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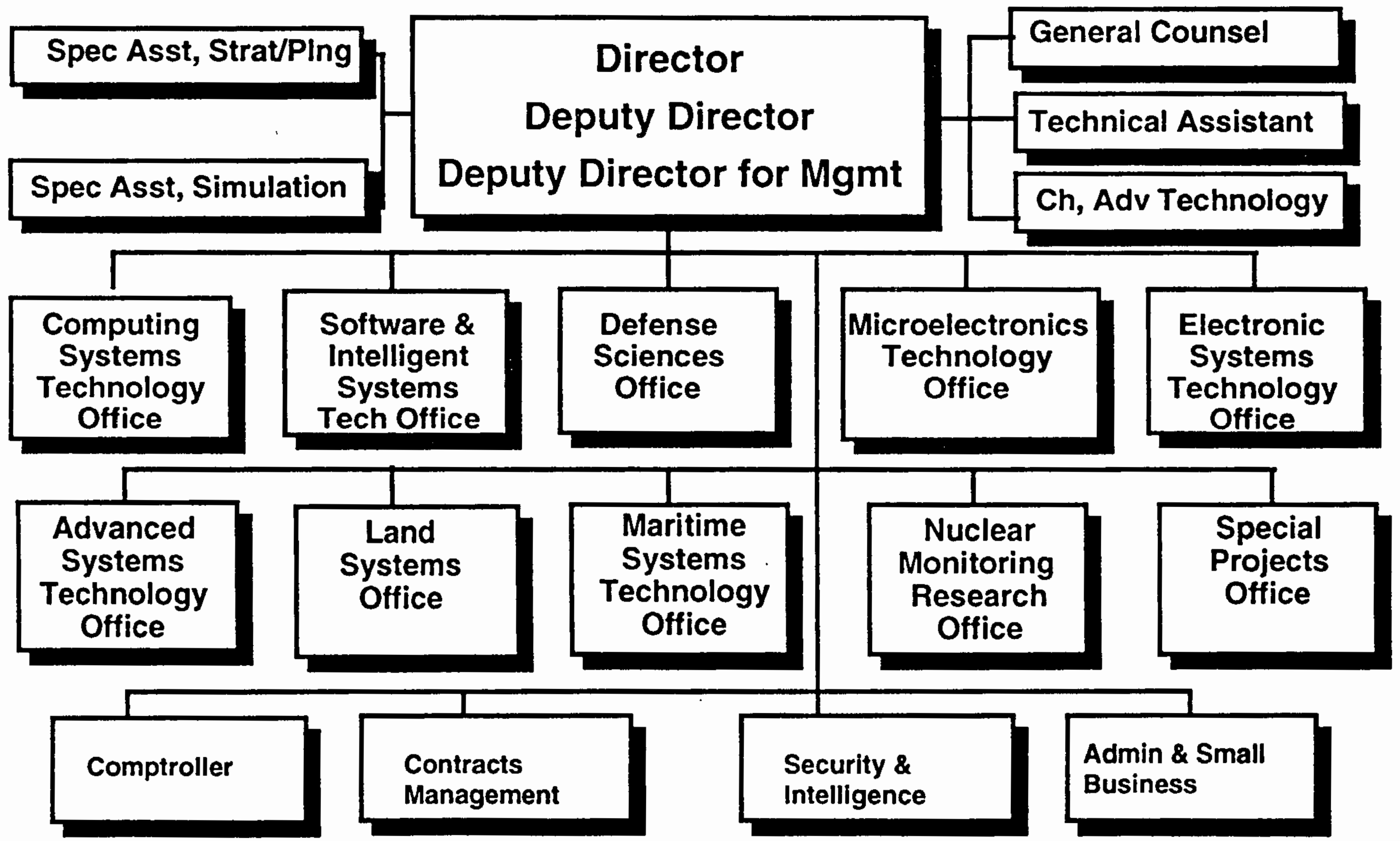
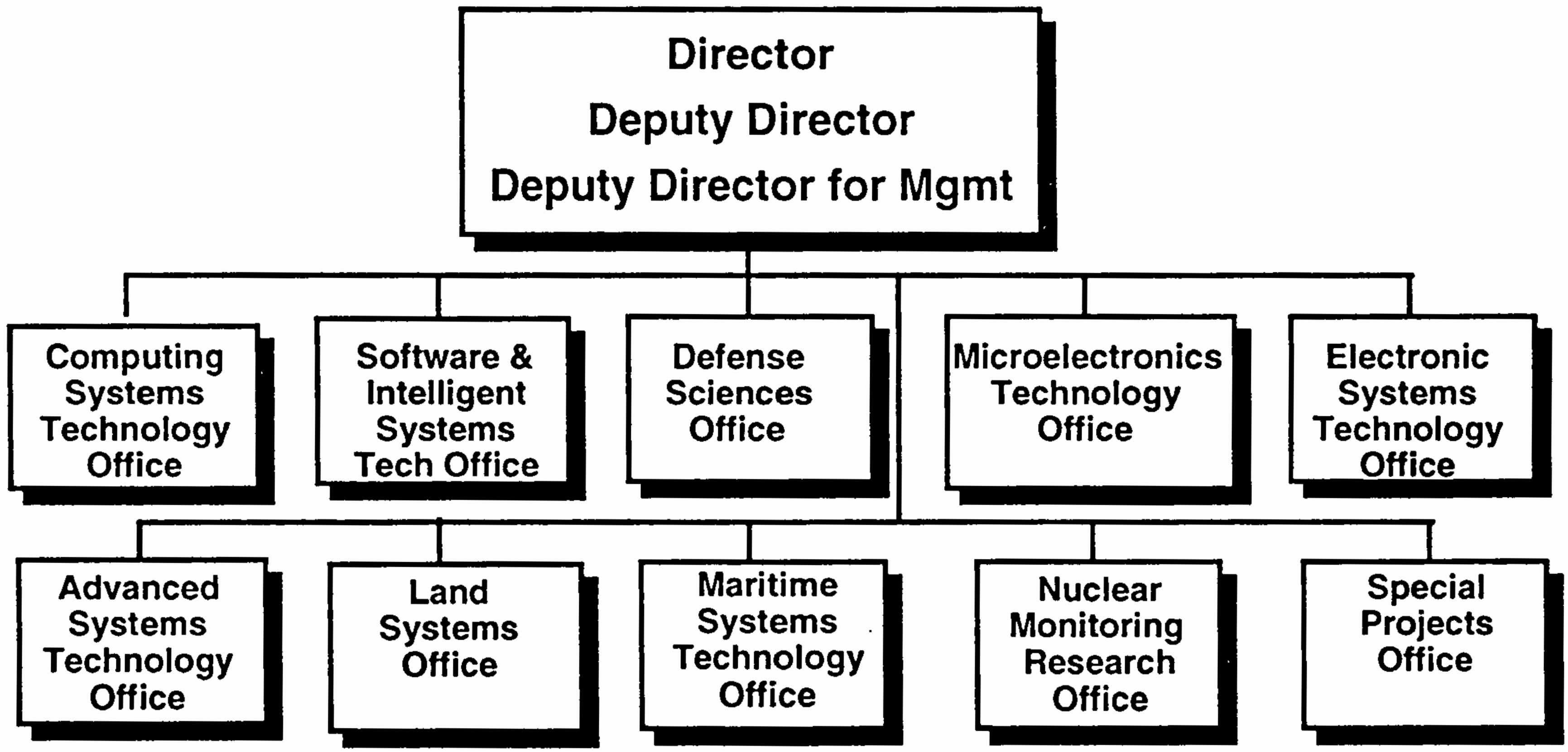
ARPA ORGANIZATION



ARPA Technical Organization



ARPA MISSIONS AND FUNCTIONS

The **Advanced Research Projects Agency** (ARPA) is a separately organized agency within the Department of Defense under a Director, appointed by the Secretary of Defense. As the central research and development organization of the Department of Defense with a primary responsibility to maintain U.S. technological superiority over potential adversaries, ARPA shall:

1. Pursue imaginative and innovative research and development projects offering significant military utility.

2. Manage and direct the conduct of basic and applied research and development projects that exploit scientific breakthroughs and demonstrate the feasibility of revolutionary approaches for improved cost and performance of advanced technology for future applications.

3. Stimulate a greater emphasis on prototyping in defense systems by conducting prototype projects that embody technology that might be incorporated in joint programs, programs in support of deployed U.S. Forces (including the Unified and Specified Commands), or selected Military Department programs, and on request, assist the Military Departments in their own prototyping programs. (DoD) Directive 5105.41, 25 January '89

The **Advanced Systems Technology Office** (ASTO) engages in advanced military research projects which will have significant impact on the defense posture of the country. The ASTO goal is to provide superior U.S. military systems in the area of space, aeronautics, weapons, C3I, Special Operations/ Low Intensity Conflict (SO/LIC), counter drug, and distributed simulation. These systems will improve our effectiveness in deterring both conventional and nuclear attack at both the tactical and strategic levels. In pursuit of this mission, ASTO performs two main functions. The primary function is the continued advancement, development, and transitioning to the appropriate Military Department of revolutionary weapon systems and associated subsystems. Secondly, ASTO will continue to identify and exploit new technologies which will serve as the basis for revolutionary systems development, maintain the necessary margin of technological superiority, and provide the flexibility and options for responding to changing U.S. strategy.

The **Computing Systems Technology Office** (CSTO) advances the frontier of computing systems technology through such approaches as scalable parallel and distributed heterogeneous computing systems technologies including computer networking technologies and the associated enabling software technologies. The technologies include both multiple use systems needed by Defense which are applicable to other Federal and National sectors and the more specialized embedded versions of these systems. The systems range from the largest scale computing and distributed systems to the workstations and embedded variants of these technologies to satisfy special requirements of Defense applications. Also, the office is responsible for the ARPA High Performance Computing and Communications (HPCC) program which represents the Defense part of the Federal High Performance Computing and Communications program In pursuit of this mission CSTO Performs two main functions. The primary function is the continued advance research and development for transition to Defense of revolutionary computing systems technologies. In addition, CSTO identifies and exploits new technologies which serve as the basis for revolutionary systems development, maintain the necessary margin of technological superiority, and provide the flexibility and options for responding to changing U.S. strategy.

The **Defense Science Office** (DSO) plans, directs, and manages activities and programs in the diverse areas of material sciences, advanced mathematics, and electromagnetics. a) In the area of material sciences, the office explores and develops new materials and processing concepts for DoD intensive materials. This includes advanced systems materials, electro-optical materials, metal and ceramic matrix composites, high temperature superconductors, unique manufacturing methods, and electrochemical power sources. This area also includes electronic applications of biological materials. b) The broad-ranging program in Applied Mathematics includes work on nonlinear differentiable dynamical systems and the application of multiprocessor architectures to the investigation of such systems; algorithms for multiprocessor architectures; applications of fractals; wavelets; and investigation of the mathematics underlying novel computer architectures. c) The focus of the electromagnetics program involves programs in the areas of efficient and high brightness lasers and particle beam devices, and advanced quantum electro-optical technology for tactical applications to include beam weapons targeted against sensors and the identification and testing of new communications, target designation and advanced surveillance concepts.

The **Electronic Systems Technology Office** (ESTO) develops advanced sensor, source, actuator, display, and signal processing technology for critical command and control, intelligence, and weapons applications. U.S. leadership in sensors, actuators, sources, and displays is a critical components of national strength, connecting information technology to people and the real world. Continued advancement of electronic systems technology is essential to maintain that lead. The ESTO science and technology program includes basic research and exploratory development.

The **Land Systems Office** (LSO) pursues advanced technology in order to create essential changes in land warfare through the introduction of innovative approaches in survivability, mobility and lethality. It is the aim of this office to develop and build land systems that considerably extend and improve operational options for US land forces, particularly in the areas of affordability and transportability. The development of enabling technologies are guided by the application of simulation in order to reduce development costs and to enhance the effectiveness of development efforts. Demonstrations on "synthetic battlefields", using advanced simulation techniques will be scheduled. These demonstrations, on the component and system levels, allow the evaluation and illustration of the benefits and shortcomings of the concept as well as providing a means to optimize combat operations. In addition, simulation will be incorporated in planning for production (e.g., concurrent production) and training simulators. This will require a large effort in simulation technologies, weapon system models and future battlefields (with advanced threats).

The **Maritime Systems Technology Office** (MSTO), plans, directs and manages activities and programs involving the application of technologies to naval warfare areas such as anti-submarine warfare, unmanned undersea vehicle applications, advanced marine vehicle design, command control and communications (C3) and special operations. Current research is focused on platform and offboard sensors for surveillance, underwater acoustics, countermine techniques, platform and combat systems automation, submarine technologies, synthetic environments and simulation- based design tools. MSTO continually explores and evaluates the possibilities for major technical improvements in the equipment and techniques for U. S. general purpose naval forces in these areas, to insure their effectiveness in deterring conventional and nuclear war and the capability to defend national interests should deterrence fail. The office explores and develops new technology to retain not only the necessary margin of technological superiority, but also the use of this technology to reduce manpower needs, increase reliability and reduce cost. This provides the flexibility and options to permit a rapid response to changing naval warfare requirements. The office, in general, carries its most promising technological developments through a sufficient demonstration of feasibility to insure that the technology results are acceptable for transition to the Navy, or to another service when appropriate.

The **Microelectronics Technology Office** (MTO) develops and demonstrates electronic and optoelectronic components and associated manufacturing processes for general-purpose computing, special-purpose processing, and sensors and sources. These advanced technologies include optoelectronics, advanced memory technology, quantum-well circuits, digital gallium arsenide (GaAs), microelectronics manufacturing technology, advanced lithography development, optical processors, artificial neural networks, analog-digital interface components, infrared (IR) focal plane arrays, and quantum-well lasers and detectors. MTO has identified and is advancing these and other key technology areas that will enable next-generation systems to support future DoD mission requirements.

The **Nuclear Monitoring Research Office** (NMRO) is responsible for research, experimentation, and systems development leading to the specification of systems, including expert systems, for detecting nuclear explosions at all distances, and for distinguishing such explosions from earthquakes or other natural or man-made phenomena. In addition, the Office is responsible for research, experimentation and systems development required to improve national capability to obtain atomic energy related intelligence information, to determine methods that might be employed by foreign powers to test nuclear weapons in secrecy, and to devise countermeasures to such evasive testing methods. The Office is a primary source of technical advice to policy agencies of the Department of Defense, the Defense Intelligence Agency, the Department of State, the Arms Control and Disarmament Agency, the Department of Energy, and other agencies responsible for developing U.S. policy and negotiating strategy for international negotiations on treaties limiting nuclear testing.

The **Software & Intelligent Systems Technology Office** (SISTO) is responsible for software database management, computer aided software engineering, intelligent systems and data processing. The SISTO goal is to provide for the advancing of the frontier of software systems technology through machine intelligence; management/automation of software engineering process; integrating frameworks for engineering/design support and software technology transfer.

The **Special Projects Office** (SPO) engages in advanced military research projects which will have significant impact on the defense posture of the country. The SPO goal is to provide superior U.S. military systems which will improve our effectiveness both in deterring attack at the tactical or strategic level and in executing assigned missions should hostilities occur. In pursuit of this mission, SPO performs two main functions. The primary function is the continued advancement, development, and transition to the appropriate Military Departments of revolutionary weapons systems and associated subsystems. Secondly, SPO will continue to identify and exploit new technologies which will serve as the basis for revolutionary systems development, maintain the necessary margin of technological superiority, and provide the flexibility and options for responding to changing U.S. strategy.

The **Comptroller** (COMP) is responsible for fiscal and budget planning activities for the agency. This includes responsibility to assure that proper procedures and control are exercised with regard to all fiscal matters, including program execution and contract management; maintains congressional liaison with regard to fiscal matters and provides for direct interaction with the congressional staff as required; and maintains a management information system to support the agency's requirements for timely fiscal, contracting and programmatic data. The operating programs for which responsible are highly complex and varied, involve a budget in excess of $2 Billion per annum, and involve numerous examples of interaction with large-scale industrial, commercial or other financial operations as well as broad research and development programs involving individual research efforts utilizing the combined efforts of many contractors, subcontractors, laboratories, universities and international organizations.

The **Contracts Management Office** (CMO) is responsible for: advising the director, deputy directors, office directors, and program managers of ARPA on acquisition matters; representing ARPA on acquisition matters with external organizations; formulating and implementing acquisition policy and procedures at ARPA; planning, negotiation, award, and administration of contracts, grants, cooperative agreements and other transactions which fall within its area of responsibility as defined in ARPA Instruction 38; and other ancillary functions arising from the acquisition process. The Contracts Management Office is intended to serve as an internal supplement to, not a substitute for, the ARPA contracting agents in the military services, which continue to handle the predominance of ARPA contracting.

The **Administration and Small Business Office** (OASB) is responsible for directing, planning and executing all technical information, administrative support, internal management control, personnel, agent liaison and small business functions for ARPA. This includes managing an annual $2 million contract for Agency-wide support; formulating, justifying and monitoring the Agency budget for these functions; administering the Agency's small business and small, disadvantaged business programs; managing the annual $50 million Small Business Innovation Research program; and formulating policy guidance for all technical information, administrative support, personnel, agent liaison and small business functions. Administrative support provided to the Agency includes facilities management, travel services, furniture and equipment acquisition, supplies and maintenance, visitor access, space allocation, correspondence and classified document control, technical library services, forms and records management, courier and staff car services, mailroom functions, and the operation of an administration support center that provides word processing, editing, graphics support, etc.

The **Security and Intelligence Office** (SIO) directs, plans, and executes the information, personnel, industrial, and physical security programs at ARPA and at specified contractor sites. This includes Sensitive Compartmented Information (SCI); Special Access Programs (SAPs); foreign disclosure of classified information; evaluation, control, and dissemination of technical information; declassification management activities; security classification management program; communications security (COMSEC); and the ARPA potential contractor program. The Office also formulates and implements security policy and procedures at ARPA and represents the Agency on security matters with external organization.

Statement by

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DIRECTOR

ADVANCED RESEARCH PROJECTS AGENCY

Before the

SUBCOMMITTEE ON DEFENSE

HOUSE APPROPRIATIONS COMMITTEE

May 4, 1993

Not for Publication until
Released by the
House Appropriations Committee

Introduction

Good afternoon Mr. Chairman, members of the committee, and staff. I am pleased to appear before you, and to outline my vision of the ARPA mission in support of the Administration's evolving technology policy and the critical DoD challenges as characterized by Secretary Aspin. I will briefly describe the Administration's Technology Reinvestment Project (TRP), which is now well underway, discuss ARPA's FY94 program, and identify significant recent R&D accomplishments.

Despite the end of the cold war and the end of the Soviet Union, the world remains a dangerous place. Secretary Aspin has identified four challenges in formulating a strategy for the Defense Department and for ultimately ensuring our national security:

1. Preserving the readiness of our armed forces to ensure the ability to quickly reach and successfully confront regional threats,
2. countering the proliferation of weapons of mass destruction,
3. promoting democratic reform and managing potential failure to reform, especially in the former Soviet Union, and
4. contributing to the economic strengthening of this country.

I believe there is a crucial role for ARPA in the execution of Secretary Aspin's strategy.

When I came before this subcommittee last year, I stressed the DARPA, now ARPA, legacy and history that demonstrates our ability to move rapidly into new areas and to respond to new challenges and opportunities. I believe this flexibility will be even more important as we respond to the Secretary's strategic planning and, concurrently, face large reductions in the defense budget. The ARPA mission remains consistent with these new DoD challenges.

As the central research and development organization of the Department of Defense with a primary responsibility to maintain U.S. technological superiority over potential adversaries, ARPA pursues imaginative and innovative research and development projects having significant potential for both military and commercial (dual-use) applications. We are also chartered to support and stimulate a national technology base that serves both civilian and military purposes through technology sharing and collaboration with broad industry segments.

Basic to our mission is a focus on scientific breakthroughs and revolutionary approaches which lead to fundamental change in DoD's ability to execute national security policy. The emphasis on fundamental change is vital to all ARPA programs. I cannot overemphasize this management strategy as the key context for planning and priortizing the ARPA program. I believe it is the major factor that makes ARPA so unique in the acquisition community.

As we remain focused on meeting future military demands and creating fundamental change in the way we develop advanced military capability, we will continue to pursue dual-use technology that meets military needs and stimulates commercial product development. Central to this dual-use emphasis is the need to integrate the military and commercial technology and production base to ultimately provide affordable products to defense. Partnering with industry will encourage us to find new ways to insert new technology and new subsystems into fielded systems.

While all ARPA efforts are structured to address one of the four challenges outlined above, the fourth challenge represents a new emphasis on the critical relationship between economic security and national security and presents a major opportunity for ARPA to seek maximum national benefit from our technology investments. This is especially significant in view of the programmed major reductions in the DoD budget which will drastically reduce the number of weapons system purchases and will permit only a few new weapon system starts. In this context, we will structure many of our programs to transition through weapons system upgrade programs.

