Report of the

Defense Science Board Task Force

for the

INVESTMENT STRATEGY FOR DARPA

July 1999

Office of the Under Secretary of Defense
For Acquisition & Technology
Washington, D.C. 20301-3140

OFFICE OF THE SECRETARY OF DEFENSE
3140 DEFENSE PENTAGON
WASHINGTON, DC 20301-3140

DEFENSE SCIENCE
BOARD

MEMORANDUM FOR UNDER SECRETARY OF DEFENSE (ACQUISITION AND TECHNOLOGY)

SUBJECT: Report of the Defense Science Board (DSB) Task Force on the Investment Strategy for the Defense Advanced Research Projects Agency (DARPA)

I am pleased to forward the Final Report of the DSB Study on the Investment Strategy for the Defense Advanced Research Projects Agency (DARPA). Mr. Vince Vitto chaired this study.

This report examines issues involved in assuring DARPA's ability to maintain the redirection of its investment portfolio as well as its ability to remain a leader in defense technology innovation. The Terms of Reference directed that the Task Force make recommendations on DARPA's mix of near, mid and far term technologies, commercial duplication, commercial relationships, as well as DARPA's relationship with the military customer and the National Intelligence Community.

Key recommendations made by the Task Force are:

Plan deliberately for the future and communicate the plan to the JCS, USD (A&T), DDR&E and Congress;

DARPA's investment portfolio and program structure should include several major thrusts that address critical national security challenges of the 21st Century;

Continue to selectively demonstrate major innovative projects/technologies with high military payoff;

Continue to recruit highly qualified program managers from the public or private sector;

Create a structure for program management that addresses the needs of longer-term programs;

Develop and maintain strong relationships with the Military, Intelligence Community, Congress, and the Private Sector.

The Task Force proposed clear and concise recommendations that can be quickly implemented. I concur with those recommendations and recommend you forward the study to the Secretary of Defense.

Craig I Fields
Chairman

OFFICE OF THE SECRETARY OF DEFENSE
3140 DEFENSE PENTAGON
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DEFENSE SCIENCE
BOARD

MEMORANDUM FOR THE CHAIRMAN DEFENSE SCIENCE BOARD

SUBJECT: Final Report of the Defense Science Board (DSB) Task Force on the Investment Strategy for the Defense Advanced Research Projects Agency (DARPA)

Attached is the report of the Defense Science Board Task Force on the Investment Strategy for the Defense Advanced Research Projects Agency. This Study was requested by the Under Secretary of Defense (Acquisition & Technology) on 30 October 1998. The Terms of Reference directed the Task Force make recommendations on these issues:

- Is there an imbalance in the current investments toward technologies with near-and far-term payoff and away from technologies with a yield in the mid-term?

- Is the current mix of the DARPA investment portfolio appropriate given directions, capabilities, and resources of industrial research and development?

- How does DARPA maintain a knowledge base on commercial technology?

- What is the strategy for DARPA taking advantage of technologies with strong commercial investment?

- How should DARPA strengthen its relationship with commercial- and defense-oriented industry?

- How should DARPA strengthen its relationship with military customers and the intelligence community?

A summary of recommendations follows:

1. Strengthen DARPA's strategic planning process based on collaboration between the Director's Office and Office Directors. The plan should be communicated to the JCS, USD (A&T), DDR&E, DoD, Congress, and DARPA's Program Managers.

2. DARPA's investment portfolio and program structure should include a mix of investments and system level technology experiments focused on new and

evolving national defense threats and warfighting concepts. The Task Force identified six areas where DARPA should significantly expand its investments: chemical and biological warfare defense, assured information dissemination and management, counter transnational threats, underground facility characterization and negation, affordable stand-off precision target engagement, and unmanned and robotics warfare.

3. Continue to selectively demonstrate major innovative projects/technologies.

4. Continue to recruit highly qualified program managers from the public or private sector and develop a program to provide the mentoring, knowledge and skills needed for successful management of DARPA programs. Since joint duty credit is critical to military career growth, DARPA should be assigned a number of joint billets to attract the very best military officers as Program Managers.

5. Create a structure for program management that addresses the needs for longer-term programs. Program Manager rotation policies need to be flexible to provide continuity, corporate history and bridge gaps in oversight due to rotations.

6. Develop and maintain strong relationships with Military, Intelligence Community, Congress, and the Private Sector

The Task Force believes that implementation of these recommendations will enhance the ability of DARPA to remain a leader in defense technology innovation. Effective leadership – in establishing an investment strategy, maintaining an effective staff, and developing and maintaining relationships with the outside community – is the key to ensuring that DARPA remains a leader well into the future.

I would like to thank the members of the Task Force for their very helpful contributions and advice.

Vincent Vitto
Task Force Chair

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PREFACE

The Defense Advanced Research Projects Agency (DARPA) was established in 1958 by the Secretary of Defense in response to the launch of Sputnik and has continued to foster innovation and pursue high-payoff, and, often, high-risk projects to assure technological superiority for U.S. military forces. Over the past 40 years, DARPA has been highly successful in developing and demonstrating advanced technologies and systems that have been incorporated into many of the major weapon systems in America's military arsenal. This success is due in large measure to the philosophy of the organization – a philosophy that promotes an entrepreneurial outlook on technology research and seeks revolutionary advances that go well beyond conventional approaches to system development.

DARPA's research agenda has varied since its inception in response to both external events such as the Soviet launch of Sputnik and to internal Department of Defense needs for technological advancement. Over time, DARPA's research has included advanced microelectronics, data processing technologies, advanced radar and optics, missile guidance and propulsion, target identification and recognition, dual-use technologies, information technologies, and biotechnology. In fact, a hallmark of DARPA's reputation has been its ability to redirect its investment portfolio with great agility.

