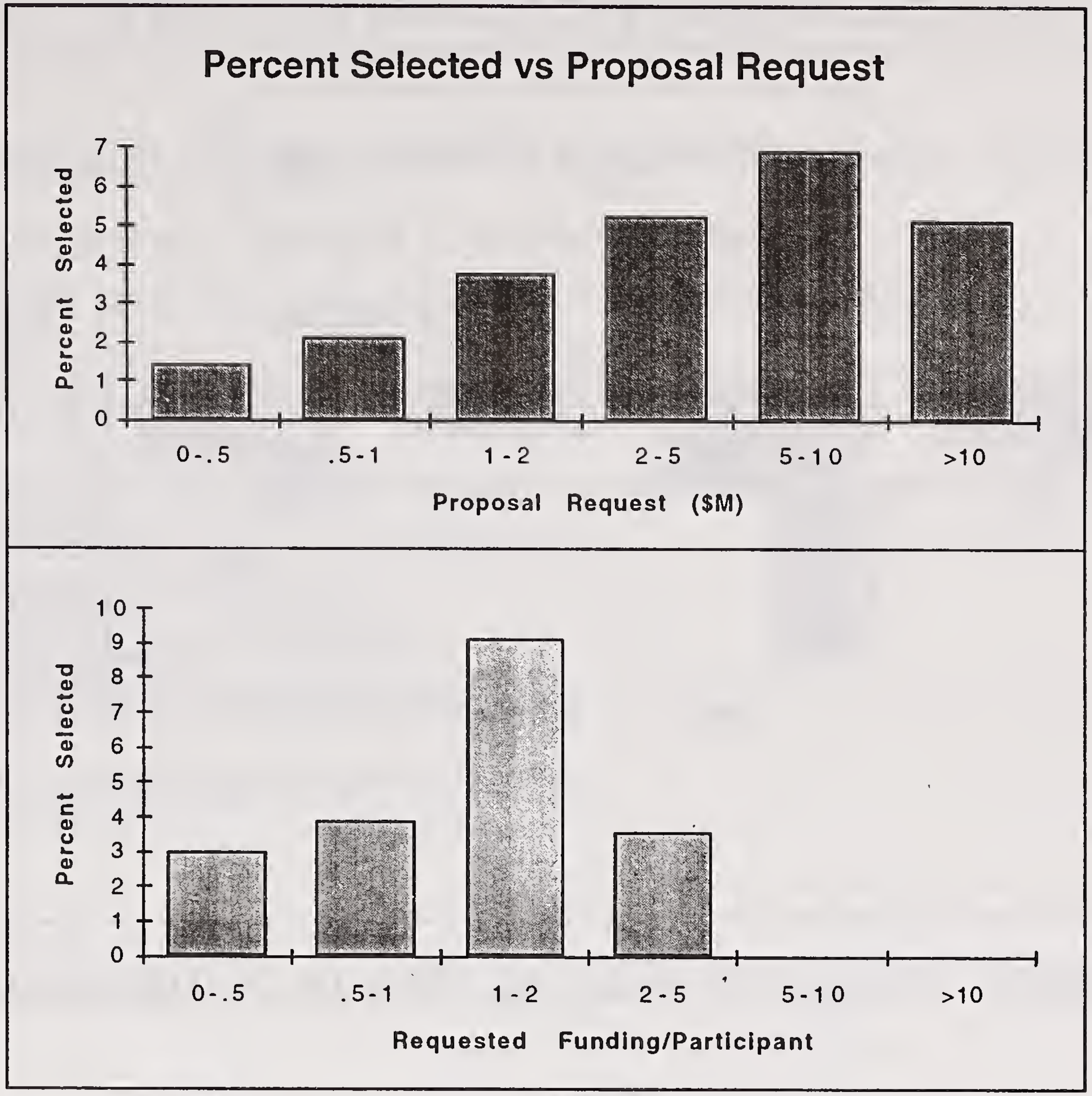


TECHNOLOGY REINVESTMENT PROJECT

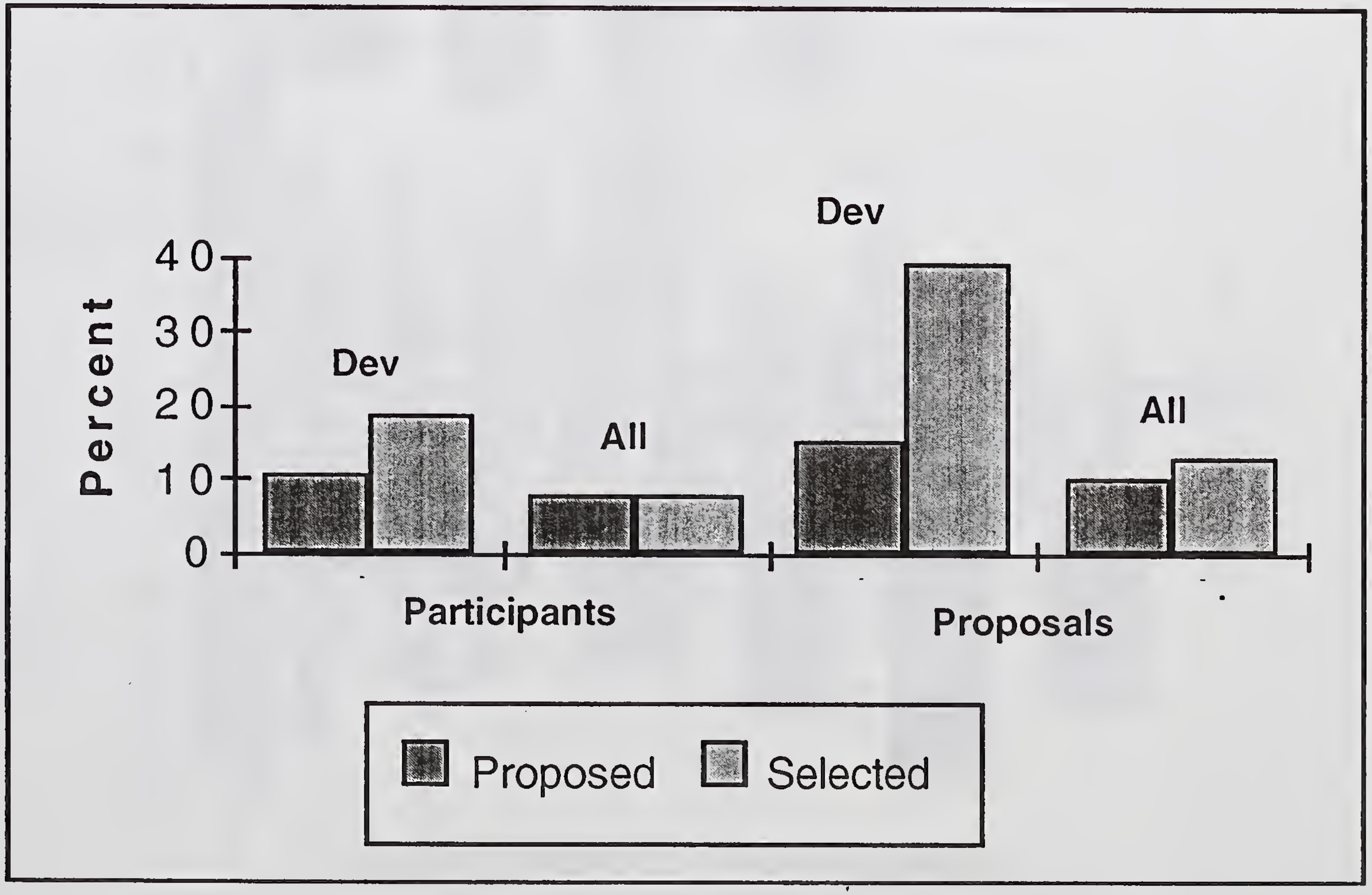
Distribution by Technology Focus Area



TRP Funding Requests



Performance of Top 25 Defense Prime Contractors



Based on FY 91 Prime Contract Awards

TRP - Preliminary Assessment

- Cooperation Among Multiple Federal Agencies - Outstanding!
- Meaningful and Unique Collaborations
  - Large Well Integrated Teams (Horizontal and Vertical)
  - Gov't, Industry, University Teams
  - Inclusion of Small Businesses
- Promising Start to Integration of Military/Commercial Base
  - Innovative Dual-Use Programs
  - Workforce Retraining
  - Infrastructure Support
  - Anecdotal Evidence of Impact
- Final Assessment Years Away!

TECHNOLOGY REINVESTMENT PROJECT

TRP - What's Next?