Technology Reinvestment Project

The Administration's decision to change the designation of DARPA to ARPA reflects our emphasis on dual-use technology development. This emphasis is also substantially reflected in the Defense Conversion, Reinvestment, and Transition Assistance Act of Fiscal Year 1993 and the implementation of that legislation through what we call the Technology Reinvestment Project (TRP). To achieve the goals of fundamental change, ARPA has taken lead roles in a number of major initiatives that cut across the government, including the TRP, High Performance Computing and Communications, Manufacturing, Education, and Electronics Programs. Each of these is not only pioneering new innovative technologies, but are seeking innovative approaches of transferring technology, developing a sound technology infrastructure base, and looking at policies needed for success.

In order to achieve the maximum payoff from dual-use technology investments, an interagency government team was formed by ARPA to manage the execution of the TRP. The Defense Technology Conversion Council (DTCC), chaired by ARPA, is administering the TRP in a fully collaborative, interagency effort with Department of Commerce/National

Institute of Standards and Technology (DoC/NIST), Department of Energy/Defense Projects (DOE/DP), National Science Foundation (NSF), and National Aeronautics and Space Administration (NASA). This revolutionary undertaking addresses a broad spectrum of essential industry and technology transition programs and ensures that industry is actively involved in shaping the programs. Our mission is to transition to a *growing, integrated, national industrial capability* which provides the most advanced, affordable, military systems and the most competitive commercial products. We are attempting to do two mutually supportive things simultaneously: simulate economic growth and bring defense and commercial industries closer together.

The eight statutory programs fall naturally into the three TRP activity areas: dual-use technology development, technology deployment, and manufacturing education and training. Approximately $240M will be invested in creation and development of dual-use technologies. Specific activities supported will seek to find commercial uses for existing defense technologies--so called spin-off; they will also seek to find defense uses for existing commercial technologies--so called spin-on; and they will seek out promising new dual-use technologies. Emphasis is being placed on leading edge technologies; eleven key technology investment areas have been identified in order to focus the program. We expect significant involvement in these programs from the DoD Laboratories, DOE Laboratories, and NASA.

Approximately $180M will also be invested in technology deployment activities. The emphasis will be on assisting U.S. small manufacturers and other enterprises to improve their performance. This will include the addition of more manufacturing technology extension and outreach centers, and the improvement of information flow between business, government and academia. Assistance will also be targeted at the task of identifying technology sources most suitable for the private sector, especially small firms. NIST is playing a major role in executing these programs.

Approximately $50M will be invested in our most important national resource: education. Specifically, it will be invested in manufacturing education and training. This will include support for additional Engineering Research Centers, innovative engineering curricula such as practice-oriented engineering masters degree programs, as well as activities that support vocational education and training. NSF is the key team member for these programs.

To date the TRP team has published an information and planning document known as the "red book", which addresses the eight programs specified in the law, identifies potential activities to be undertaken in a single competition, and describes the evaluation criteria for awarding activities to participants. As you know, each program has a unique focus, however three statutory requirements are common to all: all programs require competitive awards, all programs require cost sharing of at least 50 per cent, and all programs contain specific participation and organizational requirements. In May the actual TRP solicitation will be published, with proposals due in July, and initial awards beginning prior to the end of FY93.

As with any new effort, we have identified several issues need our attention:

1. The large defense contractors that are primarily military suppliers may have great difficulty converting to commercial products. The problems range from internal culture to a lack of understanding of the marketplace. While these large companies sort out their conformation strategies, we believe that we can be successful by placing emphasis on the first, second, or third tier of defense subcontractors. These companies have the culture and structure to make the conversion since many already participate in both military and commercial markets.

2. Another issue in implementation of the TRP is the allocation of intellectual property rights (technical data, copyrights, patents) and associated policies which are vital to successful commercialization. The statutory allocation of patent rights, for example, generally allows the contractor or subcontractor to obtain title to patents issued as a result of inventions made under government contract. However, the government retains a paid-up, royalty free license to practice or have the invention practiced on its behalf for governmental purposes including competitive procurement. In addition, the government retains "march-in rights" allowing it to recapture commercial rights in the invention under certain circumstances. This approach is frequently a disincentive to commercialization.

To help alleviate this problem we believe that a flexible approach can be successful through the use of agreements authority. ARPA has the legal authority to enter into "other transactions" under Section 2371 of Title 10, U.S. Code. These other transactions are not governed by the statute that controls patent rights under contracts and grants. This gives ARPA the flexibility to craft intellectual property provisions to meet the goals of a particular transaction.

3. The legislated cost sharing requirements pose real problems for some TRP participants. The rules are difficult; among the eight programs there are six different formulations for cost sharing. More consistent language and definitions for some terms would be helpful.

There appears to be inconsistency between the clear Congressional intent to involve small and medium sized businesses in these programs and the strict cost sharing requirement of at least 50 per cent. Large well-financed commercial firms may find the programs attractive, but for small firms cost sharing may mean they cannot participate at all. Establishing 50 per cent cost sharing as a goal where practicable, with lesser sharing expressly authorized to maximize small and medium sized business participation is recommended. This would enable funding agencies to work with small and medium sized businesses on a flexible basis.

FY94 Program

Our program is structured into three primary areas: (1) the continuation of the Technology Reinvestment Initiatives, (2) the continuation of the technology creation and maturation programs (Innovative Technology Development), and (3) military systems application and demonstration programs (Military Applications). In addition to the technology reinvestment initiatives, the vast majority of our innovative technology investments have commercial market potential as well as fill military needs. Demonstrative of our commitment to emphasize dual-use, we will continue to interact with non-DoD agencies, as well as increase interactions with commercial industries to develop strategies for integration of military and commercial products and processes. I am also pleased to report to you that we are providing funds in FY94 to continue several key programs the Congress has augmented over the past few years. These programs include High Definition Systems, Lithography, Electronic Packaging, and Materials. Developing manufacturing processes is our key thrust in implementing these programs.

Technology Reinvestment Initiatives

We plan to continue the programs initiated in FY93 under the Technology Reinvestment Project. In FY94 approximately $340M has been allocated to these programs. Since industry proposals for FY93 will not be received until July, it is difficult to specifically describe the key investments to be made. However, based on inputs from industry and multiple agency discussions, current plans are to continue activity in all eight FY93 statutory programs, with particular emphasis on the Defense Dual-Use Critical Technology Partnerships, Defense Advanced Manufacturing Technology Partnerships, and Regional Technology Alliances Assistance Programs. The extension and assistance type technology deployment programs will be executed in close collaboration with DoC/NIST. As with the FY93 effort, key technology investment areas will be finalized after receipt of proposals for the FY93 program. Based on current industry dialogue, assessments of military needs, and discussions with other agencies, emphasis will include information technologies including networking, materials, aeronautical, and vehicle technologies.

We plan to continue execution of the programs in collaboration with other agencies. Since these agencies, particularly DoC/NIST, have increased their budgets for these types of initiatives, collaboration between government agencies is critical. The White House, both the Office of

Science and Technology Policy (OSTP) and the National Economic Council (NEC), will provide overall leadership for this collaboration.

Innovative Technology Development

The ARPA FY94 program for investment in innovative technology development includes a major emphasis on a broad spectrum of information technologies including: semiconductor manufacturing, microwave integrated circuits, electronics design and manufacturing, high definition systems, high performance computing and software engineering. In addition, we are continuing efforts in materials and portable energy sources, and the relatively new area of microelectromechanical systems (MEMS). All of these investment areas have two factors in common: a significant potential for both military and commercial applications (dual-use) and a significant investment in manufacturing process technology accompanying the development of new devices and products. Our goal is to deliver advanced technology in military products that are also affordable products. The following paragraphs briefly discuss our plans in these areas:

INFORMATION TECHNOLOGIES

ARPA will continue to put major emphasis on a broad spectrum of technologies that support information technology in FY94. Our programs range from microelectronics, electronic packaging and displays to high performance computing, with increasing emphasis on network technology. We believe that information technology will have a pervasive impact on a wide variety of new innovative military systems and will continue to be the fastest growing commercial market. This emphasis on information technology is central to the overall ARPA strategy to create fundamental change in military capability and represents a major opportunity to maintain or capture wide leadership in the commercial market.

<u>Semiconductor Manufacturing</u>

To meet the future demand for affordable, advanced microelectronics we believe it is as important to develop and demonstrate semiconductor manufacturing processes as it is to advance semiconductor technology. ARPA has a substantial program in semiconductor manufacturing including continued sponsorship of the SEMATECH program and advanced lithography technology. Our program is a coordinated effort that seeks to create an environment for low-cost, flexible semiconductor manufacturing at the state-of-the art.

The *SEMATECH* program is the premiere example of ARPA's sponsorship of a true dual-use technology program through cooperative partnerships and cost sharing with industry. This partnership includes companies that supply the majority of the integrated circuits in the U.S. ARPA's FY94 efforts will focus on the manufacturing tools and methodologies needed for low cost, flexible, scalable manufacturing to meet defense and commercial needs. Currently the industry is optimized to produce single part types in large volumes. Emphasis will be on combining advances in manufacturing equipment with software innovations to enable state-of-the-art microelectronics manufacturing facilities capable of producing many part types in rapid turn around time and with reduced cost sensitivity to manufacturing volume. The resulting programmable and scalable factory system will be capable of supporting multiple technology generations with first-pass success, in a cost effective manner. This capability is vital to the creation of leading edge defense and commercial information systems.

ARPA's *Advanced Lithography* program is addressing long term developments required to establish the manufacturing capability for advanced semiconductor components for 1995 and beyond. Lithography is the key technology which has enabled the dynamic growth of the semiconductor and integrated circuit industry over the last two decades. Our program will develop capabilities for fabricating circuits with feature sizes of 0.18 - 0.1 microns. Current manufacturing utilizes 0.5 micron minimum features. Key developments being pursued include mask technology, improved alignment and overlay techniques, metrology, and systems development. Various exposure sources including x-ray, electron beam, and ion beam are being studied, and device demonstrations are being conducted to establish viability of developed systems. This research is a lynch pin in driving the advancement of the U.S. microelectronics industry and ultimately the improvement in system performance related to speed, power, weight, and reliability.

Microwave and Millimeter Wave Monolithic Integrated Circuits (MIMICs)

In contrast to digital microelectronic devices, MIMICs are solid state circuits that receive, transmit, and process analog microwave signals. These sensors can be considered the "eyes and ears" of equipment operating at microwave frequencies. MIMICs can either amplify received signals and send them to the digital processing portion of a system or transform digital information into microwave signals that are transmitted by an antenna. ARPA's MIMIC program was initiated in 1988 and has made significant strides in the development of improved gallium arsenide material and associated manufacturing, packaging, and test capabilities. The 1994 program will complete the development of fully integrated design, manufacturing, and testing capabilities that can produce a wide range of advanced microwave/millimeter wave circuits at low cost. These circuits are required for subsystems and components for both DoD and commercial systems, including smart weapons, communications, and radar.

This program is an excellent example of dual-use technology where ARPA has helped create a new industry capability. This area is at or near "ignition" in terms of a self sustaining industrial base capability to supply both military and commercial products. Today, several of these suppliers are exporting devices (not technology) to several countries.

Electronics Design and Manufacturing

ARPA's initiatives in electronics design and manufacturing are aimed at improving the design and manufacturing processes of complicated systems as well as improving performance through innovative packaging concepts.

ARPA's *Electronic Packaging and Interconnect Technology* program will result in the availability of new packaging technologies which enable electronic systems to be implemented with greater functional density, significant weight and volume reduction, and improved performance in terms of reduced power requirements and increased speed, all at lower cost and in shorter times. In addition to a sustaining military demand for high performance electronic subsystems, a huge and rapidly increasing world market in the electronic products industry demands dramatic increases in product sophistication and continually improved performance and features at little or no increased cost. ARPA has $90M budgeted for packaging activities in FY94 to focus on advancing technology, developing applications, improving accessibility, and advancing manufacturability and affordability. Initiatives in the advanced technology development area include high density interconnect substrates, conformal electronics, high speed and mixed signal technologies, and superconducting interconnects. In the application development area we are optimizing integrated circuits and system architectures to take advantage of this technology and accelerate its insertion into military and commercial applications such as high end signal processors, computing, and personal communications.

We are also developing the technology and infrastructure necessary to provide system designers with easy access to advanced packaging technologies. Specific goals in this area include one month turn around and $25,000 non recurring costs for semi-custom modules. We have an initiative underway to develop the equipment and processes necessary to produce high density electronic modules at a cost comparable to, or lower than traditional approaches. Specific goals include a substrate with 400cm/cm^2 interconnect density at a cost of $4/cm^2. We believe we have a comprehensive electronics packaging program that will ensure an end-to-end capability to rapidly acquire electronic modules and subsystems for insertion into critical military systems and promising commercial markets.

In the *Rapid Prototyping of Application Specific Signal Processors (RASSP)* program ARPA is seeking to dramatically improve the process by which complex digital systems, particularly embedded signal processors are specified, designed, documented, manufactured, and supported. Improvements are measured in terms of product cycle time, life cycle cost and product quality along with portability, ease of use, and affordability. The domain of embedded signal processing has been chosen because of its importance to a wide variety of military and commercial applications. These include automatic target recognition, communications, adaptive signal sorting, character and voice recognition, and image processing. The program has adopted a "Model Year" methodology as a way of stressing the importance of continuous improvement, meeting short development cycles (three to 12 months), and avoiding point design solutions. A key aspect of the Model Year methodology is standardization of hardware and software interfaces. The program strategy is to develop the appropriate architectures, methodologies, and a comprehensive design environment utilizing virtual prototyping. Although the program is under ARPA sponsorship, all three military services are active participants.

In the *Manufacturing Automation and Design Engineering (MADE)* program we are developing and demonstrating key software elements for Integrated Product/Process Development (IPPD) and agile manufacturing applications for both mechanical and electrical design. The application focus is on mechanical parts and electromechanical assemblies, where today's automation environment is neither integrated nor flexible. MADE will develop advanced automated CAD/CAE software generators that will enable sharing, reuse, and merged product and process models, and ultimately pave the way for populating an interoperable tool set in the electromechanical system domain. Initial demonstrations will be conducted on assembly of infrared seeker and sensor components. MADE will also establish an open architecture and interface protocols to make it easy for new tools and services to plug in to the evolving set of services accessible over widely available networks. The technologies targeted by MADE are on the critical path to creating the IPPD and flexible/agile manufacturing processes need to achieve significant reduction in acquisition time and cost for future defense and commercial systems.

High Definition Systems (HDS)

The ARPA HDS program encompasses the development of a wide variety of technologies associated with high definition systems including displays, display processors, sensors, software, high density storage, packaging, and manufacturing. The program's overall goal is to achieve a design and manufacturing capability that can provide for and sustain the affordable use of high definition technology in DoD and commercial systems in the late 1990s and beyond. Display efforts include flat panel and head-mounted displays using active matrix liquid crystals, electroluminescence, plasma, and cold cathode technologies; projection displays using digital micro-mirrors, liquid crystals, and laser projection; as well as efforts in manufacturing and enabling technologies. Modeled after SEMATECH, a consortium of display manufacturers working in partnership with the government on display industry infrastructure is being established. The $57M FY94 ARPA HDS program is developing displays for use in aircraft, tanks and shipboard applications; graphics algorithms and scalable image processors; data compression techniques; and technology for manufacturing higher resolution, full-color displays.

High Performance Computing and Communications

The ARPA High Performance Computing (HPC) Program is now halfway through its initial five year plan and is focused on developing the full range of technologies needed for a scalable technology base of interoperating workstations, networks, and parallel computing systems with mass storage, systems software and development tools. These technologies will enable solutions to some of DoD's most difficult computational challenges while providing the foundations of an information infrastructure needed in this decade. Coupled with both the Technology Reinvestment Program and other ARPA efforts, the computing technologies being developed and demonstrated represent the best information technologies available to meet DoD and commercial needs. The program consists of three major areas plus supporting technologies: *Scalable Systems*, *Scalable Software*, and *Networking Systems*.

The HPC *Scalable Systems* area is pushing the frontiers of computer architecture, component technology, and systems technology for desktop workstations through the largest scale heterogeneous systems. The goal is to develop a modular technology base that will enable a variety of system configurations over a wide performance range. In FY94, we plan to build upon the successes of the program and extend the scalable technology base to include scalable Input/Output (I/O) channels, parallel mass storage, and innovative micro-architectures while exploring alternative scalable concepts for models of computation, algorithms, computational methods, and operating systems with real time support.

The *Scalable Software* area uses parallel systems to develop environments, languages, parallel library technology, and system software services which enable users of this new class of machine to realize their potential. The results of the parallel software investments begun in 1991 will be deployed and developed next year as the HPC software community begins to mature. HPC technology requires a new software technology base and development process. We expect to demonstrate how the same technologies used in the largest and highest performing HPC systems can be used in smaller systems including workstations and single processor desktop computers. Coupled with networking technology, users may use workstations to access scalable HPC servers connected to computational resources of progressively larger scale and higher performance. In 1994, efforts will show advanced scalable architectures which support both scalability and real time; computers with efficient operating system environments up to tens of thousands of processors; deployment of the first trusted operating systems; and demonstration of new approaches to high performance parallel libraries and languages.

ARPA's *Networking Systems* area is developing high performance, interoperable networking technologies as enablers of a worldwide ubiquitous information infrastructure. There will be a focus in FY94 on a number of important areas. First, Internet capabilities will expand to include interfaces to differing communication channels including optical, satellite, cable TV, ISDN, and wireless end user access; security services needed for reliable and survivable operation of networking infrastructures; and applications for audio/video teleconferencing services. Second, networks must push high performance by increasing the speed of the underlying networks, while exploring innovative ways of delivering "bits" to customers and understanding the limits of the network architecture. In FY94, this includes experimental gigabit testbeds, new higher level protocols for all optical transmissions, and empirically measuring the limits of network performance. Finally, we will initiate an advanced technology component for the Global Grid, which includes the development and demonstration of technologies for a global, gigabit/second optical network that connects DoD operational and intelligence centers. This program is a collaborative effort being performed with many other DoD agencies, as well as industry, and builds upon the networking and other scalable computing technologies that are emerging.

Software Engineering

In FY94 ARPA will continue to pursue a broad software engineering program that supports our information technology initiatives. Our Software Engineering program encompasses technologies in establishing software engineering practices, design and development of software engineering environments, and the development of advanced languages. As systems migrate to massively parallel and heterogenous distributed computing platforms, the design and development of software architectures, languages, and applications becomes more and more critical and complicated.

The *Software Engineering Foundations* program focuses on technology for developing and supporting high assurance software systems and on developing languages used in software systems integration. We are addressing techniques by which critical properties relating to security, safety, or function can be established with high levels of assurance in software components and systems. A principal challenge is the effective integration of high assurance techniques into software engineering tools evolving in the commercial market.

Complementing the Software Engineering Foundations program is the *Evolutionary Software Development* program. This program will develop technologies that facilitate an iterative, architecture-oriented approach to the creation and support of large scale software systems. These technologies will enable early validation and the iterative refinement of both requirements and design of software intensive applications. During FY94, a key focus will be to determine the effectiveness of prototyping technologies and domain specific software architectures on a range of applications.

As the DoD sponsor for the federally funded *Software Engineering Institute (SEI)*, ARPA will continue to manage the program. In FY94 the SEI will establish a framework for process improvement based upon their highly acclaimed software capability maturity model; extend this model to address engineering processes; and expand initial work in software metrics to include process and product metrics as a foundation for long term software productivity improvements.

In the *Software Technology for Adaptable, Reliable Systems (STARS)* program we are developing, integrating, and transitioning programs to demonstrate a process and architecture driven, domain specific, reuse-based approach to software engineering. This is now know as megaprogramming. This program has now entered the demonstration and transition phase. Three teams each consisting of a service and a prime contractor will apply the STARS megaprogramming technology on three different DoD problems.

MATERIALS AND PORTABLE ENERGY

The *Materials* program at ARPA can be grouped into two categories: structural and electronic materials. In the structural area, research in ceramics and composite materials focuses on improving cost effectiveness while at the same time advancing physical performance in terms of strength-to-weight, durability, temperature capability, and geometrical tolerances. The need to improve cost effectiveness has prompted ARPA to invest in the development of freeform manufacturing capabilities for metallic, ceramic, and composite materials. Freeform manufacturing capability can be described as the ability to transform virtual objects (e.g. CAD files) into solid objects without part specific tooling or operator intervention. In FY94 structural ceramic components will be demonstrated for high temperature structures.

ARPA's programs in electronic materials application promise to improve manufacturability, reduce size and weight, increase speeds, reduce system complexity, and at the same time lower manufacturing costs for electronic components. Central to the electronic materials program is the fabrication of high temperature superconductors (HTS) for application in multichip modules (MCMs) with superconducting interconnects. HTS interconnects will greatly enhance the performance of the entire electronic circuit by reducing power requirements, cycle time and power dissipation. Also being pursued is the ability to manufacture monolithic diamond wafers for integration in electronic components. During FY94 the program goal is to develop economical diamond substrate MCM production and develop electronic packaging design concepts for thermally limited applications.

We are developing a spectrum of portable energy sources based on advanced *batteries* and *fuel cells*. For example, we have developed an all solid-state battery which is rechargeable, has 100 times the shelf life, and several times the energy density of NiCd batteries, in addition to being safe and reliable. In FY94 we will produce prototype thin filmed batteries for law enforcement and counterdrug applications in addition to producing a prototype rechargeable battery equivalent of a military primary battery. We are also researching fuel cells which will be multifuel versatile, safe, reliable, have low acoustic and thermal signature, and have three times the efficiency of Carnot cycle devices. Many applications such as portable electronics and information technology are severely hampered and restricted by a lack of energy density. Our program will develop efficient, reliable, low signature, safe, high-energy and, high-power-density electrochemical power sources.

MICROELECTROMECHANICAL SYSTEMS (MEMS)

MEMS is a term that describes the devices and technology used to make miniature electromechanical systems. Using the same fabrication processes and materials that are used to make microelectronic devices, MEMS conveys the advantages of miniaturization, multiplicity, and integrated microelectronics to the design and construction of electromechanical devices. MEMS is a revolutionary, enabling technology with widespread applications including miniature inertial measurement units for personal navigation, mass data storage devices, miniature analytical instruments, non-invasive medical sensors, fiber-optic network switches, and distributed unattended sensors for environmental and security surveillance. The long-term goal of ARPA's MEMS program is to merge computation, sensors, actuators, and mechanical structure to change the way people and machines interact with the physical world. Short-term goals include demonstration of key processes and prototype systems using MEMS technologies and lowering the barriers to access and commercialization by developing an infrastructure to support shared, multi-user design, fabrication and testing. Advances in MEMS will reduce the cost and increase both the number and capability of smart systems for defense and civilian use.

Military Applications

ARPA has traditionally invested in programs to demonstrate the military utility of emerging technologies through an aggressive set of Advanced Technology Demonstration programs. These programs have not only provided demonstrations of technology, but also have led to fundamental change in military capability, e.g., precision guided weapons, stealth, and battlefield sensors. The FY94 program continues these investments and is closely tied to the DoD S&T Thrust Strategy. Some of our key programs are described below:

SIMULATION

Advanced Distributed Simulation (ADS), a major investment area for ARPA over the past several years, has become a pervasive tool for evaluating technology impacts, providing a military context for new concepts, as well as a highly effective tool for training from the soldier to Commander in Chief (CinC). Our FY94 program continues to demonstrate our commitment to develop and apply this technology to a number of our technology demonstration programs. The ADS demonstrations we have defined are designed to stress the envelope of simulation technologies while providing for effective transition to the user.

One of the more focused ADS programs we are pursuing is the *Army National Guard/Advanced Distributed Simulation (ARNG).* This program will revolutionize the way reserve component units and individuals are trained. Because the Reserve Components provide nearly half of the land combat power, there is a critical defense requirement to ensure the readiness of these forces. As was apparent during Desert Storm, insufficient training can preclude the deployment of these forces.

New low-cost scalable simulations and devices (individual through brigade; novice through expert), distributed communications, and advanced information processing capabilities are enabling the development of this revolutionary, next-generation representation of a robust and relevant synthetic battle space. It is expected that employment of the ARNG training system will double or even triple the number of ready forces in crisis. In addition to the actual training system development, an integral part of this effort is the development of an advanced distributed simulation *environment* that will foster breakthroughs in training methodologies and tools that exploit emerging information technologies. In the FY94 program we will outfit two experimental brigades with prototype technology based training systems connected through the Defense Simulation Internet (DSI). We will also begin development of artificial intelligence assisted individual learning systems.

The successful demonstration of this ARNG system will provide a model for the conduct of training across DoD, and in the conduct of vocational and educational training and instruction in the public domain.

SPACE TECHNOLOGY

The key issue impacting our future DoD and civil space capability, U.S. competitiveness, and world leadership position is affordability. Since 1988, at the urging of Congress, we have pursued over 50 space technology programs all specifically aimed at reducing the size, weight, power, and cost of space systems. Our early successes in quickly developing, launching, and operating ten small satellites and two new launch boosters have paved the way for proving that fundamental change is possible. A simple, common sense strategy has been conceived, applicable on a national level, to enable routine, affordable space architecture modernization. The strategic vision calls for the selective use of smaller, capable satellites, as operational adjuncts, to simultaneously permit low-cost technology insertion and backbone capability augmentation. The strategy also seeks to use small and larger common bus satellites with "bolt-on" payload interface to support a wide spectrum of missions across multiple satellite constellations. This approach may be able to save billions in life cycle costs by minimizing the high cost of customization and dramatically shortening production time. The $30M ARPA FY94 program includes several pivotal Advanced Technology Demonstrations (ATDs) involving joint participation of the Services, civil agencies and the commercial sector. The ATDs will address capability shortfalls existing today in DoD MILSATCOM and remote sensing space systems. These efforts are inherently dual-use and will directly contribute to cost breakthroughs for commercial satellite production and operation.

The centerpiece for achieving affordability gains is the *Advanced Technology Standard Satellite Bus (ATSSB)* program. ATSSB will prove that satellites can be built combining high performance with common industry standards to allow for truly bolt-on payloads. This common bus will be capable of supporting a variety of high mass fraction, operationally useful payloads in a wide range of orbits and at very low recurring cost. The *Collaboration of Advanced Multispectral Earth Observation (CAMEO)* program will demonstrate a critically needed, dual-use multispectral payload hosted on ATSSB in low earth orbit to support future DoD and civil remote sensing satellite modernization and to stimulate growth in the commercial remote sensing market. The *Advanced Satellite Technology and EHF Communications (ASTEC)* program will demonstrate advanced EHF payload technologies. The final ATD, the *MILSATCOM Terminal Technology (IMPACT)* program will demonstrate improvements in future MILSATCOM terminal affordability, interoperability and mobility, and together with ASTEC, will demonstrate the means to connect theater-based warfighters with the emerging commercial global fiber grid.

WAR BREAKER

The WAR BREAKER project goal is to develop and demonstrate technologies and systems enabling a fully integrated, end-to-end system capable of targeting and neutralizing time-critical targets within enemy strike cycle times. This is being accomplished by focusing on key ARPA high-leverage initiatives and integrating these with ongoing developments and existing systems within the services. Specifically, the WAR BREAKER goals will be achieved by exploiting ARPA's electronics and information technologies including advanced sensors, computing systems, automated intelligence correlation and processing, and distributed simulation. The project is divided into three efforts: Surveillance and Targeting, Intelligence and Planning, and Systems Engineering and Evaluation. Each effort is based on multiple demonstrations of increasing complexity and integration and contributes to the overall WAR BREAKER capability, culminating in overall system demonstrations in FY99. In FY94 we will be spending about $140M across these three areas.

The Surveillance and Targeting effort concentrates on developing and integrating technologies and systems yielding wide area and focused surveillance, target detection and recognition, and precision target acquisition capabilities. Technologies being investigated include advanced 3D and polarimetric Synthetic Aperture Radar, Multi-Spectral Electro-Optical/Infrared (EO/IR), foliage penetration technologies, internetted unattended ground sensors and robust automatic target detection and recognition algorithms.

The Intelligence and Planning effort is focusing on the development of technologies and systems to provide a continuous update of enemy force status and provide a commander the means to rapidly nominate targets of interest. Efforts are underway to develop algorithms and software for the automation of intelligence processing and data correlation, automated strike planning and decision aids, automated terrain data generation, and support of distributed dynamic databases enabling theater-wide sharing of information.

The Systems Engineering and Evaluation effort concentrates on developing the WAR BREAKER system architecture, the system integration of all WAR BREAKER elements, and evaluation of the system performance. This is being implemented using simulation, system engineering tools, and the communications infrastructure necessary to conduct rapid prototyping for concept and architecture evaluation. This distributed simulation environment will provide a method of assessing existing, as well as future system capabilities, while allowing early user participation to facilitate eventual technology transition.

ADVANCED SHORT TAKE OFF, VERTICAL LANDING (ASTOVL)

The ARPA ASTOVL/Conventional Take Off and Landing, Common Affordable Lightweight Fighter Program has two primary goals. The first goal is to demonstrate, through actual flight testing of full-scale aircraft, that a common replacement for the F-18, F-16, and AV-8 fighter/attack aircraft is feasible. The Navy and Marine Corps variant of the aircraft will include a propulsive lift system to enable operations from ships and austere airfields.

The Air Force variant will have the same airframe, avionics, and engine as the Naval version but will have the propulsive lift system removed and replaced with additional fuel capacity.

The second major goal of this program is to show that military aircraft can be made more affordable. In this program ARPA intends to explore and demonstrate that innovative design, development, manufacturing, and management techniques can be employed to dramatically reduce the cost of aircraft. Among the processes being explored are the use of inexpensive "soft" throw away tooling and the lean production techniques so successfully employed by the automobile industry. Our emphasis in FY94 is to validate critical technologies, perform manufacturability demonstrations, and mature a demonstrator aircraft design. Our commitment is only to this risk reduction phase. A commitment to a technology demonstrator will not occur until FY95 or 96.

MARITIME SYSTEMS TECHNOLOGY

ARPA's traditional support to the Navy for technologies such as signal processing and sensor development has been broadened to include a larger spectrum of technologies related to Maritime Systems. ARPA is pursuing programs that will help solve technology shortfalls and affordability issues in Maritime applications.

The *Simulation Based Design* program focus is on the potential to reduce the cost of the ship design and acquisition process through the use of simulation in all phases of a ship's life cycle; from initial concept through ship service life. Virtual prototyping will be used to produce designs that are optimized at the system level vice the traditional method of design where optimized subsystems are integrated into a whole. The overriding program goal is to reduce the cost of large, complex vehicles by reducing design time and reducing the number of design changes made from initial concept through manufacture.

Complementing the Simulation Based Design program is the *Ship Systems Automation* program. Automation technologies and distributed virtual environments to promote integrated product and process development will pave the way for quicker, affordable development of ship systems. The actual systems being pursued include both combat and platform systems which show promise in reducing manning requirements while improving ship performance.

CONTINGENCY MISSION TECHNOLOGY PROGRAMS

The emergence of regional conflicts which threaten U.S. vital interests highlight the need for a survivable U.S. force which can deploy quickly any where on the globe. ARPA's contingency mission technology programs are focused on easing deployment burdens and making U.S. forces more survivable. The centerpiece effort is the *Light Contingency Vehicle (LCV)* technology program. LCV is a technology development program for lightweight, highly deployable vehicles which will form the basis for a variety of mission variant (scout or target acquisition roles) platforms in the next century. The LCV will help protect soldiers from the most likely threats by using advanced, light weight, innovative integrated survivability measures such as signature management technologies and an advanced structure which will resist penetration by small arms fire and artillery and mine fragments. The LCV program will also feature active countermeasures to disrupt attacks by rocket propelled grenades and smart weapons.

The *Land Warrior program*, a separate ARPA Contingency Mission technology program, will seek to enhance the effectiveness of dismounted soldiers by applying advanced civilian information and communications technology. Hands-free personal communications ("spin-on" from the commercial personal communications industry) are being coupled with position location and digital assistant technology to enhance the effectiveness of dismounted soldiers for real time mission planning and situational awareness.

NUCLEAR MONITORING PROGRAM

ARPA has the primary responsibility within the Department of Defense for developing the technologies which are needed to verify a nuclear test ban treaty. Completing a verifiable treaty has been a long-standing goal of the U.S. and is supported by this Administration. ARPA is actively pursuing and demonstrating innovative technologies which will be available as the negotiations on such a treaty progress. The ARPA efforts are a key part of the administration's approach to verification of this treaty. The ARPA technologies focus on separation of background noise and detection of small explosions which could be detonated under evasive conditions. For example, our seismic array technologies have set the standard for ultra-sensitivity, and using advanced electronics we have significantly reduced the costs of these systems. The processing of data from our seismic arrays is a complex problem which we are solving by implementing advanced artificial intelligence methodologies and distributed signal processing knowledge acquisition tools.

As a key part of its responsibilities, ARPA is providing the technical support in the development and demonstration of a cooperative international monitoring system being carried out under the auspices of the Conference on Disarmament, Group of Scientific Experts. The Conference has agreed to use the ARPA-developed facilities as the prototype International Data Center in the large-scale experiments which will begin next year. While the key elements of the system have been developed and tested, additional research is required in seismic signal processing methods and signal identification techniques, as well as integration of advanced methods of radionuclide detection.

ARPA is also actively involved in developing new technologies which can contribute in innovative ways to the U.S. counter-proliferation efforts. The ARPA program goal is to provide fundamental technologies that will enhance the global surveillance of the production, testing, and storage of nuclear materials and weapons. A prototype Non-Proliferation Monitoring System is being developed which could be deployed world-wide to collect unique data on nuclear activities. By providing means of detection and verification of proliferation activity, enhanced safeguards may be developed to inhibit the spread of weapons of mass destruction.

Program Accomplishments

ARPA continues to develop and demonstrate this country's most exciting technologies; technologies that serve as the foundation for the future. The following list of recent accomplishments demonstrates ARPA's unsurpassed research and development legacy in both the defense and commercial sectors.

- MIMICs are being used in a large number of DoD systems development programs and have seen record increases in use in the commercial markets, especially in communication and automotive applications. In addition, U.S. world-wide market share is on the rise; many chip sales are being made to Japan and to European nations. Decreasing chip costs, increasing yields, and higher performance MIMICs will continue to increase demand in the world market and positively impact the U.S. market share.

- The SEMATECH program continues to make remarkable strides in advancing the manufacturing technology and the domestic infrastructure to provide U.S. semiconductor companies the capability to be world class suppliers. In the last two years we have, for the first time in over ten years, seen the U.S. semiconductor equipment manufacturers surpass the Japanese in world market share.

- In the last year the High Definition Systems program has seen numerous accomplishments. To cite just a few: Texas Instruments demonstrated the world's most complex micromechanical device using digital micromirror technology to build a 640 x 480 pixel, color, video projection display; the world's first 13-inch diagonal 6 million pixel monochrome active matrix liquid crystal display was demonstrated by Xerox; and the David Sarnoff Research Center/Sun/Texas Instruments team demonstrated video frame rates on a high-resolution (1920 x 1080 pixel) workstation.

- The National Consortium on High Performance Computing was formed by ARPA using precompetitive technology funding. It essentially forms a heterogeneous shared environment between several consortia consisting of government labs, academia, and some of the leading National Science Foundation Centers. This unique project is able to accelerate sharing of technology between the very best centers developed by the Federal program. Within DoD, the HPC Modernization Plan, managed by Director, Defense Research & Engineering (DDR&E), has decided to work with the National Consortium on HPC.

- Last year we had several exceptional and exciting accomplishments under the HPC program. Among the most notable were the demonstration of a 10 billion operation per second class scalable computing system, the prototype demonstration of scalable operating systems, compilers for programming languages with parallel extensions, and scalable libraries. These systems are now being experimentally used throughout the research communities, DoD, NASA, NSF, DOE among others.

- ARPA has invested in technology to support high performance storage systems since the 1980s. We have now seen the productization of ARPA research in this area in the Redundant Arrays of Inexpensive Disks or RAID technology. RAID technology has enabled high performance storage systems in new 2.5" and 1.8" drives. U.S. firms continue to be the world leaders in small disk technology.

- Under our Software Engineering program, we recently released a beta-test version of an open architecture object oriented database which will enable sharing of persistent objects in a distributed network. This technology supports the next generation of distributed systems.

- Our Materials program continues to make great strides in advancing the state-of-the-art. We have demonstrated low-cost particulate reinforced metal matrix composites made with high thermal conductivity and tailorable thermal expansion. Today these materials are being used for thermal management in high power density electronic packages. These same composites also have very high damping capacity which has found application in avionics chassis to reduce vibration.

- In our High Temperature Superconducting Materials program we have demonstrated high temperature superconducting interconnects in packaged microelectronic multi-chip modules (MCMs). The ability of superconductors to carry large currents allows fine-line wiring construction of the package. Cryogenic operation also improves the basic performance at room temperature, with reduced size and power consumption.

- In addition to interconnects, receiver and transmitter technology are benefitting from high temperature superconductor components, such as filters, resonators, delay lines, antenna couplers, which can be fabricated in thin-film circuitry. These are inherently low-loss, low-power, compact devices which improve performance greatly. Receivers are now being constructed which provide much greater discrimination against interfering signals, and can be fabricated on a single wafer.

- Under ARPA's supported MEMS research program microactuator operation in a variety of liquids and flow controllers appropriate for semiconductor process control was developed and demonstrated. Fluid control is a critical component in miniature analytical instruments, aerospace applications, biomedical devices and process control.

- In our Distributed Simulation program we demonstrated interoperation of multiple wargame models on a secure network between Europe, the Continental U.S., and Pacific Commands. This technical accomplishment supported two CinC exercises with participating commands remaining at their home stations. This approach allowed strategic leaders to fashion far more realistic and complex events at significantly less cost. We also successfully demonstrated man-in-the-loop simulation as a tool for acquisition streamlining. The result of this investigation has been a richer understanding of how simulation technology can foster significant changes to the acquisition process in the future.

- In the last year ARPA has realized several major accomplishments in the WAR BREAKER program: we demonstrated the first truly successful target detection algorithms to find targets in foliage; established in the Zealous Pursuit Demonstration the potential for distributed interactive simulation as a systems engineering tool for extremely complex systems; and put in place an operational prototype for automated time critical garrison monitoring at USAEUR.

- Under our maritime systems program we demonstrated at sea a semi-autonomous unmanned underwater vehicle deployed ahead of a ship to detect mines and provide sufficient warning for avoidance. This same unmanned vehicle, in an autonomous mode, demonstrated the ability to search an ocean area and locate randomly placed mines. An acoustic warfare battle management prototype and synthetic ocean prototype was demonstrated in distributed simulation using the Defense Simulation Internet. And, finally we transitioned to the Navy the Hydrodynamic/ Hydroacoustic Technology Center, which was a product of the highly successful Congressionally directed program in advanced submarine technology.

- FY93 marks the end of the ARPA-led joint program with the Army and Marine Corps on Armor Anti-Armor. This successful program has led to a number of transitions of systems and technology to the Services which hold revolutionary promise. Armor weight and space efficiencies twice that of existing deployed technology have been demonstrated. A novel survivability technology has been proven that could protect a medium weight vehicle better than a current heavy tank against some threats. Kinetic energy penetrators that work on new physical principles have been demonstrated at scale, while a rocket boosted tank round with unparalleled accuracy and effectiveness has been designed and components tested. In addition, using computer-aided design, shaped charge warheads have been developed that have the highest tip speed and best performance of any in the world.

Summary

In summary, I hope I have given you an appreciation of our continued commitment to pursue research and development projects that will keep U.S. forces technologically superior, and at the same time support U.S. economic growth. Our investment in dual-use technologies will allow us to leverage limited resources to increase the availability of critical technologies *and* make application of these technologies affordable in commercial and defense markets. As we emphasize dual-use, and implement the Technology Reinvestment Project, we will continue to interact with non-DoD Agencies and increase interactions with commercial industries to develop strategies for integration of military and commercial products and processes. This new emphasis on the critical relationship between economic security and national security presents a major opportunity for ARPA to seek maximum national benefit from our technology investments.

Thank you for the opportunity to be with you today. I am ready to answer any questions you may have.

ARPA

Advanced Research Projects Agency

ARPA PERSPECTIVE

The Advanced Research Projects Agency (ARPA) is the central research and development organization for the Department of Defense (DoD). As such, it manages and directs selected basic and applied research and development projects for DoD, and pursues research and technology where risk and payoff are both very high and where success may provide dramatic advances for traditional military roles and missions and dual-use applications. ARPA's primary responsibility is to help maintain U. S. technological superiority and guard against unforeseen technological advances by potential adversaries.

Consequently, the ARPA mission is to develop imaginative, innovative, and often high risk research ideas offering significant technological impact that will go well beyond the normal evolutionary developmental approaches, and to pursue these ideas through to demonstrations of technical feasibility and development of prototype systems.

As the Department of Defense's central research organization, ARPA focuses on the future, is responsible to the Department as a whole, and reports directly to its executive management within DoD. ARPA is organized and operates in a manner which is unique in the Federal Government. What ARPA does is reach out beyond the traditional federal laboratory structure to deal directly with the nation's industrial and academic communities. In this sense, ARPA plays a special role in the Department's Research & Development (R&D) investment portfolio, acting in large measure as a venture capitalist, but with return on investment measured in terms of products and processes rather than in dollars. In addition to a history of continued accomplishment, the "groups" that ARPA works with are generally recognized as the best in the world.

History

ARPA was created by Public Law 85-325 (DoD Directive 5105.41) in February, 1958. Its creation was directly attributed to the launching of Sputnik and to U. S. realization that the Soviet Union had developed the capacity to rapidly exploit military technology. Additionally, the political and defense communities had recognized the need for a high-level organization within the DoD to formulate and execute R&D projects that would expand the frontiers of technology beyond the immediate and specific requirements of the military services and their laboratories. In pursuit of this mission, ARPA has developed and transferred technology programs encompassing a wide range of scientific disciplines which address the full spectrum of national security needs.