- Dual-Use, Defense Conversion Will Continue
  - TRP Funded in FY 1994, in FY 95 Budget
- Collaboration, Partnerships, Cost Sharing Still Required
  - Use of SBIR, STTR for Cost Share
- FY 94 Plan
  - $140 Million Used for FY 1993 Competition
  - Limited FY 94 Competition
    - » Focused on 7 Specific Technologies
      - » $150-175 Million
    - » Deployment Component
  - Large Competition
    - » Remainder FY 94 and Substantial Portion of FY 95

TECHNOLOGY REINVESTMENT PROJECT

Defense FY 94 Appropriations/Authorizations

($1,000,000)

	PB	App	Auth
Dual-Use Partnerships	324	474	624
•Dual-Use Critical Technology Partnership		150	250
•Commercial-Military Integration Partnership		100	75
•Advanced Manufacturing Technology Partnership		30	50
•Regional Technology Alliance		100	75
•Defense Dual-Use Assistance Extension		0	30
•Manufacturing Extension Service Providers		0	30
•Defense Manufacturing Engineering Education Pgm		24	24
		(404)	(524)
•Agile Manufacturing/Enterprise Integration		35	50
•Advanced Material Partnership		30	30
•United States-Japan Management Training Program		5	10

Technology Reinvestment - Expectations

- TRP Will Not "Convert" Defense Industry
  - Downsize Too Large
  - Acquisition Reform Probably More Critical
- TRP Will Allow Specific Participants to Capitalize on Under-utilized Technical Capabilities
- TRP Will Provide Model For Long-Term, Structural Changes in Defense R&D
  - Defense and Corporate Perspective

TRP - Summary

- Proposals Provide Optimistic Picture of TRP Success
  - Major Issues Reflect Business as Usual Attitude
  - Cured via “Natural Selection”
- Need Mechanisms in Place to Foster Teaming
  - Additional Solicitations
  - Formal Federal, State, Local Approaches
- Real Measure of Success is Still Years Away!
  - Prior ARPA, NIST Efforts Encouraging

TRP Information

- General Information, Mailing List
  - 1-800-DUAL-USE
- Copies of Announcements
  - OSD Public Affairs: 703-697-5737
- TRP Consortia /Lessons Learned Workshops
  - » Los Angeles (23-24 March)
  - » Boston (30-31 March)
- National Technical Information Service (NTIS)
  - (703)487-4650
    - » PB94 - 161148

Technology Reinvestment Project

Focused Competition

Overview

Richard Flake
ARPA/TRP

For Additional Information Please Call 1-800-DUAL-USE

Technology Reinvestment Project

All Activities Are Conducted Jointly By Six Federal Agencies

- Department of Defense (ARPA) -- Lead
- Department of Commerce (NIST)
- Department of Energy
- Department of Transportation
- National Aeronautics and Space Administration (NASA)
- National Science Foundation (NSF)

TRP Programs

Defense Dual-Use Critical Technology Partnerships

Commercial-Military Integration Partnerships

Defense Advanced Manufacturing Technology Partnerships

Regional Technology Alliances Assistance Program

Manufacturing Extension Programs

Defense Dual-Use Assistance Extension Program

Manufacturing Engineering Education: Grant Program

Manufacturing Experts in the Classroom

Small Business Innovative Research Program

Technology Development
Technology Deployment
Manfuacturing Education and Training

Common Requirements

Statutory Requirements Common to All TRP Programs

(1) Competitive Award

(2) Specific Participation (Emphasis on Partnerships)

(3) Cost Sharing of at Least Fifty Percent (50%)

(4) Defense Emphasis–10 U.S.C. § 2501

TECHNOLOGY REINVESTMENT PROJECT

FY 1994 TRP Competitions

- Focused Competion
  - Announced April 8, 1994
  - Technology Development - 7 Focus Areas
    - » $150-180 Million
  - Technology Deployment - Manufacturing Extension Centers
    - » $23 Million
- General Competition
  - **To Be Announced Summer 1994**
  - **Development, Deployment, MET, SBIR**
  - **FY 94 Plus FY 95 Funds**

TECHNOLOGY REINVESTMENT PROJECT

FY 1994 Focused Competition - Schedule

- April 8, 1994
  - Announcement Published in Commerce Business Daily
- April 8 -- May 19, 1994
  - TRP Outreach Activities (Including Workshops)
  - Program Information Package - Late April
- May 20, 1994
  - Solicitation Published in Commerce Business Daily.
- June 30, 1994
  - Planned Deadline for Receipt of Proposals.
- Planned Announcements
  - By End of September 1994

Please Call 1-800-Dual-Use To Ensure You Receive All Information Related to This Competition

Focused Competition - Highlights

- Technology Development -- Seven Focus Areas Only
- Technology Deployment -- Manufacturing Extension Centers
- No Manufacturing Education and Training
- No SBIR Proposals
- No "Associated" Proposals
  - Each Evaluated on Its Own Merits
- Small Business Innovative Reasearch (SBIR) and Small Business Technology Transfer (STTR) Funds May Be Used as Cost Share

A Second Competition Will Be Held in Summer Which Will Include Development, Deployment, Manufacturing Education and Training and SBIR