From its inception in 1958 through 1965, ARPA's emphasis centered on "extensive presidential" issues, including space, ballistic missile defense, and nuclear test detection. In 1960, all of its civilian space programs were transferred to the National Aeronautics and Space Administration (NASA) and the military space programs to the individual Services. This allowed ARPA to concentrate its efforts on the DEFENDER (defense against ballistic missiles), VELA (nuclear test detection), and AGILE (counter-insurgency R&D) programs, and to begin work on computer processing, behavioral sciences, and materials sciences. The DEFENDER and AGILE programs formed the foundation of ARPA sensor and surveillance and directed energy R&D, particularly in the study of radars, infrared sensing, and x-ray/gamma ray detection.

In the late 1960s with the transfer of these mature programs to the Services, ARPA redefined its role and concentrated on a diverse set of relatively small, essentially exploratory research programs. The early seventies emphasized directed energy programs, information processing, and tactical technologies. In the area of information processing, ARPA made great strides through the evolution of ARPANET (telecommunications network and precursor to the Defense Data Network) and research in the artificial intelligence (AI) fields of speech recognition and signal processing.

From 1976 through 1981, ARPA's major thrusts were dominated by: follow-on forces attack with stand-off weapons and associated Command, Control, and Communications; tactical armor and anti-armor programs; infrared sensing for space-based surveillance; high-energy laser technology for space-based missile defense; anti-submarine warfare; advanced cruise missiles; advanced aircraft; defense applications of advanced computing; and STEALTH technology. These large-scale technology demonstration programs were joined by integrated circuit research (resulting in sub-micron electronic technology and electron devices that evolved into the Very Large Scale Integration (VLSI) program) and the Congressionally-mandated charged particle beam program.

During the 1980s, the attention of the Agency was centered on information processing and aircraft-related programs, including the National Aerospace Plane (NASP or hypersonic research program). The Strategic Computing Program enabled ARPA to exploit advanced processing and networking technologies and to rebuild and to rebuild relationships with universities after the Vietnam War. In addition, ARPA began to pursue new concepts for satellites (LIGHTSAT) and new directed programs regarding defense manufacturing, submarine technology, and armor/anti-armor.

Now, in the 1990s, ARPA is reenergized to develop revolutionary new technologies, both in products and processes, that will form the basis for new defense and civilian capabilities in the next century. Starting with basic technologies such as electronics and materials processing, ARPA will create new computers, sensors, and communications devices, develop new ways of manufacturing and apply these creations using advanced technology demonstrators in operational environment, and, thus, get involved in the whole process from design to logistics.

Operations

ARPA's approach is to ensure funding at a level that does not compromise the attainment of the technical goals of the project. This approach has been successful because ARPA accepts the risk associated with high technology research and selectively extends the most promising projects into modest-scale demonstrations for evaluation. During the planning and conduct of these demonstrations, ARPA seeks increased participation by the military and intelligence departments in formulating the objectives and scenarios consistent with the criteria for evaluating and selecting technology. ARPA executes its programs through the military departments and other U. S. Government agencies

— called Agents — and, where appropriate, demonstrates technical feasibility and defense utility in joint experiments and demonstrations with the Agents. This joint participation facilitates the subsequent transition of selected technology programs to the services for engineering development.

In 1987, ARPA established an in-house contracting capability; however, ARPA still does most of its work through its Agents. These selected Agents perform functions such as award and administration of contracts, oversight of technical efforts, and various support functions. In addition, they may actively participate in the development of technology. The Agents' contracting officers enforce compliance with the contract, the Federal Acquisition Regulations (FAR), the Defense Supplement to the FAR (DFARS), and other applicable governing statutes and regulations.

ORGANIZATION

ARPA is a separate agency under the Office of the Secretary of Defense, reporting to the Director of Defense Research and Engineering.

Within ARPA, there are two levels of activity: technical program management and internal support functions. ARPA has four support offices: Contracts Management, Comptroller, Administration and Small Business, and Security and Intelligence. In addition, a General Counsel and Special Technical Assistants provide support to ARPA's Director in planning, directing, and managing the Agency and its advanced research activities. The other level of activity focuses on the technical offices, which will be discussed in later sections.

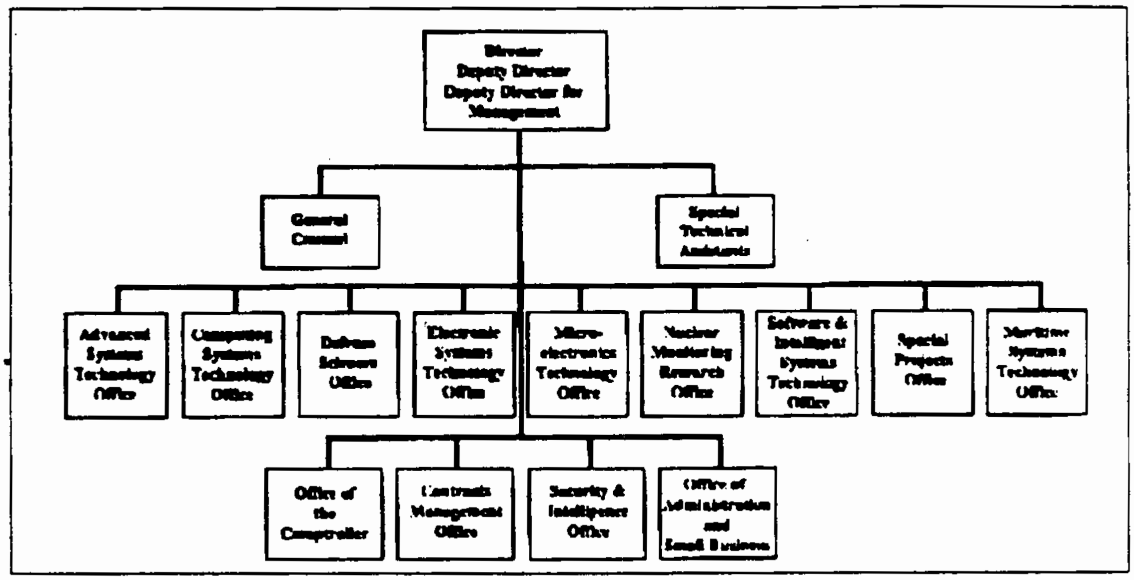
The Contracts Management Office (CMO) is responsible for planning, negotiating, awarding, and administering the contracts, grants, cooperative agreements, and other transactions for the early stages of prototyping projects and, on a limited basis, R&D and support projects as approved by the ARPA Director.

The Office of the Comptroller (COMP) is the nucleus of "corporate" fiscal activities and bears the responsibility for preparation and submission of the consolidated annual Agency budget, as well as general management of the planning, programming and budgeting system process.

COMP develops and implements the proper procedures and controls for program execution; maintains adequate program accountability documentation; provides for liaison with the General Accounting Office and the DoD Inspector General on audit activities; and serves as the Congressional focal point for the Agency. COMP also maintains a management information system (MIS) to support ARPA requirements for accurate and timely fiscal, contractual, and programmatic information services.

The Office of Administration and Small Business (OASB) plans, develops, and coordinates the administrative service functions of the Agency. This office supervises records management, personnel functions, technical information programs, travel services, correspondence and classified document control, and supply functions; and serves as the liaison between the technical offices and the ARPA agents. OASB also implements the Small and Disadvantaged Business Utilization Program and serves as the Small Business Innovation Research (SBIR) Program administrator.

The Security and Intelligence Office (S&IO) directs, plans and executes the Information, Personnel, Industrial and Physical security programs at ARPA and at specified contractor sites. This includes Sensitive Compartmented Information (SCI); Special Access Programs (SAP); foreign disclosure of



ARPA Organizational Chart

classified information; evaluation, control and dissemination of technical information; declassification management activities; security classification management program; Communication Security Program (COMSEC); and the ARPA Potential Contractor Program (PCP). S&IO also formulates and implements security policy and procedures at ARPA and represents ARPA on security matters with external organizations.

The General Counsel (GC) supervises the Freedom of Information and Privacy Act programs within the Agency; assists in the negotiation of Cooperative Agreements; monitors the Ethics and Procurement Integrity programs; and provides legal advice and counsel to the Agency management.

ARPA's technical program offices manage the R&D activities. They support not only broad, basic technology programs, but also small, discretionary projects that prepare the way for major programs to demonstrate future defense systems.

Thus, ARPA research and development projects encompass the widest possible definition of technology. For example, a small scale project might be energy dense fuel cells, artificial neural network research, or new p-n junction techniques for chips; at mid-scale it might be new low frequency acoustic devices, anti-armor appliques, or a dynamic analysis and replanning tool; and, in large scale, a manned aircraft exploring the limits of maneuverability, a seismic array, or high performance computing networks and internets. Sensors and communications systems which exploit every new law of physics and each new advance in mathematics are continually investigated and enhanced. The potential to increase the value of computers in military development and operations is continuously examined for every advantage, such a examinations extending even to a simulation testbed of all engaged forces on the last day of Operation Desert Storm.

Research and development activities pursued by ARPA are funded using several Program Element

(PE) types of funds. These fund types, generally called Research, Development, Test, and Evaluation (RDT&E) funds, allow ARPA to perform basic scientific research and limited system acquisition activities.

Program Element 6.1 (Research)

PE 6.1 funds are established to provide for all efforts of scientific study and experimentation directed toward increasing knowledge and understanding in those fields of the physical, engineering, environmental, and life sciences related to long-term national security needs. It provides for the fundamental knowledge required for the solution of military problems. It forms a part of the base for: 1) subsequent exploratory and advanced developments in Defense-related technologies, and 2) new and improved military functional capabilities in areas such as computing, communications, control, navigation, energy conversion, materials and structures, and personnel support.

Program Element 6.2 (Exploratory Development)

PE 6.2 funds are established to provide for all efforts directed toward the solution of specific military problems, short of major development projects. This type of effort may vary from fairly fundamental applied research to sophisticated "breadboard" hardware, study, programming, and planning activities. The dominant characteristic of this fund category is that the effort must be directed toward specific military problem areas with a view toward developing and evaluating the feasibility and practicality of proposed solutions and determining their parameters.

Program Element 6.3 (Advanced Development)

PE 6.3 funds are established to provide for all efforts directed toward projects that have evolved into the development of hardware or software for testing. The prime result of this type of effort is proof of design concept rather than the development of hardware for specific Service use. Projects funded in this category have a potential military application and can be included in the concept exploration, demonstration, and validation phases of a system life-cycle. ARPA PE 6.3 efforts are normally further defined as 6.3A programs, which conduct advanced development through the prototyping stage. Further development in preparation for engineering development is defined as 6.3B and usually conducted by an acquisition element of one of the Services.

Advanced Systems Technology Office

The **Advanced Systems Technology Office (ASTO)** engages in advanced military research projects which have significant impact on the defense posture of the country and the country's industrial base. ASTO is committed to providing superior U. S. military systems in the areas of aeronautics, space, precision strike, counter drugs, advanced distributed and acquisition simulation, advanced land vehicles, armor/anti-armor technologies, and survivability systems. The key to ASTO's success is the identification and development of affordable systems and subsystems exhibiting significant increases in performance and reliability. Promising technologies are developed, integrated and demonstrated to sufficient levels of maturity to ensure adequate assessment of their military effectiveness and to enable insertion or transfer to an appropriate Service or Agency.

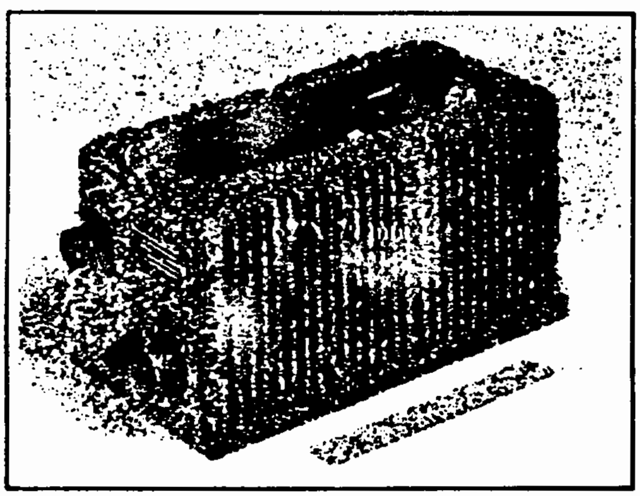
AERONAUTICS INITIATIVES

Aeronautics research initiatives are intended to enhance all aspects of the airborne system, including airframe, avionics, and mission payloads. The aeronautics programs stress concept demonstration of technologies that apply to both manned and unmanned aircraft, as well as, fixed and rotary wing systems. Research areas include advanced aerodynamics, structures, and propulsion technologies integrated into unique airborne platforms; precision low-cost

ARPA

X-31

navigation and guidance subsystems; advanced communications; wide area surveillance sensors and processing; and terrain mapping. Representative aeronautics programs are the Enhanced Fighter Maneuverability aircraft (X-31), the Global Positioning Systems (GPS) Guidance Package (GGP), and the Advanced Short Takeoff and Vertical Landing (ASTOVL) Program. The X-31 experimental aircraft is extending the classical stall boundaries and leading the way to a new class of highly agile fighter aircraft with unique maneuvering capability which will increase close-in aerial combat exchange ratios. Affordable, precision vehicle guidance, navigation, and control (GN&C) is the goal of the GGP Program. This effort is developing GN&C subsystems that are small (< 120 in^3), lightweight (< 10 lbs), and low-cost (<$15k/unit in limited production). The ASTOVL program is developing concepts leading to the flight test of an advanced technology demonstrator aircraft emphasizing the employment of design principles and processes focused on overall system affordability. ASTO is currently exploring a demonstration phase that would



GPS Guidance Package

validate newly defined engineering, design and manufacturing techniques to ensure both an affordable technology demonstration system and an affordable operational system.

ADVANCED SPACE TECHNOLOGY

MICROSATS

Assured military use of space is the theme of ASTO's Advanced Space Technology Program (ASTP). The focus of this program is to apply and rapidly transfer advanced technologies and cost reduction techniques to all elements of space systems development. ASTP is developing and demonstrating survivable space launch capability through two mobile launchers: the air-launched "Pegasus" space booster, which is launched from a B-52, and the ground transportable "Taurus" Standard Small Launch Vehicle (SSLV). Two early developments intended to demonstrate the utility of dedicated space assets are the MACSATS and MICROSATS. These small UHF communications satellites have been placed in orbit to commence a series of joint demonstrations with tactical users from all the services. The MACSATS found immediate utility when they were pressed into service to provide long-haul communications for Marine logistics units deployed to the Middle East during Operation Desert Storm. Much of the ASTP investment relates to obtaining a more capable payload in a smaller package. Additional efforts are being pursued in a variety of space technologies involving communications, visible and infrared optics, advanced microelectronics and microwave integrated circuits, advanced computer processors, and techniques that will improve the ability of satellites to operate autonomously and thus reduce operations expenses.

High Speed Smart Weapons Embedded Processor (ALADDIN)

TIME CRITICAL TARGETS

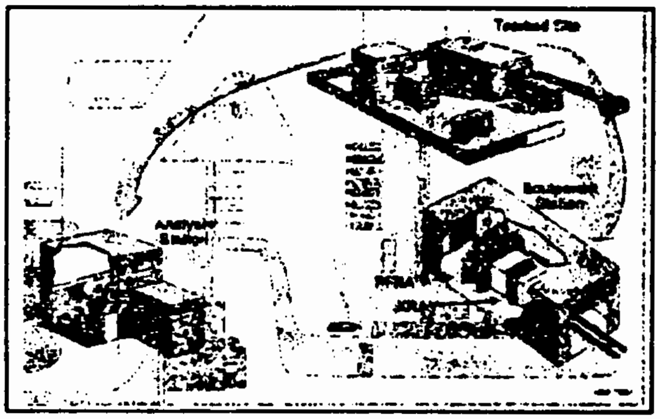
Precision strike against time critical targets (TCTs), both fixed and mobile, is the goal of ASTO's WAR BREAKER Program. This program focuses on advanced technology demonstrations to support an integrated, end-to-end system which will revolutionize battle management and enable world-wide, accurate, synchronized prosecution of TCTs. WAR BREAKER is comprised of three major thrust areas. The Intelligence and Planning thrust develops technology and systems to support the rapid decision making and command and control necessary to issue target nominations and tasking within the TCTs cycle time. The Surveillance and Targeting thrust develops technologies and systems to support the detection, classification and localization of threat targets, in conditions ranging from fully exposed to deeply hidden, using a layered system of sensors. The System Engineering and Evaluation thrust provides advanced tools to bring a systems engineering discipline to the development of all technologies within the program to insure focus of the common WAR BREAKER objectives. Key to this effort is the development of a distributed simulation of the full WAR BREAKER concept that will be employed as a systems engineering tool to establish technical requirements and conduct system-level trades as well as host demonstrations of technologies and systems developed within the program.

Distributed Simulation Workstation

DISTRIBUTED SIMULATION

Seamless war-fighting simulation is the goal of ASTO's Advanced Distributed Simulation Programs. Advanced technology is being developed and applied to support interoperability of war-fighting simulations spanning echelons, modes of simulation, and Services. This capability will enable more affordable and realistic training, operational or strategic level evaluation of new systems, and more efficient and effective operational planning and battle management within a joint warfighting environment.

In some cases, such as aviation acquisition simulation, this means developing high speed interfaces among existing systems; in other cases, intelligent gateways are needed to translate between dissimilar representations of the same forces. In all cases, the goal is to enable embedded capabilities for interoperable simulations within next generation C^3I systems and to realize the synergy and cost savings possible by combining C^3I and simulation.



Drug Detection Prototype Testbed

COUNTER DRUGS

The ASTO counter drug program provides the focus for the DoD prototype technology in contraband detection and cargo container inspection. Technologies are being developed to improve dramatically the capabilities of the various law enforcement and military forces in attacking the flow of illegal drugs in the source countries, in transit to the United States, and in distribution in the United States. Technology efforts are underway in non-intrusive inspection, wide area surveillance, surveillance and tracking, data fusion and correlation, and C^3. Testbeds will be utilized to field evaluate the technology developments.

ADVANCED LAND SYSTEMS DIVISION

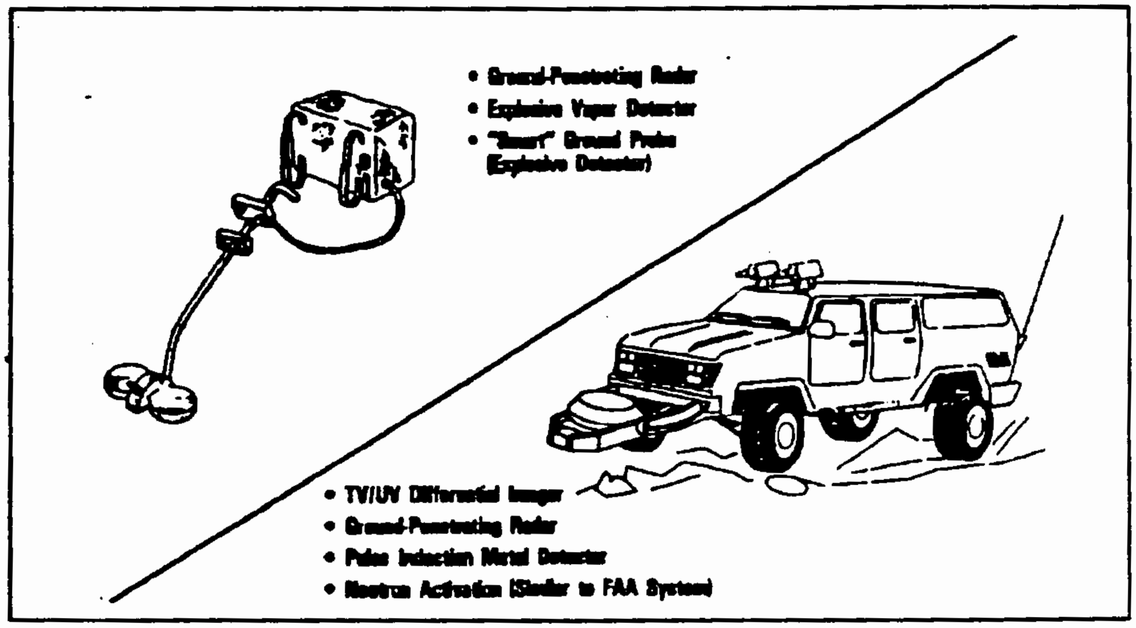
ASTO's Advanced Land Systems Division applies advanced technology to achieve revolutionary changes in tomorrow's surface warfare capabilities. Principal research involves advanced land vehicles, armor/anti-armor technologies, survivability systems, and the application of simulation to developing and demonstrating advanced battlefield technology. The Advanced Land Systems Division expands and exploits the technical base to achieve breakthroughs in performance and operational capability, while maintaining affordability. The goal is to multiply the survivability, effectiveness, deployability, and affordability of advanced land systems through high risk/high payoff technology pursuits in order to maintain U. S. military superiority, as force structure and budgets shrink, while worldwide commitments and vital national interests remain.