Technology Deployment

- Technology Deployment Proposals Will Be Accepted in Manufacturing Extension Centers Only
- Approximately $23 Million Will Be Available
- Requirements
  - Proposers: Non-profit Organizations; Federal, State or Local Governments ; Institutions of Higher Learning; Combinations
  - 50% Cost Share
    - » Half in Cash if Over $1 Million in TRP Request
- Deployment Workshops: (301-975-5020)
  - April 25, 1994: Gaithersburg MD
  - April 27, 1994: Salt Lake City, UT

Technology Development Focus Areas

- High Density Data Storage Systems
- Object Technology for Rapid Software Development and Delivery
- Interoperability Testbeds for the National Information Infrastructure (NII)
- High Definition Systems Manufacturing
- Low Cost Electronic Packaging
    - » PB94 - 161155
- Uncooled Infrared Sensors
- Environmental Sensors

National Technical Information Service (NTIS) - (703)487-4650

TECHNOLOGY REINVESTMENT PROJECT

TRP Selection Criteria

- Scientific and Technical Merit
  - Innovative -- Advance State-of-the Art
  - Not Basic Research, Not Commercialization
- Technical Approach and Management Plan
  - Team Structure
  - Intellectual Property
- Pervasive Impact
  - Defense and Commercial Relevance
  - Realistic, Defendable Markets
- Commitment to “Productization”
  - Commitment and Capabilities of Team

Each of the Four Selection Criteria Is Equally Weighted

Participant Requirements

- Minimum Two or More “Eligible Firms”
  - Defined in A.1 of PIP for Focused Competition
- Any Other Participants Can Be Part of Team
  - Industry, Including Foreign Owned
  - Academic Institutions
  - National, Defense Laboratories
  - Not-for-profit, FFRDC, etc.
- Broad Expertise/Experience Sought
  - Strong Technology Source
  - Experience Commercializing
  - Knowledge of (or Participation by) Customers

Cost Share Requirements

- Philosophy
  - Demonstrates Risk on Part of Team
  - True Partnership with Federal Government
- At Least 50% Non-Federal Funding
  - Commercial-Military Integration: 50%, 60%, 70%
- Allowable
  - Cash (Funds, Salaries, etc.)
  - In-Kind (Equipment, Leases, Intellectual Property)
  - IR&D

All Cost Share Must Defray the Actual Cost of the Project

TECHNOLOGY REINVESTMENT PROJECT

Types of Cost Share

- Cash:
  - Outlays of Funds to Support Project
    - » Material, Labor, Equipment Purchases
  - Sources
    - » Independent Research and Development (IR&D)
    - » Non-Federal Funds, Profit or Fee (Except from TRP effort)
    - » SBIR/STTR
- In-Kind:
  - Reasonable, Fair Market Value of:
    - » Existing Equipment, Materials, Property Used in Effort
    - » Tech Transfer
  - Prorated by Use in TRP Project

Cash is Considered to be Highest Quality Match

SBIR/STTR Funds as Non-Federal Cost Match

- Work to Be Done Under SBIR/STTR Contract Clearly Identified in TRP Proposal as Integral
- Funds to be Counted Must Be Expended <u>After</u> Proposal Due Date to TRP
  - These Funds May Count, Even If Expended Prior to Award
- Small Businesses Integrated Into A TRP Proposal After Selection May Count SBIR/STTR Funds As Cost Match
  - Same Rule for Counting Funds
- To Count SBIR/STTR, Small Business Must Demonstrate Commitment to the Project Similar to Other Participants

Program Funding/Cost-Share

Program	Funding	Cost Share
Defense Dual-Use Critical Technology Partnerships	$47 Million	50%
Commercial- Military Integration Partnerships	$74 Million	50%, 60%, 70%*
Defense Advanced Manufacturing Partnerships	$28 Million	50%

- The Above Funding is Currently Planned for the Focused Competition.
  - Additional Funds May Be Added Based on Further Appropriations
  - Use of All Funds Depends on Quality of Proposals Received

* First Year, Second Year, Years Three Through Five

Submitting Proposals

- One Technology Focus Area, One Statutory Program
  - Note Cost-Share Differences in Programs
  - “Out of Scope” Proposals Will Not Be Evaluated
  - Propose Baseline Program (12-24 Months)
    - » Options May Be Proposed
- Technical Proposal (35 Page Limit)
  - Section 1 -- Executive Summary (5 Page Limit)
  - Section 2 -- Body of Proposal
  - Section 3 -- Statement of Work
  - Section 4 -- Selection Criteria Index
- Cost Proposal (50 Page Limit)
  - Section 1 -- Total Proposed Cost
  - Section 2 -- Cost Share/In-Kind
  - Section 3 -- Cost to Government
  - Section 4 -- Off-Budget Supporting Resources