Future combat vehicles will require superior survivability and deployability, powerful weapons systems, and high technology crew augmentation techniques to reduce crew size and improve performance. Advanced Land Systems is developing both components and systems for future vehicles and demonstrating and evaluating them through advanced simulation and testing.

EXTENDED RANGE COMBAT

Future land military operations will need to take place from standoff ranges in order to significantly increase force survivability while radically reducing requirements for forward basing and transportation. Land forces traditionally suffer the highest casualties in military conflicts. If an overmatch in standoff capability can be achieved for close combat forces similar to what has been done for modern U. S. aircraft, a significant number of casualties may be reduced in future conflict, and a decisive combat advantage can be provided. One example of this research is X-Rod, a rocket-boosted and sensor-guided tank round that is supported by the Balanced Technology Initiative and managed by ARPA. When completed, X-Rod should outrange all other tank ammunition, permitting U. S. armored forces to dominate direct fire battles in the future.

Another example of limiting risk to U. S. forces is through the development of smart mines and advanced robotic countermine systems. Smart machines can "go in harm's way," are easily deployable, and provide extremely cost-effective defenses. High-technology countermine systems use earth penetrating radar to identify suspect objects underground that may then be probed by chemical vapor sensors that can detect even minute



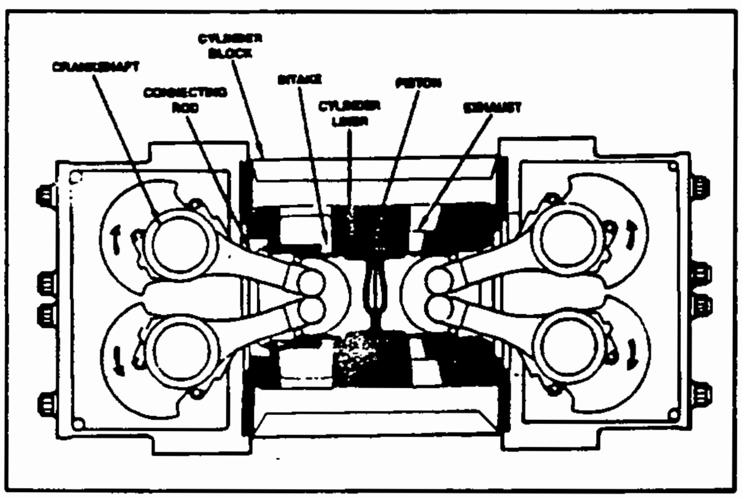
Countermine Mine Detection Testbed Concepts

quantities of explosives. Alternatively, minefields may be "painted" with high energy systems in order to stimulate detectable particle emissions.

Advanced Land Systems is also exploring new ways to identify friends and foes at long ranges so that fratricide can be avoided, while enabling weapons to be used at optimum standoff.

SURVIVABILITY SYSTEMS

In traditional military technology, increased vehicle survivability virtually equates to additional armor weight and volume. Advanced Land Systems is working on advanced materials and structures to radically reduce armor weight and bulk, but still remain affordab!e. Major thrusts in advanced survivability are based on different physical principles than traditional techniques, which sought mainly to maximize hardness, toughness, and mass. These alternative means add entirely new factors to the survivability equation and provide unique new operational capabilities through increased flexibility and deployability.



TRC Monocylinder Test Rig Assembly

ADVANCED VEHICLE TECHNOLOGY

In advanced propulsion, Advanced Land Systems is developing a revolutionary turbocharged rotary compound (TRC) diesel engine that works at high pressures and efficiencies with major decreases in weight and volume. It has significantly fewer moving parts than traditional engine designs and works on a wide variety of fuels. The high-efficiency TRC engine is scalable; it should be applicable to many military uses, from unmanned aerial vehicles to tanks. It should also be directly applicable to civilian markets once its revolutionary concept has been demonstrated. A prototype TRC engine is currently being constructed for use in an advanced land combat vehicle.

ACQUISITION SIMULATION

Advanced Land Systems is also addressing several important problems that currently restrict the application of new technology in military systems generally. Advanced man-in-the-loop and physics simulations are keys to reducing costs, increasing performance, and slashing acquisition time so that the most promising new technologies may be fielded more quickly. Advanced Land Systems is sponsoring acquisition simulation to accelerate development schedules. New technologies and operational concepts can be screened before development in order to select the most promising approaches to develop. Advanced Land Systems is also enhancing physical simulation technology in order to increase the fidelity and credibility of advanced simulation. Finally, it is improving material models and applying parallel processing to modern physics simulations in order to radically reduce run times so that advanced simulation becomes more available and useful to armor and munition designers, reducing the amount of experimentation required for development of new systems.

Computing Systems Technology Office

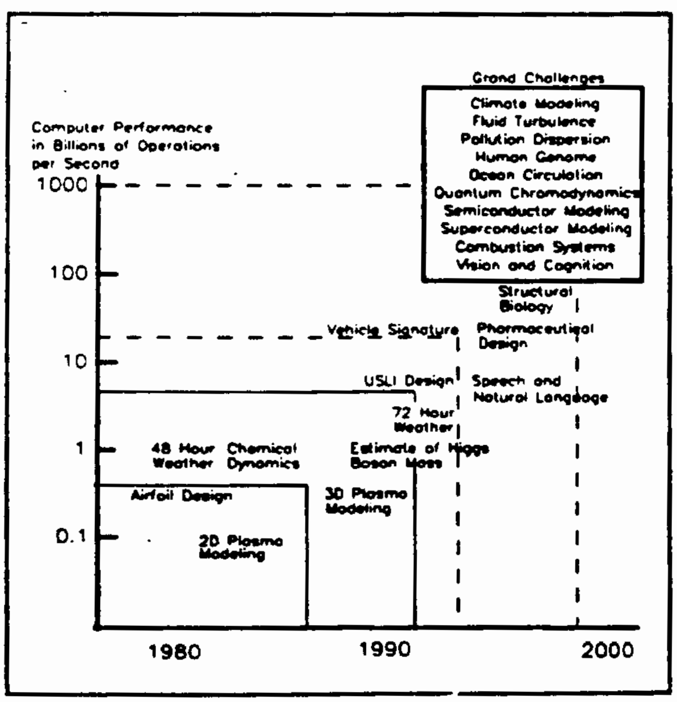
The **Computing Systems Technology Office (CSTO)** is responsible for advancing the frontier of computing system technology to insure that DoD has the technologies needed for future mission capabilities. CSTO builds upon the advanced computing systems technologies developed by ARPA programs such as timesharing, graphics, networking, personal computing, and high performance computing. These technologies are developed with the associated software and system design tools to enable their effective use. These advances have enabled dramatically new Defense mission capabilities and depend upon underlying microelectronics, photonics, and packaging technologies.

CSTO is responsible for leading DoD participation in the Presidential Initiative in High Performance Computing and Communication (HPCC) that was announced in FY 1992. ARPA programs have produced both the computing and networking foundation for the Federal HPCC Program, including the first generation of scalable parallel computing systems and large scale computer networks, and the associated system software and supporting technologies. As new technologies are developed, they are experimentally applied to a wide variety of problems in cooperation with the ARPA offices, Defense organizations, and Federal agencies.

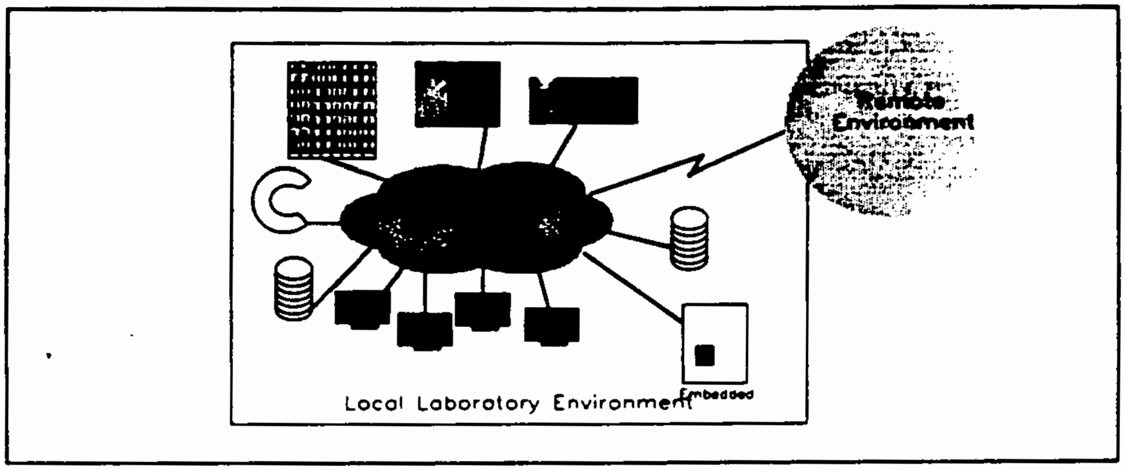
The ARPA High Performance Computing (HPC) Program for the 1990s builds upon the ARPA Strategic Computing Program (SCP) of the 1980s, and includes the advanced technologies needed for High Performance Computing Systems (HPCS), Advanced Software Technology and Algorithms (ASTA), High Performance Networking, and the associated Basic Research.

HIGH PERFORMANCE COMPUTING

Performance Requirements for Grand Challenge Problems



HPCS will be produced through the progressive development of the concepts and components for future generations, the system design tools needed for their effective use, the development of advanced prototype systems on a cost-shared basis with industry, and the evaluation of early systems in cooperation with potential users in realistic system contexts. Systems capable of sustaining 100 billion operations per second (gigaops) for large problems will be available for deployment during 1993 and systems capable of trillions of operations per second (tera-ops) will be available by 1996.



Scalable, Modular, Heterogeneous Systems

SOFTWARE TECHNOLOGY & ALGORITHMS

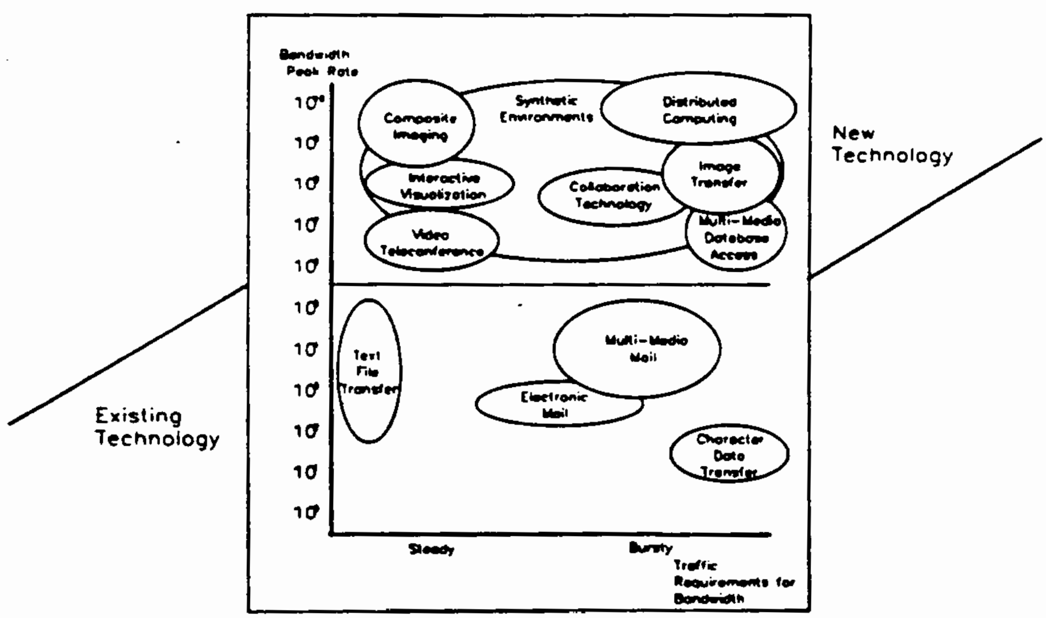
In ASTA, projects will produce the scalable and portable libraries, programming languages and environments, and design, analysis, and visualization tools for the new HPC Systems. This will enable the effective use of scalable parallel and distributed heterogeneous systems in workstation/server configurations including compatible embedded systems and accelerators.

HIGH PERFORMANCE NETWORKING

For High Performance Networking, new protocols, switching, and transmission technologies, and a wide range of advanced networking services will be developed to enable billion bit per second (gigabits) data rates to end users by 1996.

The Basic Research projects focus on fundamental scientific issues at the limitations of these advanced technologies to identify the potential alternatives needed to sustain their continued and balanced advance. Provision is made for smaller individual investigator projects in addition to the large systems projects.

Applications by Bandwidth and Traffic Characteristics



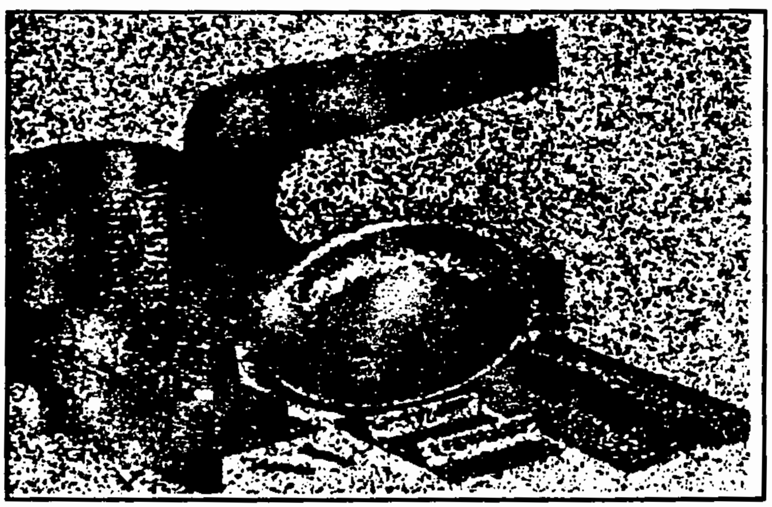
DEFENSE SCIENCES OFFICE

The **Defense Sciences Office** (DSO) is chartered to identify the newest and most important ideas within the basic science and engineering research community and develop from them new DoD capability. Drawing heavily from industry, university, and government laboratories as well as small business and individuals, DSO R&D activities span from idea conception to actual production. DSO exploits compelling opportunities in the development of new devices, such as advanced batteries and superconducting components; new technologies, such as vacuum microelectronics and micro-lasers; new manufacturing techniques, such as intelligent processing and the production of metal and ceramic matrix composites; and advanced methods of design, such as advanced computational mathematics and concurrent engineering.

DESIGN METHODS

Little is certain as to the needs of the post-Cold War military; however, one thing is clear: the expense of future platforms and weapon systems must be reduced. Among the things that must be accomplished is the institution of practices in engineering and design throughout the acquisition process which result in the production of the right product made right the first time. The traditional design-build-fix mentality must be cast aside. This has become a major theme of DSO and underlies each and every program. At the core of this activity is the opportunity of exploiting the most recent breakthroughs in information technology, rapid fabrication, and freeform fabrication into a coherent applied thrust focused on both the near-term and long-term acquisition needs of the DoD. The ARPA Initiative in Concurrent Engineering (DICE) is one example as it is concerned with the development of technologies which will enable collaborative design among teams that are widely dispersed both in location and technical discipline.

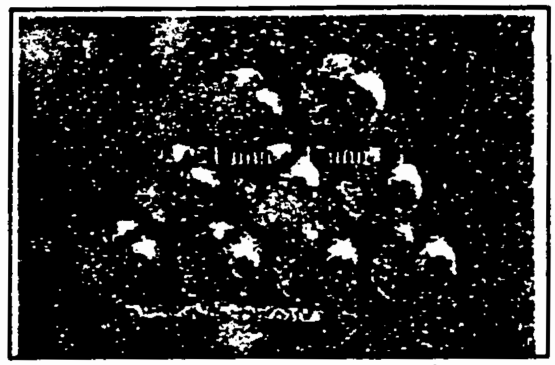
Strong Stiff Fiber



Reinforced Composites

MANUFACTURING TECHNIQUES

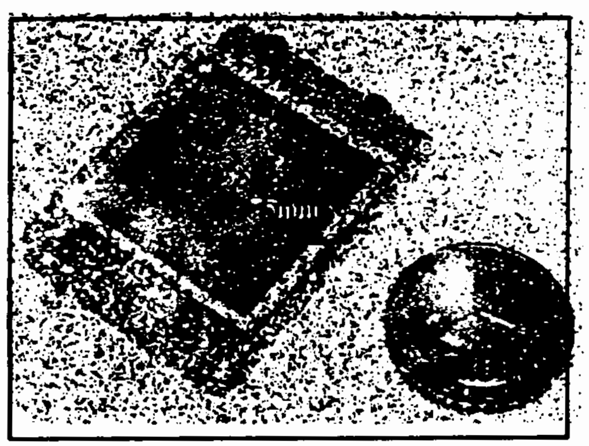
In line with this focus are other DSO efforts in the development of methods for processing advanced materials which increase the flexibility and decrease the cost of weapon systems. Of particular importance are ceramic-matrix composites, which were used to demonstrate applique armor during Operation Desert Storm, and metal-matrix composites, which promise the properties at high temperature that are required for the next generation of advanced jet engines. Not too far in the future, a DSO program in the fabrication of large diamond films is expected to provide a new class of electronic substrate. In order for these materials to become practical, new methods for manufacturing at high quality and at high yield must be developed. Great promise lies in an approach in which each stage of the manufacturing process is richly monitored and controlled (in a closed loop) to conform to an accurate mathematical model. When compared to traditional "recipe" methods, these Intelligent Processing Methods (IPM) provide dramatic increases in uniformity and yield. In addition, they make feasible the production of some materials that cannot be produced any other way.



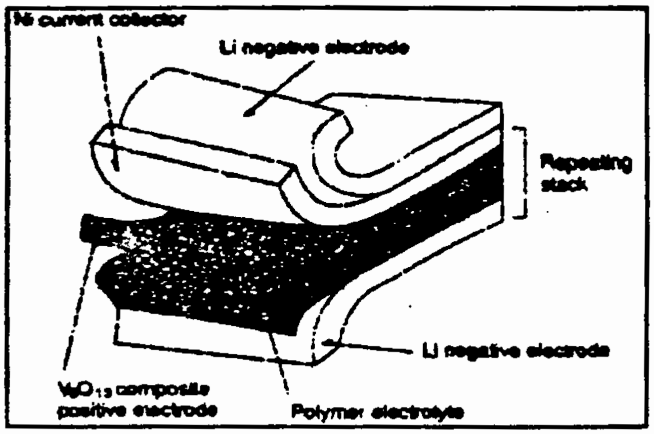
Sapphire Domes

ADVANCED ELECTRONIC DEVICES

A primary mission of DSO is to rapidly exploit scientific breakthroughs to enhance military capability. An example of this mission is the area of high temperature superconductivity. These new materials enable electronic components with dramatically increased performance. Similarly, the discovery of a new class of highly conducting polymers makes possible rechargeable batteries with several times the energy density of the best current technology.



Tiny, 28 Nsec Delay Line Made Using High Temperature Superconductor Material



Improving the Energy Density
(of Rechargeable Batteries)
Via Highly Conducting Polymers

ELECTRONIC TECHNOLOGIES

Advances in vacuum micro-electronics and micro-lasers enable the insertion of much smaller, cheaper, and increasingly reliable and efficient RF, IR, and optical systems for DoD needs. Final examples include the invention of new micro-biologic sensors for the detection of threatening chemical and biological warfare agents and the discovery of new, highly efficient algorithms which enable the computational simulation of complex systems for the first time.

These four programs and their management are typical of a process in which DSO guides and nurtures the development activity from the original discovery to the insertion of a prototype component into actual military hardware.

DSO's role is unique within ARPA and within the DoD both in its focus on the applied physical sciences and in its ability to exploit a good, basic idea all the way to a product.

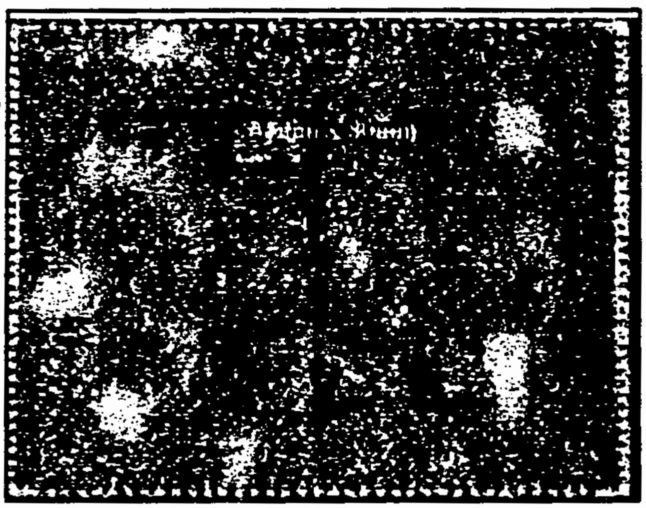
ELECTRONIC SYSTEMS TECHNOLOGY OFFICE

The **Electronic Systems Technology Office (ESTO)** focuses on electronic systems technology to produce information supremacy in forward-deployed military systems. ESTO's scope includes: sensors, sources, actuators, and displays; signal-processing; and packaging and interconnect systems.

The major ESTO programs are High Definition Systems (HDS), including high definition displays; Application Specific Electronic Modules (ASEM); and the Microwave and Millimeter Wave Monolithic Integrated Circuit (MIMIC) program. ESTO also has programs in the areas of embedded microsystems (advanced signal processing with special emphasis on techniques that minimize energy dissipation), microsensors and actuators, and conformal electronics (packaging technologies for shape-constrained environments, with the long-term goal of being able to intermingle computation, sensors and actuators, and mechanical structure). Manufacturing and affordability concerns pervade ESTO programs.

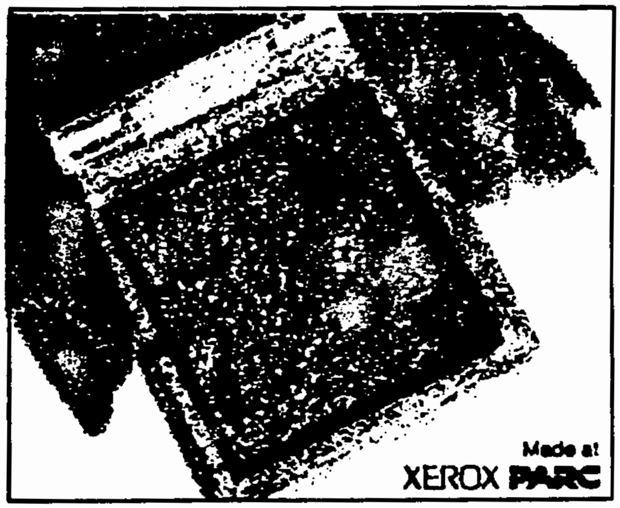
HIGH DEFINITION SYSTEMS

The High Definition System (HDS) program encompasses the development of a wide variety of technologies associated with high definition systems including displays, display processors, sensors, software, high density storage, packaging, and manufacturing. The overall goal of the program is to achieve a design and manufacturing capability that can provide for and sustain the affordable use of high definition technology in DoD systems in the late 1990s and beyond. High definition systems are the integrated hardware, software, and networks that enhance the data that is used to make decisions in time-critical military environments. Display efforts include improved cathode ray tubes; flat panel displays using active matrix liquid crystals, electroluminescence, plasma, and cold cathode technologies; projection displays using deformable mirrors, liquid crystals, and laser projection, as well as efforts in manufacturing and enabling technologies. Display processor efforts include development of high-speed video processor modules, workstations, high-bandwidth busses, image transmission over packet networks, and a high-bandwidth, digital-compressed video and data system for education and training. Various compression algorithms including interframe compression based on the adaptive block size discrete cosine transform, MIT-CC adaptive subband video compression, and compression techniques involving fractal image coding are being investigated. New graphics tools, graphics



ARPA Sponsored TI/GE Advanced High-Density Interconnect (HDI) Chip-Packaging Technology standards, and user interfaces are being developed.

Research on virtual/augmented environments and scientific visualization is being conducted. New magnetic tape and recording heads for high density storage devices are being developed. An image sensor based upon acoustic charge transport devices is being developed for use in an all digital camera. Finally, a variety of military applications are being targeted to serve as demonstration vehicles for high definition system technologies.



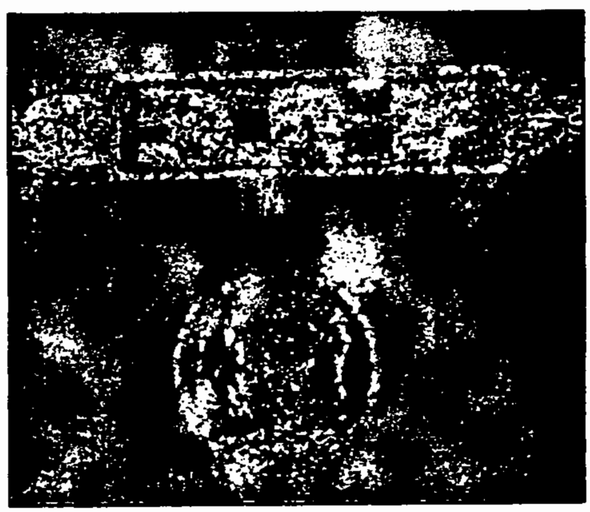
Active Matrix Liquid Crystal Projection Cell

APPLICATION SPECIFIC ELECTRONIC MODULE

The Application Specific Electronic Module (ASEM) program involves several offices at ARPA. The program will ensure the existence of an end-to-end capability to rapidly acquire electronic modules and subsystems. In addition to the key capabilities of design, manufacturing, and test, the program also addresses the technologies and infrastructure needed for rapid acquisition, such as brokering. The program integrates domain-specific building blocks such as physical packaging technology, packaging computer aided design (CAD), flexible manufacturing processes and equipment, computer-integrated manufacturing

(CIM), intelligent test, and design, interface, and test standards. The physical packaging portion of the program is developing Multi-Chip Module (MCM) technology for digital systems operating at clock rates from 100 MHz to several GHz. With MCMs, bare chips are interconnected via a common substrate instead of packaging each chip individually in single chip carriers. This approach offers increased density and reduction in electrical parasitics. For system clock rates exceeding 50 MHz, conventional chip-to-chip interconnects can significantly negate system performance improvements derivable from advances in devices and circuits. In addition, MCM technology offers the potential of 10-100X improvements in density, as much as 2-3X reduction in power, 10X improvement in reliability, and reduced cost. Applications are tri-service, including, for example, satellite electronics, advanced work station, smart munitions, avionics, man portable devices, and autonomous underwater vehicles. The present physical packaging program has two main thrusts: establishment of merchant foundries capable of low volume (several hundred per month) production of MCMs for 100 MHz and greater operation and demonstrations in applications, such as parallel processors for the High Performance Computing and Communications Program, and development of materials, processing testing, and simulation for 3-D and GHz clock-rate MCMs. Technologies include diamond-based 3-D MCM structures, optical testing, flip-chip conducting adhesive chip attachment, high-speed membrane probe testing, ferroelectric materials for decoupling capacitors, very low dielectric constant materials for GHz signal planes, full wave electromagnetic simulation, laser writing for MCM rework and prototyping, and optical MCM-MCM interconnect.

MICROWAVE & MILLIMETER WAVE MONOLITHIC INTEGRATED CIRCUITS



Raytheon/TI Electronic Warfare Phased Array Module Produced Under ARPA MIMIC Program

Microwave and Millimeter Wave Monolithic Integrated Circuits (MIMICs) are solid state circuits used to receive, transmit, and process microwave signals. They are the sensors, or "eyes and ears," of any equipment operating at the microwave (and millimeter wave) frequencies. MIMICs can either amplify received signals and send them to the digital processing portion of a system, or they can transform digital information into microwave signals to be transmitted by an antenna. The overall goal of the MIMIC program is to provide affordable, reproducible, and reliable "front end" components and subsystems for DoD systems such as smart weapons, radar, communications, and electronic warfare. During the first three years of hardware development, which began in May 1988, improved gallium arsenide material was developed and made available. Computer aided design, fabrication, and test capabilities were substantially extended. Integrated, high-throughput manufacturing facilities were installed. Fabrication recipes were refined and demonstrated to result in high-yield MIMIC chips. New techniques have drastically reduced the cost of packaging and testing MIMIC chips. Over 80 MIMIC chip types were fabricated and demonstrated in sixteen MIMIC brassboards. The goal of the next three year hardware development portion of the program is to complete the development of fully integrated design, manufacturing, and testing capabilities that can produce, inexpensively and rapidly, the full range of advanced microwave/millimeter wave circuits required for systems. In Operation Desert Shield, MIMICs were used in both the HARM missile and in LANTIRN's terrain following radar system. Other systems, such as the ALQ-136, will retrofit MIMIC hardware into existing modules and subsystems to reduce costs, increase unit-to-unit reproducibility, achieve higher reliability, and improve component performance. Most importantly, MIMIC is an enabling technology for many systems; without MIMIC, it will be impossible to field these systems at an affordable cost. Some of the system areas that MIMIC is favorably impacting are: smart weapons, radars, electronic warfare systems and communication systems. The MIMIC program represents a national asset which is providing an excellent return on the investment made by the Department of Defense.

INFORMATION TECHNOLOGY SYSTEMS AND PROCESSES

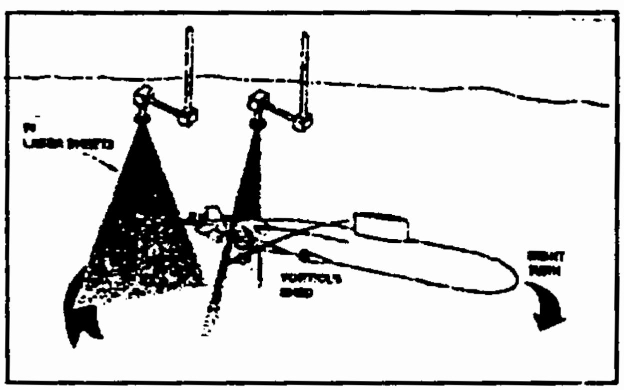
ESTO is a contributor to a ARPA-wide vision of providing information technology support to mobile systems and individuals not served by conventional computer terminals and network ports. These systems are envisioned to provide people on the move with information such as maps, instruction manuals, medical support, personal communication, rehearsal/ training support, and decision and annotation tools. ESTO technologies that support this vision include novel man-machine interfaces (including head-mounted systems, minimal-energy signal processing, conformal electronics, microsensors and actuators, and high-density packaging.

ESTO pursues fundamental change by investing across the full maturity range from basic research in key sciences and technologies to selected technology insertions into existing military platforms. ESTO seeks both technology products (such as displays, packages, actuators, and analog integrated circuits) and processes (including issues such as manufacturing, prototyping, infrastructure, and computer- aided design).

Maritime Systems Technology Office

The Maritime Systems Technology Office (MSTO) pursues a wide range of technologies to maintain U. S. undersea superiority as the world's power bases and threats evolve. Activities being supported focus on stealth, counterstealth, and automation.

These efforts are integrated into three major programs: the Submarine Technology Program, the Unmanned Undersea Vehicles Program, and the Anti-Submarine Warfare Program.



Submarine Technology Program

SUBMARINE TECHNOLOGY

The Submarine Technology Program identifies and develops revolutionary technologies that will provide innovative design options to dramatically improve U. S. submarine performance. The program emphasis is on hull, mechanical, and electrical system applications. Technologies include, but are not necessarily limited to, advanced hydrodynamic/ hydroacoustic design tools, advanced composite materials, new propulsion subsystems, improving submarine stealth by reducing acoustic target strength, and automating signature management. As these technologies mature, the program will transition them to the Navy for use in existing and future submarine designs. Examples of technologies approaching transition are the non-penetrating periscope, an advanced propulsor, and an advanced energy storage system.

UNMANNED UNDERSEA VEHICLE

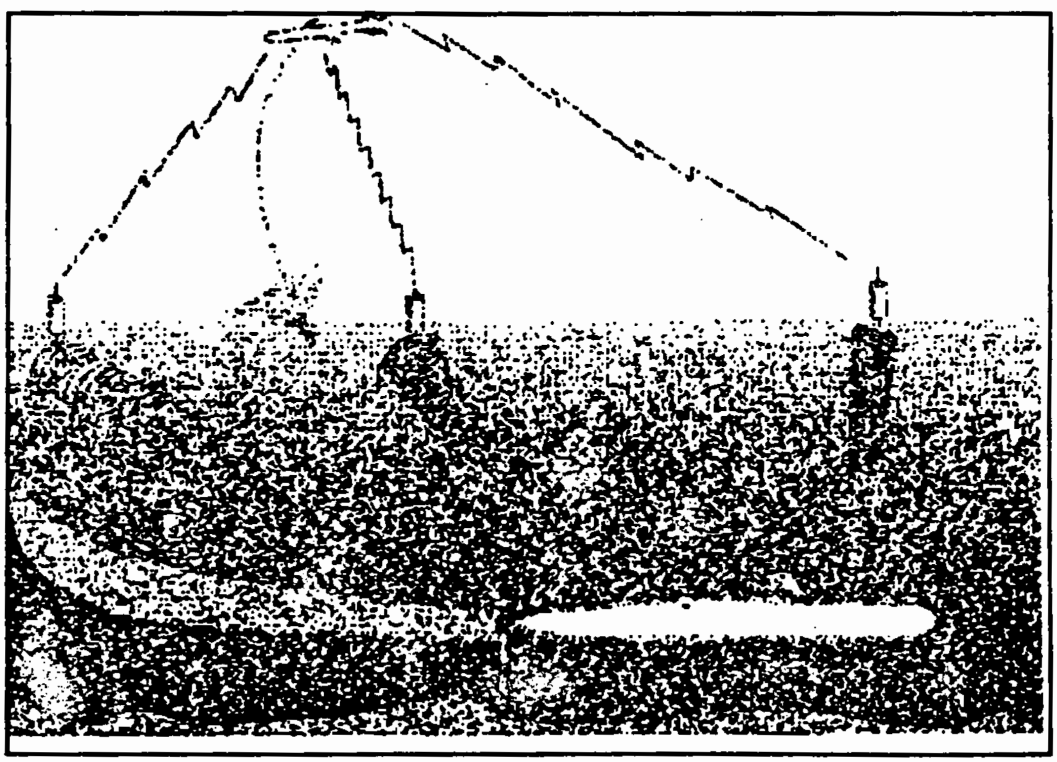
Unmanned Undersea Vehicle Resting in Launch Cradle

The ARPA Unmanned Undersea Vehicle (UUV) Program was initiated to demonstrate that UUVs could meet specific Navy mission requirements. This program is jointly funded by both ARPA and the Navy. Program emphasis is on building integrated UUV systems using state-of-the-art technology and demonstrating the utility of these systems in operational demonstrations. The results of this testing will support a Navy decision to proceed directly to full scale development.

The program developed a UUV Master Plan identifying missions that could be demonstrated with existing technology and specifying technologies that should be developed to enable UUVs to perform more difficult missions. The missions selected were the Tactical Acoustic System (TAS), the details of which are classified; the Mine Search System (MSS), a minefield penetration aid; and the Remote Surveillance System (RSS), a vehicle that deploys an underwater sensor system and provides a link from that sensor to a remote platform. The UUV Program was expanded recently to include the development of supporting technologies critical to new applications for UUVs in undersea warfare. These technologies include high energy density power systems, high data rate acoustic communications, precision navigation, and the modification of existing technology for use in small diameter UUVs.

ANTI-SUBMARINE WARFARE

The Anti-Submarine Warfare Program focuses on



Acoustic Warfare Initiative

counterstealth technology. Undersea warfare in the next century will require advance detection capabilities to find and kill much stealthier threat platforms. These platforms include both advanced quiet nuclear submarines of modern design and the increasing number of capable, quiet, diesel submarines, likely to be encountered in regional conflicts. To maintain U. S. undersea superiority, automated sensor systems must be developed to exploit even glimpses of threat signatures and those systems must exploit both active and passive technologies.

The Anti-Submarine Warfare Program is pursuing a multi-year acoustic warfare (AcW) initiative aimed at developing and demonstrating the technologies to meet this challenge. Technologies in signal processing, signal generation, autonomous systems, and data fusion are being developed and demonstrated to address this complex problem. If successful, these efforts will have a profound effect on future U. S. undersea warfare capabilities.

Micro-Electronics Technology Office

The **Microelectronics Technology Office (MTO)** drives the development of key electronic component technologies and their rapid implementation in systems. Microelectronics is a vitally important technology in defense, since it provides the components for sensing, processing, storing, and transmitting information in military systems and computers. MTO's programs are designed to develop and demonstrate critical microelectronics technologies, along with their associated manufacturing processes, for computing, special-purpose processors, and sensors.

One group of MTO's programs is designed to explore and establish those technologies necessary to achieve performance beyond the limitations of today's digital silicon-based microelectronics. These include Optoelectronics, Artificial Neural Network Technology, Digital Gallium Arsenide, and Ultra Dense Ultra Fast computing components. Another group of MTO programs strives to strengthen the semiconductor manufacturing infrastructure to assure the continued availability of advanced microelectronics for national security needs. These include SEMATECH, Advanced Lithography, and Microelectronics Manufacturing Science and Technology. MTO also supports the Infrared Focal Plane Array producibility program.

ARPA

SEMICONDUCTOR R&D

Optoelectronics technology offers an approach to surmount the barriers of conventional electronic computing. The MTO Optoelectronics program develops optical materials and devices to use photons instead of electrons in the handling, processing, and storage of information. In addition, the program is demonstrating optoelectronic interconnect technology, to dramatically surpass current interconnect throughput limitations for large-scale computing systems, and a group of optical processors tailored for use in specific military systems.

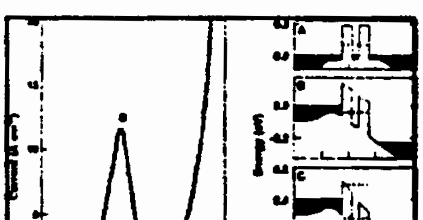
Optoelectronic Interconnect Replaces 1024 Electrical Wires with Two Fibers

Artificial neural network technology (ANNT) will potentially revolutionize information processing for pattern classification and autonomous control. MTO's ANNT program is demonstrating the utility of neural nets (as contrasted to conventional approaches) for a variety of military applications, developing hardware implementation technologies, and exploring advanced ANN architec-tures for future system improvements.

Upgraded DRFM Module with Digital GaAs

MH-60 Special Operations Helicopter

Digital GaAs Enhances Army Jammers



Ultra Fast Resonant Tunneling Device

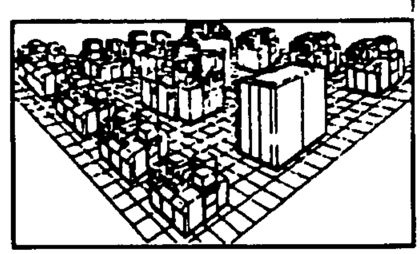
MTO's Digital Gallium Arsenide (GaAs) program is currently focused on the demonstration of nine digital GaAs upgrades for fielded military platforms. These insertion projects will result in rapid transition of this high-speed, low-power technology to utilization in such systems as the P-3C's surface search radar, a spacecraft data processor, an RC-135's array processor, and radar jammers for Army and Navy aircraft. The upgrade demonstrations represent the culmination of the ARPA digital GaAs investment, which had previously brought this advanced technology out of the research laboratory into a viable manufacturing capability.

The basic research program in Ultra Dense Ultra Fast Computing Components (ULTRA) explores both electronic and optical approaches to reach beyond the scaling limits of the transistor technology that has been the basis for the last 30 years of the microelectronics revolution. ULTRA focuses on developing quantum-well electronics (nanoelectronics), optical computing devices, interconnects and input/output links, nanotechnology for fabrication, and terabit memory technology.

The United States' rapidly growing dependence on foreign sources for advanced semiconductors in weapons systems has been recognized by the Defense Science Board as a major source of concern, resulting in the formation of the semiconductor manufacturing consortium SEMATECH. The consortium is a cooperative effort of 14 semiconductor companies and the U. S. Government that is developing semiconductor manufacturing technology to meet the challenges of the nineties.

Sub-0.2-Micron Resolution with X-Ray Lithography

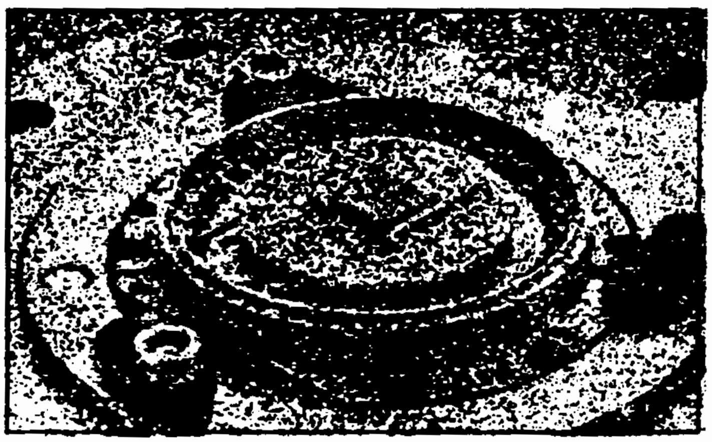
MTO's efforts in Advanced Lithography include developing lithography techniques and tools required for production of the semiconductor devices of the mid- and late-1990s. In this time frame, the minimum size for features on integrated circuits will be 0.25 microns or less, circuit complexities will be 64-256 megabit memory chips, and circuits will contain 10,000,000 transistors for logic and microprocessors. This MTO program addresses mask technology, exposure sources, processes, alignment, metrology, and device demonstration.