TECHNOLOGY REINVESTMENT PROJECT

Other Considerations

- Funding Instruments
  - Expect Cooperative Agreements or "Other Transactions"
- Intellectual Property
  - Government Purpose and "March-in"
  - Flexibility If Justified
- HBCU/MI's -- SDB's
  - Preference Given to Proposals With HBCU/Mi's or SBD's When Evaluation is Substantially Equal

TECHNOLOGY REINVESTMENT PROJECT

Common Themes in Successful Proposals

- Goal/Customer Oriented
- Well Balanced, Well Structured Partnerships
- High Quality/Credible Cost Share
- Real Industrial Leadership
- Dual-Use

Lessons Learned

- Consortia Building
- Problems with Cost Share
- Intellectual Property
- Agreements

Appendix N
Intelligent Manufacturing Systems (IMS) Tutorial

Intelligent Manufacturing Systems

IMS

Providing a framework for industry-led international collaborative R&D in advanced manufacturing

IMS Briefing

Outline

- Introduction - Andy Wan
- IMS Secretariat - Paul Follansbee
- CIMS - Bill Morin
- ACIMS - Paul Huray

IMS Briefing
Introduction

Andy Wan
IMS Secretariat
U.S. Department of Commerce

INTELLIGENT MANUFACTURING SYSTEMS (IMS) PROGRAM

o An industry-led international collaborative R&D program for advanced manufacturing

  - to meet the global needs of business and society of the 21st century
  - to advance a technological and organizational agenda
  - to launch a full-scale 10-year program by January 1, 1995

INTELLIGENT MANUFACTURING SYSTEMS (IMS) PROGRAM

o IMS Program to foster forming of consortia to tackle common challenges of

  - shortening time to market,
  - manufacturing and marketing for global demands
  - influencing standards setting
  - raising manufacturing professionalism

INTELLIGENT MANUFACTURING SYSTEMS (IMS) PROGRAM

o Partners will be large and small companies, universities, and national laboratories from

- the U.S.,
- the European Union,
- the European Free Trade Association,
- Japan,
- Canada, and
- Australia.

INTELLIGENT MANUFACTURING SYSTEMS (IMS) PROGRAM

o In the U. S., the IMS Program stresses raising and maintaining U.S. manufacturing to world class standards through international collaboration.

United States IMS Secretariat

- o resides within the Department of Commerce's Technology Administration
- o the focal point for U.S. domestic IMS activities
- o coordinates international start-up of the full-scale IMS Program

United States IMS Secretariat

- o responsible for:
  - dissemination of organizational information and research results
  - outreach to industry and academia
  - domestic consensus-building
  - U.S. Government coordination
  - consortium-forming for IMS R&D projects
  - coordination of proposal submission and regional review

United States IMS Secretariat

To reach U.S. IMS Secretariat, call or write:

Dr. Andy Wan
IMS Point of Contact
Room 4226
Department of Commerce
Washington, D. C. 20230
Phone (202) 482-0151
Fax (202) 219-3310

IMS Briefing

The IMS Secretariat

Paul Follansbee
IMS Secretariat
U.S. Department of Commerce

Terms of Reference For The IMS Program

- Define a common vision relating economic growth with
  - manufacturing excellence
  - collaborative R&D in manufacturing technologies
- State objectives of the IMS Program consistent with vision
- Define a management structure, including roles and responsibilities of
  - International Steering Committee
  - Inter-Regional Secretariat,
  - Regional Secretariats
- Define conditions for
  - commencement and termination of Program
  - membership
- Provide guidance for project initiators
- List the kinds of technical themes encompassed
- Address protection of IPR, including
  - mandatory requirements
  - recommended principles

Recommendations Following IMS Feasibility Study

- a full-scale, 10-year program be initiated
- the agreed upon Terms of Reference establish a Program framework
  - including minimal IPR guidelines
- a smaller International Steering Committee be established
  - to provide overall guidance
- technical themes not be restricted, but projects:
  - maintain a sharp focus
  - be industry led
  - cover any phase of the product life cycle

What is the Current Status of the IMS Program?

- Awaiting ratification of Terms of Reference
  - procedures vary across Regions
  - commitment to begin Program no later than January 1, 1995
- Industry outreach and information dissemination
  - IMS North American Symposium - Preparing for the Future Program
    - Dallas, June 23-24, 1994

Intelligent Manufacturing Systems (IMS) Program
Why should the U.S. participate in IMS?