MMST Semiconductor Fabrication Facility

The Microelectronics Manufacturing Science and Technology (MMST) Program, jointly sponsored by MTO and the Air Force, is demonstrating a radically different approach to semiconductor manufacturing by combining techniques to control the wafer environment, real-time *in situ* process control, and sophisticated computer-integrated manufacturing (CIM) tools. MMST will demonstrate a complete 0.35-micron fabrication capability costing $30 million, achieving this state of the art with conventional technology currently cost over $500 million.

The Infrared Focal Plane Array (IRFPA) producibility program establishes a manufacturing base for the infrared (IR) sensor arrays that are critical components for major weapons systems. This program is driving the cost for IRFPAs down by a factor of 100, making IRFPA system applications affordable. In addition, the program explores novel concepts for next-generation integrated IR sensors.



Infrared Focal Plane Array
Mounted in Missile Seeker

NUCLEAR MONITORING RESEARCH OFFICE

The Nuclear Monitoring Research Office (NMRO) pursues research and development (R&D) to provide technological options for improving nuclear weapons treaty monitoring. To this end, NMRO supports efforts which address major problems associated with the detection and characterization of foreign nuclear explosions and nuclear weapons deployments. Major areas requiring research include the detection of low-yield underground bursts, their unambiguous differentiation from earthquakes, and sensitive methods of detecting nuclear materials. Another major problem area is the accurate estimation of the methodologies for determining the presence and characteristics of nuclear bursts in remote locations on earth or in space. R&D efforts in geophysics, nuclear materials detection and related disciplines, the development of advanced instrumentation for detection and related disciplines, explosion-related phenomena, and the development of a variety of advanced sensors and data-processing hardware are supported.

Gamma Ray Sensor

ARPA

Software & Intelligent Systems Technology Office

The Software and Intelligent Systems Technology Office (SSTO) is responsible for developing advanced software technology required to produce and manage affordable defense systems, and for developing advanced functionality required for future defense systems through the exploitation of intelligent systems science and technology. SSTO builds on a long history of investment in key software areas including database systems, window management systems, software engineering environments, formal methods, advanced algorithms, computational geometry, computer aided design, computer aided manufacturing, image understanding, speech and natural language systems, robotics and intelligent planning systems. SSTO now has major thrusts in three (3) areas: Software, Manufacturing, and Intelligent Systems.

SOFTWARE

In direct support of DoD's advanced software technology requirements, SSTO invests in basic research focused on the development of affordable software by enabling work avoidance through software reuse technology; pursuing sophisticated software development methods utilizing software process technology; and enabling rapid software development by leading the development of industry supported software engineering environments and tools.

ARPA

The Software Technology for Adaptable and

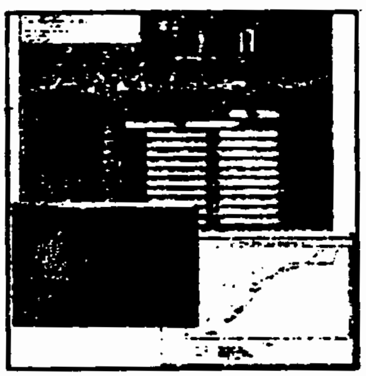
Reliable Systems (STARS) Program is focusing on the development of software engineering environment frameworks and advanced software processes enabling a domain-specific reuse based approach to software development.

The Software Engineering Institute expedites the transition of software technology into DoD practice. Its major contributions have included the SEI Process Maturity Assessments, Ada real-time scheduling capabilities, the SEI Masters' curriculum in software engineering, and the Computer Emergency Response Team.

The Domain Specific Software Architectures (DSSA) Program is developing the technology for producing software systems of interest to DoD by constructing domain models of generic classes of systems, such as avionics, vehicle management systems, missile guidance systems, and Command and Control systems, from which extensible software architectures are developed. These architectures are then represented in architecture specification languages, and used to support rapid construction of large programs through integration of reused software components, generated components from software generators, or hand-written code into the DSS architecture.

Design support for a Synthetic Environment

The PROTOTECH Program is developing powerful prototyping languages, instrumentation and analysis tools, and module interconnect formalisms required to interconnect software developed in multiple programming languages, including existing software systems. This technology has shown that prototype development and analysis significantly reduces both the risk and time of large scale software development activities.



Intelligent Systems Display from DART

The Software Science Program provides research in Persistent Object Bases, Formal Methods, Algorithms, and Advanced Software Environments. The Persistent Object Base (POB) Program is focused on the development of the technology to provide seamless, scalable storage, distribution, and communication of structured objects. The Formal Methods Program provides high assurance for software systems through analytical approaches to specifying and reasoning about systems. The Algorithms Program provides high performance computational methods for generic computational tasks. The Advanced Environments Program develops and demonstrates new concepts for supporting teams of people collaborating in the development and support of large scale software systems.

MANUFACTURING

Manufacturing research in applying information science to the manufacturing process is a key element of the office investment strategy which is resulting in the development of an integrated manufacturing automation and design environment supporting DoD acquisition.

INTELLIGENT SYSTEMS

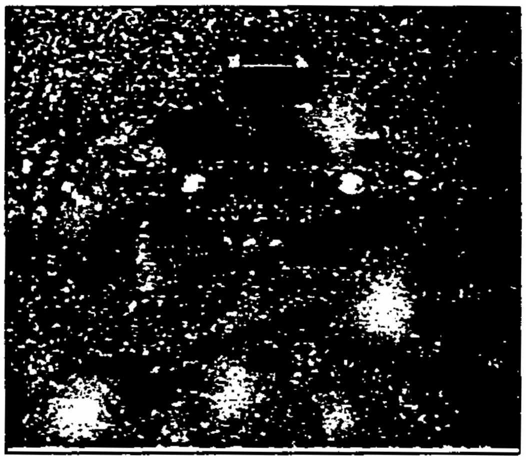
This basic research program supports efforts in machine vision, speech and natural language, planning, knowledge based systems, and robotics programs.

The Machine Vision Program sponsors basic research in image understanding.

DEMO II Semi-Automous Surrogate Vehicle (SSV)

The Speech and Natural Language Program has provided a sustained investment in signal processing, phoneme understanding, and statistical methods enabling computer understanding of spoken speech. Currently, the rigorous performance requirements of spoken language interfaces for use in hostile environments in support of future defense critical applications is being developed.

The Autonomous Planning Program focuses on the development of the next generation of planning, resource allocation, and scheduling technology. Current research thrusts are targeted to the development of adaptive, real-time, "human-like" agents that can provide doctrinally realistic, automated adversaries in advanced simulations.



NAVLAB II, with a Laser Range Finder on Top and a Computer Behind the Wheel, Climbs a Hill Near Pittsburgh

The Knowledge-Based Systems Program sponsors basic research in knowledge acquisition, representation, and reasoning. The recent focus is to develop new techniques to fuse and reason about disparate sources of information. The resulting technology is being stress-tested in large-scale system demonstration including the new ARPA thrusts in manufacturing and engineering.

Other SSTO on-going application efforts include an image understanding application, a speech understanding application, a document under-standing application, a transportation planning application called DART, and a robotics and machine vision application.

Seeking ARPA Support

ARPA's mission is to support innovative research ideas that offer significant military advantages. ARPA's strategy to accomplish this mission is to provide a forum for the evaluation of competing scientific and technological ideas. This is accomplished by the review of solicited and unsolicited proposals, white papers and technical abstracts, the holding of industry briefings, and the use of cooperative agreements. In this regard, ARPA welcomes new technical ideas at any time from all public and private entities.

Solicited Proposals

Entities seeking R&D support from ARPA should explore the Agency's interests in research by reviewing sources such as the *Commerce Business Daily* (*CBD*), open literature, published testimony before Congressional committees, information contained in this brochure, and *The Department of Defense Small Business Innovation Research (SBIR) Program Solicitation*. Additional information on doing business with ARPA is available upon request from the Office of Administration and Small Business at (703) 696-2448.

Primarily, ARPA solicits R&D work through advertising in the *CBD* and the *DoD SBIR Program Solicitation.* The *CBD* is a Department of Commerce publication in which all federal

Superintendent of Documents
Government Printing Office
Washington, DC 20402-9373

procurements over $25,000 in value are synopsized. Solicitations in the *CBD* may be broad agency announcements (BAA), requests for a proposal (RFP), sources-sought announcements (SSA), or special research announcements (SRA). A BAA provides a general description of a particular ARPA program, identifies broad evaluation criteria, and solicits proposals for participation in that program. An RFP provides a more specific statement of work, contract deliverables, and evaluation criteria for government selection. An SSA or an SRA is an advance notice of ARPA's interest in a particular area of technology and provides a vehicle through which ARPA may develop competition within a technology area or survey the market for potential qualified offerors. The *CBD* is available in public libraries or can be ordered at the address at the top of this page.

The DoD SBIR Program invites firms with strong research and development capabilities in science or engineering in any of the topic areas described in the annual *DoD SBIR Program Solicitation* to participate. Subject to the availability of funds, DoD and its components will support high-quality research and development proposals on innovative concepts related to important defense-related scientific or engineering problems.

Defense Technical Information Center
Attn: DTIC/SBIR
Building 5
Cameron Station
Alexandria, VA 22304-6145
1-800-225-DTIC
(703) 274-6902

Proposals submitted under the SBIR Program must comply with the specific criteria and requirements stated in the annual *DoD SBIR Program Solicitation*. A copy of the current solicitation can be obtained by contacting the Defense Technical Information Center (DTIC).

Unsolicited Proposals

Although most ARPA R&D contracts are awarded via standard competitive procurement procedures, another important method of doing business with ARPA is through the submission of relevant new ideas and concepts in the form of unsolicited proposals. Before soliciting ARPA for a specific research project, it is advisable to determine if the contemplated study is within the scope of ARPA interests. This can be achieved through direct contact with ARPA technical personnel. If uncertain as to which technical person to contact, the inquiry should be made to the Director, Administration and Small Business, at the address in the box.

ARPA
Attn: Director, Office of Administration and Small Business
3701 N. Fairfax Drive
Arlington, VA 22203-1714
(703) 696-2448

Furthermore, proposers without a current DoD contract to establish clearances and a need-to-know for access to classified information may request assistance from ARPA's Security and Intelligence Office under the Potential Contractor Program (PCP). Such communications in advance increase the likelihood that an unsolicited proposal will be appropriately handled.

Unsolicited Proposal Requirements

Although there is flexibility in the format, an unsolicited proposal should contain the following information to permit consideration in an objective and timely manner:

A. **Basic information including -**

1. Offeror's name, address, and type of organization (e.g., profit, nonprofit, educational, small business).
2. Names and telephone numbers of technical and business personnel to be contacted for evaluation or negotiation purposes.
3. Identity of proprietary data to be used only for evaluation purposes.
4. Names of other Federal, State, and local agencies, or parties receiving the proposal or funding the proposed effort.
5. Date of submission.
6. Signature of a person authorized to represent and contractually obligate the offeror.

B. **Technical information including -**

1. Concise title and abstract (approximately 200 words) of the proposed effort.
2. A reasonably complete discussion stating the objectives of the effort or activity, the method of approach and extent of effort to be employed, the

nature and extent of the anticipated results, and the manner in which the work will help to support accomplishment of the Agency's mission.

3. Names and biographical information on the offeror's key personnel who would be involved, including alternates.
4. Type of support needed from the Agency (e.g., facilities, equipment, materials, or personnel resources).

C. **Supporting information including -**

1. Proposed price or total estimated cost for the effort in sufficient detail for meaningful evaluation.
2. Period of time for which the proposal is valid (a six month minimum is suggested).
3. Type of contract preferred.
4. Proposed duration of effort.
5. Brief description of the organization, previous experience in the field, and facilities to be used.
6. Required statements, if applicable, about organizational conflicts of interest, security clearances, and environmental impacts.

Proposal Evaluation

An evaluation usually requires four to eight weeks to complete, and unsolicited proposals will not be returned. Proposal evaluation and the associated award decisions will be based on the following criteria:

1. Unique and innovative methods, approaches, or concepts demonstrated by the proposal.
2. Overall scientific, technical, or socio-economic merits of the proposal.
3. Potential contribution of the effort to the Agency's specific mission, and to the civilian technology base.
4. The offeror's capabilities, related experience, facilities, techniques, or unique combinations of these which are integral factors for achieving the proposal objectives.
5. The qualifications, capabilities, and experience of the proposed principal investigator, team leader, or key personnel who are critical in achieving the proposal objectives.

Industry Briefings

ARPA uses industry briefings whenever possible to outline problems within specific technology areas and to request submission of technical solutions to these problems. During these briefings, all potential offerors are provided with identical information and therefore equal opportunity to respond. ARPA advertises its industry briefings through the *CBD*.

Cooperative Agreements

In addition to legal authority to enter into contracts and grants, ARPA has been granted broad authority to enter into cooperative agreements to support research and development activities. Thus, ARPA is able to channel its support through a variety of legal instruments and flexible arrangements. The Federal Acquisition Regulations (FAR) are not applicable to agreements under this authority. Proposals may, but need not, state that an agreement rather than a contract or grant is desired. Furthermore, ARPA does not enter into agreements when a contract or grant is feasible or appropriate. See FAR 35.003 for government-wide policy on use of contracts for research and development.

Agreements are potentially applicable to a wide variety of ARPA programs. They are likely to be particularly applicable to support dual-use technologies (those with commercial nonmilitary potential as well as potential military applications), consortia or multi-party agreements, and work supported by multiple funding sources. Joint funding is the norm for agreements. A provision may also be made for payments to ARPA somewhat similar to the recoupment policy applicable to procurement contracts. ARPA also encourages cost-sharing in procurement contracts and grants.

Other Opportunities

NDSEG Fellowship Program
Suite 211
200 Park Drive
P.O. Box 13444
Research Triangle Park, NC
27709-3444
(919) 549-8505

Although ARPA does not have its own fellowship program, it is a cosponsor of the DoD National Defense Science and Engineering Graduate Fellowship Program. The purpose of this program is to increase the number of U. S. citizens trained in disciplines of science and engineering of military importance. Those interested in applying for a fellowship should contact Dr. George Outterson at the address shown in the box on this page.

Advanced Research
Projects Agency
Defense Sciences Office
Attn: URI RIP
3701 North Fairfax Drive
Arlington, VA 22203-1714
(703) 696-2241

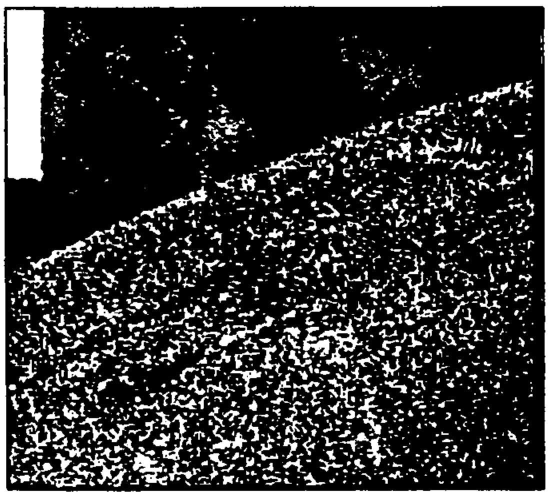
Another opportunity for universities to get involved with ARPA's R&D efforts is the University Research Initiative (URI), which began in 1986. The URI's central emphasis is multidisciplinary research and includes funding for graduate fellowships, young faculty investigator awards, scientific exchanges, and the Research Initiation Program (RIP). ARPA's participation within the URI focuses predominantly on the RIP. To broaden the university base, the RIP is competed among institutions that have not been major recipients of DoD research and development funding. The three-year RIP awards emphasize human resources, the most critical infrastructure element for university research and for science and engineering graduate education. Additionally, proposers are encouraged to request major pieces of instrumentation needed to perform the proposed research and to budget more for equipment than the 10%-15% typically allotted within DoD's traditional single-investigator awards. Inquiries regarding ARPA's role in the URI RIP should be sent to the address shown in the box on this page.

Advanced Research
Projects Agency
Defense Sciences Office
Attn: AASERT
3701 North Fairfax Drive
Arlington, VA 22203-1714
(703) 696-2241

The Augmentation Awards for Science and Engineering Research Training (AASERT) program is another opportunity for DoD research and development funding. AASERT is designed to increase the number of high-quality scientists and engineers as a result of DoD-sponsored research. Within this program, each DoD agency, including ARPA, requests proposals from Principal Investigators at colleges and universities already working on DoD-funded research grants or contracts to augment support of research training for one or two additional graduate students that the "parent" award would not otherwise support. AASERT awards are competitive and are for three years, paralleling the usual duration of the parent awards. Inquiries regarding ARPA's participation in the AASERT Program should be sent to the address in the box on this page.

The ARPA Message

The development of imaginative and innovative research ideas which offer significant technological impact, and the transformation of these ideas to demonstrations of technical feasibility or prototype is imperative, for these are the ideas which will be the foundation of the nation's defense and industrial capability into the next century. In this light, ARPA encourages all potentially high payoff ideas to be submitted for evaluation.



Non-Acoustic ASW

Gas Turbine Engine Airfoil Made from Rapidly Solidified Alloy Powders

X-Wing (RSRA)

Computational Aerodynamics

X-29 Advanced Technology Demonstrator

Space Based Laser System

AMBER-Unmanned AirVehicle

National Aerospace Plane

Atlas-Agena

Ceramic Applique Armor Tile on LAV Marine Corp.

NEWS RELEASE
OFFICE OF ASSISTANT SECRETARY OF DEFENSE
(PUBLIC AFFAIRS)
WASHINGTON, D.C. - 20301
PLEASE NOTE DATE

No. 283-93
(703) 695-0192 (media)
(703) 697-3189 (copies)
IMMEDIATE RELEASE June 18, 1993 (703) 697-5737 (public/industry)

ARPA RECOGNIZES EXCELLENCE BY CONTRACTORS AND GOVERNMENT AGENTS

Director of the Department of Defense's Advanced Research Projects Agency (ARPA) Gary L. Denman today announced the winners of the 1993 ARPA Awards for Outstanding Performance. These awards have been presented annually since 1985. They are designed to reward and encourage excellence among scientists and engineers working with ARPA.

The X-31 International Test Organization and the Command and Control Directorate of the Air Force Rome Laboratory each separately received the ARPA Award for Outstanding Performance by a Government Agent. EMS Technologies will receive the ARPA Award for Technical Achievement, and the team of BBN Systems and Technologies Corp. and ISX Corp. were chosen for the ARPA Award for Outstanding Performance by a Contractor.

The X-31 International Test Organization received the ARPA Award for Outstanding Performance by a Government Agent for superior accomplishments in spite of its unique nature. The X-31 program is the first X-plane program to be co-managed in cooperation with a foreign government, and the International Test Organization involves multiple agencies from both the U.S. and the Federal Republic of Germany. The following individuals were specifically cited: Charles Johnson, ARPA agent and Navy X-31 program manager; Gary Trippensee, director of the X-31 International Test Organization and National Aeronautics and Space Administration X-31 project manager; and Joe Cosenza, former chief of the Air Force Wright Laboratories Investment Strategy Division. They were recognized for their management skills, teamwork and leadership in activating and integrating the X-31 International Test Organization, and for overcoming institutional biases to lead and foster a superior level of teamwork in a complex and technically demanding experimental program.

The Command and Control Directorate of the Air Force Laboratory, Rome AFB, N.Y., was selected for the ARPA Award for Outstanding Performance by a Government Agent for outstanding technical leadership, management, innovativeness and creativity in managing the DARPA-Rome Laboratory Planning Initiative in knowledge-based planning and scheduling. The Laboratory team has directly contributed to the state-of-the-art, and used proactive, effective leadership to advocate the transition of planning initiative technology in the government. The award specifically mentions the efforts of Ray Urtz, Nort Fowler and Don Roberts.

(more)

EMS Technologies Inc., Norcross, Ga., was selected to receive the ARPA Award for Technical Achievement for outstanding technical performance in the development of light-weight beamforming networks that achieve a 10 to one weight reduction over existing feed networks. In just three years, EMS has developed and tested two multiple beam antenna breadboards, each of which advanced the state-of-the-art at an amazingly low cost to the government of only $750,000. The potential savings to the overall military satellite communications architecture may approach $1 billion. Specifically mentioned were Donald Runyon, the program manager, and Jim Fuller, director of engineering.

BBN Systems and Technologies Corp., San Diego, Calif., and ISX Corp.,West Lake Village, Calif., jointly were selected to receive the ARPA Award for Outstanding Performance by a Contractor for their outstanding technical leadership and management, and for the spirit of teamwork they created. Their work to broker technology transition proved highly effective, spanning the gap from laboratory to foxhole. Their efforts were key to the successful operational demonstration of the Dynamic Analysis and Replanning Tool, the SRI Operations Crisis Action Planning prototype and the Theater Graphical Execution Toolkit. Specifically mentioned were Ed Walker, BBN; Ted Kral, BBN; and Scott Fouse, ISX.