- Help to raise U.S. manufacturing to world standards through international cooperation
    - especially within Small and Medium Enterprises
- Be at the front end of influencing standard setting
    - communications, logic segmentation, user interface
- Involve key U.S. universities which should result in much improved manufacturing engineering education
- Involve national laboratories and focus a segment of their commercialization activity on real manufacturing issues
- Raise the professionalism of U.S. manufacturing engineers to encourage participation of our highly capable young people
- Increase awareness by U.S. manufacturing constituencies of advanced manufacturing in other developed countries

For More Information

U.S. Secretariat
U.S. Department of Commerce
Room H4226
14th and Constitution, NW
Washington, D.C., 20230
FAX: 202/219-3310
Dr. Andy Wan 202/482-0151
email: aw@banyan.doc.gov
Dr. Paul Follansbee 202/482-0150
email: pfollansbee@banyan.doc.gov

Coalition for Intelligent Manufacturing Systems
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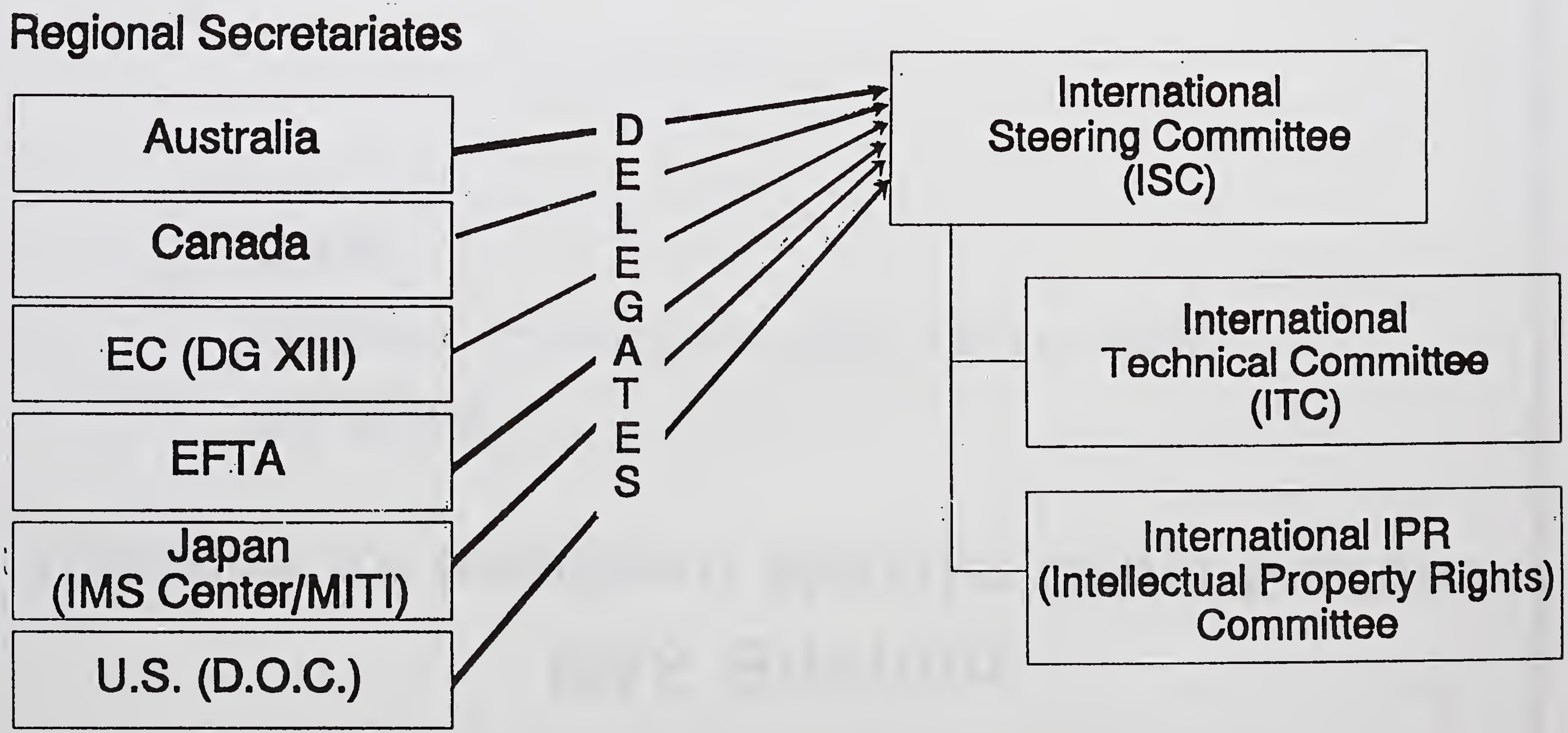
John Kania 202/638-4434

IMS Briefing

Coalition for Intelligent Manufacturing Systems

Bill Morin
Director, Council on High Technology
NAM

International IMS Organization



Regional Secretariates

Australia

Canada

EC (DG XIII)

EFTA

Japan
(IMS Center/MITI)

U.S. (D.O.C.)