All awards will be formally presented in a ceremony at the ARPA 16th Annual Systems and Technology Symposium on Tuesday, June 22 in Newport, Rhode Island.

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NEWS RELEASE

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No. 355-93
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IMMEDIATE RELEASE July 30, 1993 (703) 697-5737 (public/industry)

MARTIN MARIETTA AND LOCKHEED SANDERS RECEIVE CONTRACTS FOR WORK ON SIGNAL PROCESSORS

The Advanced Research Projects Agency (ARPA) announced today that Martin Marietta Advanced Technology Laboratories, Moorestown, N. J., and Lockheed Sanders, Nashua, N. H., have received contracts for the primary development and demonstration portion of the Rapid Prototyping of Application Specific Signal Processors (RASSP) Program.

Martin Marietta is receiving a $53,411,583 contract from the Army Research Laboratory; the Lockheed Sanders contract is for $42,460,707, and is being awarded by the Naval Research Laboratory.

The goal of the RASSP effort is to develop and demonstrate the capabilities essential to the rapid and affordable design, manufacture, and support of embedded signal processors. Current DoD processor designs often take many years to develop, and may no longer be state-of-the art when they are fielded because signal processing technology is advancing so quickly. RASSP seeks a four-fold decrease in the amount of time required to develop a fielded prototype from the initial concept. Another key program goal is to develop the ability to upgrade designs rapidly and cost-efficiently to take advantage of evolving technology.

Each contractor is leading a team developing capabilities that include a comprehensive computer-aided design environment; a design methodology and signal processor architectural approaches which support a wide spectrum of implementation technologies and encourage modular design and reuse of hardware and software subsystems and components; and comprehensive testing capabilities at all levels of the design. Much of the design and manufacturing technology developed under the RASSP program is expected to be applicable to other classes of electronic products, both military and commercial.

The RASSP design process will be demonstrated periodically throughout the four-year contracts through an extensive series of design exercises. Semi-annual "benchmark" designs will assess the full design, fabrication, and test capabilities of the contractors' RASSP design systems as well as the quality of the signal processors which result. In addition, each contractor will develop demonstration designs for specific DoD systems, such as the F-22. The needs of all military services will be addressed by the collective efforts of the selected contractors.

(more)

Signal processors are specialized, high-speed computers that transform raw sensor and communications signals into a form to be analyzed so that useful information can be extracted. They are used in military and commercial radar and communications systems, military electronic warfare equipment, and commercial medical imaging and voice synthesis devices.

The RASSP effort is sponsored by ARPA and will be managed by an ARPA/tri-Service team.

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NEWS RELEASE
OFFICE OF ASSISTANT SECRETARY OF DEFENSE
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WASHINGTON, D.C. - 20301
PLEASE NOTE DATE

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(703) 695-0192 (media)
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IMMEDIATE RELEASE August 9, 1993

FACT SHEET
ARPA'S HIGH-DENSITY MICROWAVE PACKAGING PROGRAM

Three contractors have received contracts for the Advanced Research Projects Agency (ARPA) High-Density Microwave Packaging for Next-Generation Aircraft and Space-Based Phased-Array Radar Systems program.

The contractors and the amounts of their contracts are:

- Hughes Aircraft Company, Radar Systems Group, Los Angeles, Calif., received $6,400,000 on July 30.

- Texas Instruments, Defense Systems Electronics Group, Dallas, Texas, teamed with Martin-Marietta, Electronics Laboratory, Syracuse, N.Y., received $13,207,787 on June 30.

- Westinghouse Electric Corporation, Electronics Systems Group, Baltimore, Md., received $6,651,722 on August 6.

The emphasis of the program is to develop appropriate designs, materials, and manufacturing processes that lead to the production of interconnected, very thin radar modules. These thin modules or groups of modules, which are mounted parallel to the radar array face, are often called "tiles." At present, "brick" designs consisting of modules mounted perpendicular to the array face are being used in arrays under development. The "tile" technology has the potential for offering lighter weight, smaller size, and lower cost than "brick" technology, but a number of technical barriers must be overcome and suitable low-cost manufacturing processes established before this type of module can be produced in large quantities and at sufficiently low cost.

Key program goals are reduction of cost, weight, and volume, while achieving improved electrical performance required for the next generation of phased-array radar systems. The interconnected modules, in turn, are expected to be considered for use in future versions of the Air Force's F-22 fighter, other advanced aircraft, and space-based applications.

Each of the contractors receiving awards will explore different advanced packaging techniques. Advanced manufacturing processes for the packages will also be developed.

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The Texas Instruments/Martin-Marietta team will use a high-density interconnection system known as Microwave High Density Interconnect for connecting Microwave Monolithic Integrated Circuits (MMICs) mounted face up. They will demonstrate and deliver a 100-module brassboard.

Hughes and Westinghouse will each use MMICs mounted face down with other novel schemes for chip interconnections, and will each produce, demonstrate and deliver approximately 50 to 60 tile modules.

The program is under overall ARPA management with the Air Force, Army, and Navy sharing in the technical guidance and support. Contracts are being awarded by the Air Force's Wright Laboratory, Wright-Patterson Air Force Base, Ohio, which will continue to serve as the primary monitor for the contracts.

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NEWS RELEASE
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No. 396-93
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IMMEDIATE RELEASE August 26, 1993

ARPA Signs Agreement for Manufacture of Active Matrix Liquid Crystal Displays

The Department of Defense's Advanced Research Projects Agency (ARPA) announced today that it signed an agreement with Optical Imaging Systems (OIS), Inc. of Troy, Mich. to develop manufacturing technology and build a manufacturing demonstration facility based on active matrix liquid crystal display (AMLCD) technology.

The agreement was a joint effort of ARPA and the Air Force Wright Laboratory, Wright-Patterson AFB, Ohio. Wright Laboratory played a key role in drafting and negotiating the agreement, which they will administer as ARPA's agent. World-class AMCLD manufacturing capability is critical for U. S. defense because of the needs of the F-22 and other high-priority military applications.

Under the $98 million jointly funded agreement, the government anticipates an initial investment of $24 million to develop the AMLCD manufacturing technology and demonstration facility with the total estimated government funding to be up to $48 million. The five-year program expects to demonstrate display manufacturing in the spring of 1995. This agreement was competitively awarded as a result of ARPA's earlier broad agency announcement on AMLCD manufacturing technology.

The demonstration facility will build upon the research results of ARPA's high definition systems program. Its purpose will be to respond to military requirements for high definition monochrome and full color flat panel display applications ranging from the controlled environments of submarines and combat information centers to the sunlight-illuminated cockpits of high performance aircraft. In addition, the demonstration facility will provide a dual-use entry for the United States into the large commercial market of displays for portable and lap-top computers, small portable and conventional televisions, video camera color viewers, protable test equipment monitors, automotive dashboards, and commercial aircraft instrumentations.

The director of ARPA's Electronic Systems Technology Office Lance Glasser said, "The OIS agreement is a key milestone in the ARPA high definition systems program as we advance from a focus on technology to a focus on technology plus manufacturing. While the first phase of the high definition program produced world-class technology demonstrations, the next phase of the program will generate manufacturing capability to satisfy military requirements and promote the health, strength, and competiveness of the U. S. display industry."

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OIS has selected Northville Township in southeast Michigan as the site for the demonstration facility. The company will develop, construct, integrate, and demonstrate a fully automated manufacturing cleanroom facility for the medium scale domestic production of AMLCDs. The contractor also will work to produce military and commercial products with the intent to develop stable domestic sources of required materials in order to sustain a full and stable U. S. display industry. Once the demonstration facility is operational, it will be available to the DoD and its suppliers on a priority basis for the development and manufacture of displays.

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No. 195-93
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IMMEDIATE RELEASE April 30, 1993

ARPA CHOOSES PARTICIPANTS FOR ADVANCED MATERIALS WORK

The Department of Defense's Advanced Research Projects Agency (ARPA) announced today the first groups of companies, universities and government institutions selected under the FY92 Advanced Materials Synthesis and Processing Partnerships program.

These participants are grouped into four teams. Each team will demonstrate management mechanisms and concepts to facilitate the military and civilian application of advanced materials and the processes used to produce these materials. An interactive approach is being used, with some traditional competitors linking together to advance technology at the precompetitive stage.

The teams are:

<u>MBE In-Situ Process Control Partnership</u>
Hughes Research Laboratories
Central Research Laboratories of Texas Instruments
J.A. Woollam Co.
Superior Vacuum Technology
EPI Division of Chorus Corp.
University of Virginia
University of New Mexico
University of Southern California
University of Colorado
Sandia National Laboratory

<u>Affordable Polymeric Composites Team</u>
McDonnell Douglas
BP Chemicals
Naval Research Laboratory
Washington University
Virginia Polytechnic Institute
Zoltek Inc.
Production Products
Missouri Advanced Technologies Institute

<u>Smart Materials and Structures Team</u>
Martin Marietta Laboratories and Astronautics Group
Lockheed
AVX Inc.
Timet
BDM International
Naval Research Laboratory
Johns Hopkins University
University of Utah
University of Maryland
University of Denver
Clemson University
State of Colorado
State of Maryland
State of South Carolina

<u>Organic Thin-film Materials for Optoelectronics Technologies Team</u>
Princeton University
University of Southern California
Hughes Research Laboratories
IBM
University of Colorado

(more)

The MBE In-Situ Process Control Partnership will study ways to improve molecular beam epitaxy (MBE) using predictive and intelligent manufacturing techniques. MBE is the method used to manufacture quantum well resonant tunneling devices and optoelectronic devices, advanced electronics devices that offers promise for extraordinary improvements in communications, high-speed computing and signal processing. The partnership combines research organizations, for technology advances, and small business equipment vendors, who will translate the technology advances directly into prototype equipment. Technology improvements to these electronics devices will engender new high performance systems and assure U.S. leadership in these markets. This partnership received $4,685,000 in ARPA funding.

The Smart Materials and Structures Team will develop advanced manufacturing processes for a new class of smart materials and devices, leading to commercially viable, state-of-the-art products for active control of vibration of structures. The program is a $5,004,000 effort over 24 months.

The Affordable Polymeric Composite Team will develop advanced continuous resin transfer modeling processes using intelligent manufacturing concepts which include real-time process control. The program also focuses on developing a new, low cost, high performance graphite fiber. The program will develop technologies that are expected to significantly reduce the cost of polymer composite components for military and commercial applications. This effort is expected to receive $5,348,000, and is expected to last 24 months.

The Organic Thin-Film Materials for Optoelectronics Technologies Team will investigate the growth, processing and fabrication of organic thin-film materials for optoelectronic integrated device technologies. The group seeks to surmount the main barrier to the use of polymer waveguides and polymer devices in optoelectronic integrated circuits by developing polymer materials and material processing that are compatible to semiconductor material processing. Polymer materials that are capable of high operating temperatures (125 degrees Celsius), and even higher processing temperatures (300 degrees Celsius) are the foci of this 24-month research and development effort, funded at $2,537,082.

Each partnership will at least match the Defense funding received. Participants announced today were selected based on proposals submitted under Research Announcement 92-15, which was published in the Commerce Business Daily on February 24, 1992. The Federal government effort involved proposal review by representatives from the Army, Navy, and Air Force. In addition, Sandia National Laboratory (Department of Energy) is a partner in one of the teams. Additional funding is available as part of the FY93 Defense Reinvestment and Conversion Initiative. Additional FY93 partnerships will be selected from proposals that were previously submitted under the 1992 Research Announcement.

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OFFICE OF ASSISTANT SECRETARY OF DEFENSE
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WASHINGTON, D.C. - 20301
PLEASE NOTE DATE

No. 076-94
(703)695-0192(media)
(703)697-3189(copies)
(703)697-5737(public/industry)

IMMEDIATE RELEASE February 16, 1994

ARPA ANNOUNCES MULTICHIP INTEGRATION EFFORTS

The Department of Defense's Advanced Research Projects Agency (ARPA) today announced the 15 contracts, grants and other agreements that have been funded to date under the Multichip Integration program.

The Multichip Integration program will reduce manufacturing cost, develop a domestic supplier infrastructure, and accelerate the acceptance and insertion of advanced multichip integration technologies. It is part of the Clinton Administration's defense reinvestment program.

Negotiations are underway on three additional efforts also announced today, with awards expected within the next 60 days.

The Clinton Administration's defense reinvestment program emphasizes investments in dual use technology for both commercial and military applications. This dual use strategy is one key to creating long term jobs and stimulating economic growth, and at the same time posturing the nation for the requisite defense to meet our future national security challenges. The Multi-chip Integration program exemplifies several principal Clinton Administration dual use technology concepts: active participation by industry in the design of the program, cost-sharing, facilitation of industrial and academic cooperation, selection of projects likely to have wide-ranging impacts throughout an industry and the economy, and a long-term emphasis on ensuring that key U.S. industries stay on the technological leading edge.

Multichip module technology offers the potential to interconnect dozens of "bare" silicon chips in a single package that is often no larger than the conventional package used for a single complex integrated circuit. At the system level, this can mean as much as a 70 percent reduction in volume and weight, a doubling of the performance, and a tenfold increase in reliability. While such a capability would have obvious payoffs in a variety of military systems, there is also an enormous potential in volume commercial markets such as personal computing, automotive engine controls, and personal communications. Use of multichip module technology for high volume applications is limited by cost, availability and perceived risks. ARPA's Multi-chip Integration program is aimed at solving these problems.

Efforts selected for funding under this program are:

Aehr Test Systems (Mountain View, CA), working with Motorola (Chandler, AZ) - Wafer Level Burn-In: This customer/supplier team will

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develop and demonstrate a complete system for wafer-level burn-in and test of semiconductor devices. ($4,080,250; awarded 11/29/93)

BBN Systems and Technology (Cambridge, MA), working with Motorola (Chandler, AZ) - General Purpose Noise Cancellation Processor: BBN will design and demonstrate a multichip module noise cancellation processor for several high-volume automotive and military applications. ($2,357,720; awarded 12/16/93)

GM Hughes Electronics, Microelectronics Division (Newport Beach, CA), with Litel Instruments (San Diego, CA) - Breakthrough Production Capability for This Film Multichip Module (MCM-D) - Large-Panel Very Low Cost Manufacturing: Hughes will work with Litel Instruments to develop a direct laser patterning process, adapted from a proven production process that is currently used to fabricate large quantities of two by four inch MCM-D substrates, which will be applicable to the manufacturing of multichip modules on large format panels to achieve low cost and high throughput. (Under negotiation)

IBIS Associates, Inc. (Wellesley, MA) - Cost Simulation for Alternative Multi-Chip Module Technologies: IBIS will develop cost models for various multichip module technologies and manufacturing techniques and apply these to asses the cost of various case studies. (Under negotiation)

Integrated Device Technology (San Jose, CA) and nChip Inc. (San Jose, CA) - MCM-Optimized Boundary Scan ICs: This team will develop multichip module-optimized integrated circuits which can be inserted into multichip module designs to gain additional testability. ($808,833; awarded 2/4/94)

Kulicke and Soffa Industries Inc. (Willow Grove, PA), working with National Semiconductor (Santa Clara, CA) and nChip Inc. (San Jose, CA) - Multichip Module Assembly Equipment Development: Kulicke and Soffa will design, develop, and demonstrate next-generation die-attach and wire-bond assembly equipment to support high-volume production on large substrates. ($1,756,000; awarded 9/24/93)

Litel Instruments Inc. (San Diego, CA), working with Assist Associates (Minneapolis, MN), ALCOA Electronic Packaging (Rancho Bernardo, CA), GM Hughes Electronics (Newport Beach, CA), and Sheldahl, Inc. (Northfield, MN) - Phase Mask Machining for Multi-Chip Modules: Litel will improve existing eximer lasers for use with their innovative parallel via formation technology and demonstrate its application to four types of multichip module substrate technologies. ($839,000; awarded 9/24/93)

National Semiconductor (Santa Clara, CA), working with E-Systems (Dallas, TX) and IBM (Hopewell Junction, NY) - Field Configurable Multichip

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Modules: This team will develop a generic multichip module component which leverages integrated circuits that have been specifically optimized to take advantage of area input/output and high-density interconnect substrates. ($2,620,112; awarded 1/3/94)

North Carolina State University (Raleigh, NC) - Methodology, Tools and Demo. of Multichip Module System Optimization: North Carolina State will collaborate with industry to demonstrate how to optimize a subsystem design, including management of circuit and partitioning issues, to take maximum advantage of multichip module technology. ($677,440, awarded 11/1/93)

Sheldahl Inc. (Northfield, MN), working with Delco Electronics (Kokoma, IN), GM Hughes Electronics (Newport Beach, CA), Jabil Circuit Inc. (San Jose, CA), Litronic Industries (Costa Mesa, CA), Mentor Graphics (San Jose, CA), Micro Module Systems (Cupertino, CA), Silicon Graphics, Inc. (Mountain View, CA), and Wireless Access (San Jose, CA) - Substrate Materials and Infrastructure Plan for Laminate-based Multichip Modules (MCM-L): This vertically integrated team will develop a revolutionary, new, high-density laminate multichip module substrate technology and infrastructure and insert it into applications in computing, telecommunications, and automotive products. ($19,009,452; awarded 1/10/94)

Tektronix, Inc. (Beaverton, OR) - Thoroughly Testing Known Good Die: Tektronix will work with leading integrated circuit, multichip module, and design software manufacturers to integrate test capabilities for at-speed and analog measurements. ($4,196,580; awarded 1/10/94)

University of Arkansas (Fayetteville, AR), working with nChip Inc. (San Jose, CA), Mentor Graphics (San Jose, CA) - Low Cost Multichip Module Manufacturing: This team will develop a novel multichip module interconnect topology that will half the number of metal layers required for multichip modules, thus reducing the cost. ($5,600,000; awarded 9/1/93)

University of Tennessee (Knoxville, TN), working with IBM (East Fishkill, NY), MCC (Austin, TX) and Sun Microsystems (Mountain View, CA) - Design for Packageability: This team will explore the impact of new multichip module technologies on central processing unit architectures and integrated circuit design. ($1,468,236, awarded 1/1/94)

A total of approximately 275 proposal topics were submitted under the Multichip Integration Broad Agency Announcement, as either full proposals or white papers. Of those, 110 were eventually submitted as full proposals. Seventy of the full proposals, totaling over $500 million, were judged "selectable." The above 13 selections were the first group identified for funding, and will result in contracts and agreements totalling over $40 million. The remaining selectable proposals will remain under consideration for additional awards, which are expected within 90 days.

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Five additional proposals submitted under related solicitations were also identified for funding as a part of the Multichip Integration program:

E-Systems, Inc. (Garland, TX), Silicon Graphics, Inc. (Mountain View, CA), and Micro Module Systems (Cupertino, CA) - RISC Central Processing Unit Insertion: E-Systems, Silicon Graphics, and Micro Module Systems will work with merchant multichip module suppliers to demonstrate alternative approaches to packaging a RISC processor for both military and commercial applications. ($3,248,723; awarded 12/20/93)

McDonnell Douglas (Santa Ana, CA) - Gallium Arsenide Processor Module Insertion:: McDonnell Douglas will work with merchant multichip module suppliers to develop and qualify a gallium arsenide processor module for insertion into the mast-mounted sight system of the Army's OH-58D helicopter.

Microelectronics Center of North Carolina (Research Triangle Park, NC), working with Chip Supply (Orlando, FL), Coors Ceramics (Golden, CO), IBM (East Fishkill, NY), National Semiconductor (Santa Clara, CA), Motorola (Chandler, AZ), Rockwell/Collins (Anaheim, CA) - Flip-chip Technology Center: MCNC will work with leading integrated circuit suppliers and users to develop low-cost wafer bumping and flip-chip assembly technology and infrastructure. ($4,600,000; awarded 6/29/93)

Micro Module Systems Incorporated (Cupertino, CA) - Interconnects for Bare Die Test: Micro Module Systems will refine their bare die carrier technology for burn-in and test, and demonstrate its utility for several classes of integrated circuits. ($958,856; awarded 11/30/93)

Texas Instruments Inc. (Dallas, TX) and Anvik Corporation (Elmsford, NY) - High Throughout Patterning System: This team will develop an optical lithography system capable of imaging very fine (less than 10 microns) lines and etching vias across large format (larger than 400 by 400 millimeter) substrates. ($1,633,000; awarded 9/13/93)

ARPA Program Manager Nicholas Naclerio has said, "We were very pleased by the overwhelming response we received to our Broad Agency Announcement. The teams selected involve some of our leading domestic merchant suppliers for MCMs, semiconductor devices, and manufacturing equipment teamed with forward-looking electronic systems companies and research institutions. In addition to the projects announced today, we are still reviewing a number of other outstanding proposals and expect to make additional announcements in the coming months. These efforts will compliment prior ARPA and industry investments in developing and making available MCM technologies by reducing the cost of MCM solutions and accelerating the insertion of MCM technology into high volume applications."

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