DELEGATES

International
Steering Committee
(ISC)

International
Technical Committee
(ITC)

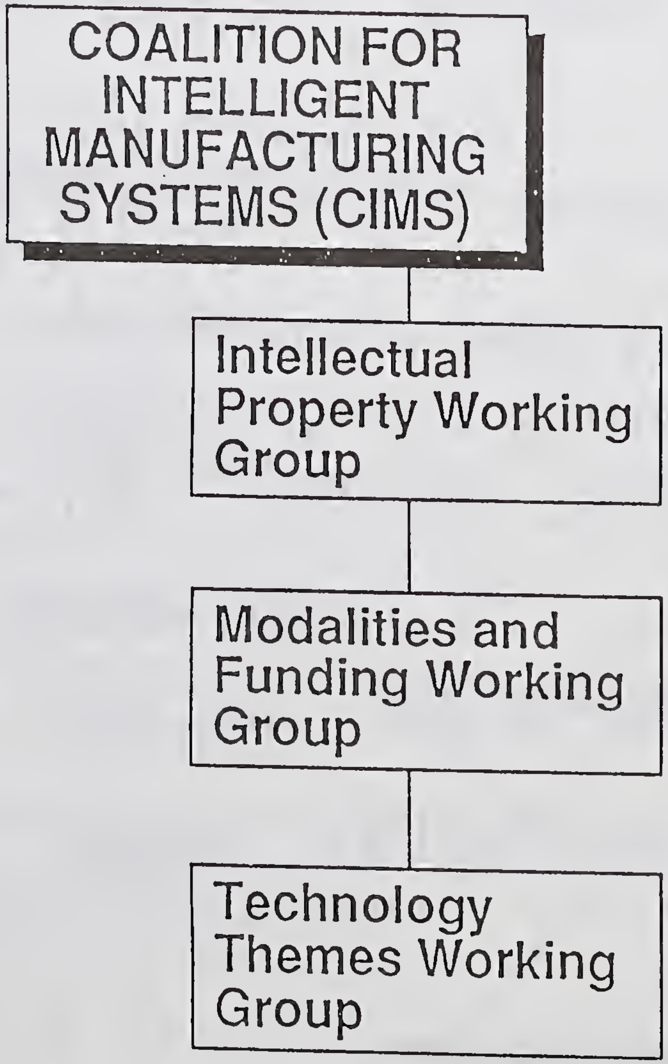
International IPR
(Intellectual Property Rights)
Committee

Supporting Infrastructure

- JAPAN - MITI and IMS Promotion Center
- EUROPE - EC Technical Community-Esprit model development
- U.S. - Industry Coalition for Intelligent Manufacturing Systems (CIMS) with strong participation from Department of Commerce
- AUSTRALIA - Department of Industry, Technology and Commerce
- CANADA - National Research Council Interaction

CIMS

U.S. SUPPORTING INFRASTRUCTURE



The Coalition for Intelligent Manufacturing Systems (CIMS) is a broad-based industry organization formed to further the interest of U.S. industry in the context of the proposed international Intelligent Manufacturing Systems . . . CIMS activities will focus initially on providing U.S. members of the international IMS committees with broad American industry input during the IMS feasibility study....

- Development of Guidelines and Supporting Processes
  - Intellectual Property
  - Technical Theme Development
  - Test Case Evaluation and Selection Criteria
- Linkage to Government and Academia
- Information Dissemination

Post-Feasibility Study

Goals & Objectives

- Keep IMS a growing, viable, and industrially relevant
- Communicate value of IMS to U.S. industry
  - Outreach and dissemination of information
  - Newsletter, brochure, press ...
  - Workshops: Stanford, NIST, Dallas, Chicago
- Promote linkage to academia via A-CIMS
- Promote SME participation in IMS
  - MTC involvement
  - Workshops via member associations (NAM, IPC, SEMI) and, consortia (NCMS, CAM-I)
  - Supplier linkages

CIMS

Post-Feasibility Study

Goals & Objectives

- Support U.S. activities in implementing full-scale program
  - ISC nominations
  - Technical, IPR, modalities, public relations committees
- Integration into U.S. manufacturing strategy
  - Reduce duplication of efforts
  - Consistent with IMS themes
  - NSTC

CIMS

Industry Expectations

- IMS MUST ADD VALUE NOT BUREAUCRACY
- INDUSTRY MUST LEAD BUT GOVERNMENT MUST BE THE CONVENING AUTHORITY
- LINKAGE OF INTERNATIONAL AND DOMESTIC ACTIVITIES

CIMS

CIMS
Board of Directors

- Applied Materials
- AT&T
- Avalon Software
- CAM-I
- EDS
- General Electric
- Honeywell
- Intel
- IBM
- IPC
- Material Handling Industry
- Motorola
- NAM
- National Semiconductor
- Polaroid
- Rockwell
- SEMI
- Sheldahl
- Structural Dynamics
- Texas Instruments
- United Technologies

CIMS

IMS Briefing

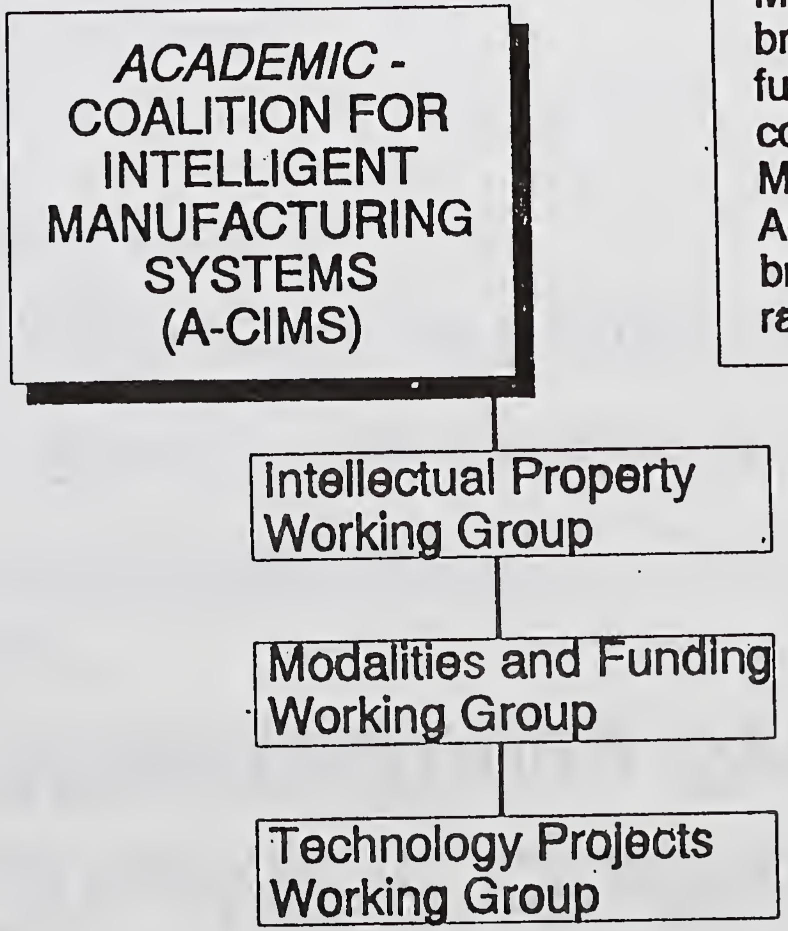
Academic Coalition for Intelligent Manufacturing Systems (A-CIMS)

Paul Huray

Senior Vice President for Research

University of South Carolina

U.S. Supporting Infrastructure



ACADEMIC - COALITION FOR INTELLIGENT MANUFACTURING SYSTEMS (A-CIMS)

Intellectual Property Working Group

Modalities and Funding Working Group

Technology Projects Working Group

The *Academic* Coalition for Intelligent Manufacturing Systems (A-CIMS) is a broad-based academic organization formed to further the interest of U.S. academia in the context of the proposed international Intelligent Manufacturing Systems...
A-CIMS activities will focus initially on providing broad American academic input during the IMS ratification period to government and industry...

- Development of Guidelines and Supporting Processes
  - Intellectual Property
  - Technical Project Development
  - Evaluation and Selection Criteria
- Linkage to Government and Industry
- Information Dissemination
- Mirror organization to CIMS

ACTIVITIES OF A-CIMS

The overall mission of the A-CIMS is to broker information and to assist partnerships on advanced manufacturing research between academia, industry, and the Federal Government, primarily concerning issues related to the international Intelligent Manufacturing Systems (IMS) program.

- Provide academic leadership during the ratification period of the IMS program,
- Support the international IMS steering committee on intellectual property issues, technical project development, and evaluation/selection criteria,
- Inform the academic community about specific opportunities to participate in joint programs with industry partners,
- Inform industry planners about academic institutions which have special strengths in specific areas, and
- Provide information to Federal agencies about academic/industry IMS partnerships which are worthy of Federal support.

A-CIMS Objectives

- Provide Information to Academia, Industry and Government,
- Assist Partnership Development between the sectors,
- Influence Domestic and International IMS Policy,
- Influence funding of IMS projects.

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Periodical

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