With the change in the worldwide socio-political situation over the past ten years and the changing threats to U.S. national security, the DoD is reassessing its missions, goals, force structures, and national defense needs in the future. In this vein, the purpose of this study is to examine DARPA's investment strategy for the 21st century.

EXECUTIVE SUMMARY

At the request of the Under Secretary of Defense for Acquisition and Technology (USD(A&T)), the Defense Science Board (DSB) formed a Task Force to examine the future investment strategy for the Defense Advanced Research Projects Agency (DARPA). The Task Force was formed to respond to concerns that DARPA has developed an investment bias that favors near- and long-term projects and that this perceived bias might leave an investment gap in mid-term technologies that offer potential yield within five to seven years and are important to maintaining our national defense superiority in the next several decades. Thus, the Task Force specifically focused on assessing this perceived imbalance in DARPA's investment mix of near-, mid-, and far-term technologies. The Task Force concluded that it is not possible to quantitatively make judgements on the portfolio mix. Moreover, the term of a technology's applicability is not an appropriate judgement criteria. Instead the Task Force recommends that the level of risk versus the degree of military utility offered by a specific program are the appropriate criteria to judge DARPA's portfolio.

DARPA serves as the agency responsible for pursuing research and development (R&D) for the Department of Defense, responding to tasks and guidance from the Office of the Secretary of Defense and Joint Chiefs of Staff. The Agency focuses on revolutionary initiatives with high technical risk, thus pursuing a different class of programs from the typically evolutionary efforts appropriate to the research and development programs undertaken in the individual military Services. While primarily focused on its core research program – balancing innovative basic research, applied research, and advanced technology development – it is appropriate for DARPA to respond, from time to time, to pressing near- or mid-term technological gaps that the Services need to have filled. DARPA is uniquely positioned to address technology developments that cut across all Services or respond to Joint Service needs.

During the early 1990s, a technological gap in the area of command, control, and communications became evident. While Operation Desert Storm was a military success, post conflict assessments identified a number of deficiencies and fundamental limits in U.S. military capability, particularly in the area of command, control, communications, computers, and intelligence, surveillance, and reconnaissance (C^4ISR). Pressure mounted from DoD and Congress to focus post Desert Storm science and technology investment strategies on addressing these shortfalls.

The Director, Defense Research and Engineering (DDR&E) made joint C^4ISR solutions a major priority within the science and technology budget and looked to DARPA to solve these problems, recognizing that the Services were not able to address these issues alone. DARPA's response to this requirement had a major influence on the character of many of its programs, which became shorter term in duration with specific joint warfare demonstrations as the focus. In addition, DARPA Program Managers faced requirements to solicit early buy-in for their programs from a military Service and to define technology transition plans early in the program. This requirement to secure buy-in led to pressures for early demonstrations of particular technologies or systems and a higher degree of risk aversion than had been the norm.

At the same time, DARPA took steps to improve the quality and technical expertise of its Program Managers by enforcing a four-year rotation cycle and significantly increasing the number of Program Managers drawn from universities and other not-for-profit research agencies, federally funded research and development centers, and government laboratories. While this policy change was important, it did create incentives for Program Managers to define programs that had at best a near-term horizon.

Together this complex set of factors resulted in a DARPA program portfolio in the post Desert Storm era that had many programs focused on near-term demonstrations. This result was not by accident, and it is consistent with DARPA's charter. However this trend can and should now be adjusted. With stabilization of the defense budget and the establishment of warfighting laboratories within the Services and the Joint Experimentation Organization at U.S. Atlantic Command, the burden of near-term demonstration of C^4ISR systems is being shifted from DARPA to the military Services.

DARPA now has an opportunity to redefine its overall objectives and portfolio mix and characteristics. As the 21st century approaches, it is evident that DoD needs to develop warfighting capabilities - and the technologies to support those capabilities - that are more far-reaching and complex than the C^4ISR deficiencies identified by the Desert Storm experience. These capability requirements are driven by the emergence of new asymmetric threats and the complex and diverse missions that America's military forces will be called upon to execute.

DARPA needs to transition to an investment strategy that shifts emphasis from a portfolio biased toward near-term demonstrations to one with high risk and initiatives that have high military utility as demanded by the emerging threats and the new military paradigms of the 21st century. To accomplish this transition DARPA management and Program Managers must have a better appreciation for intelligence assessments, military operational needs, and trends within private sector technology development.

To execute this strategy, DARPA must take the following steps:

Plan deliberately for the future. DARPA should emphasize strategic planning, which should be based on a collaboration between the Director's Office and Office Directors. The resulting plan must be communicated to the Agency's Program Managers as well as the USD(A&T), DDR&E, the Joint Staff, and Congress. Caution should be taken not to make this process too bureaucratic, and resource flexibility must be maintained to address emerging opportunities. DARPA's culture and approach to R&D management is unique and draws its strength from the independence and quality of its Program Managers. While DARPA management should regularly communicate their strategic plans, program composition, and research goals to DDR&E, care should be taken to not burden DARPA Program Managers with the TAP and TARA review processes that are used by DDR&E to coordinate the overall DoD science and technology investment portfolio.

Structure an investment portfolio and program that includes several major thrusts that address critical national security challenges of the 21st century. DARPA's investment portfolio should include a mix of investments in technologies and system-level technology experiments to support the new and evolving warfighting concepts. The Task Force highlights six areas where DARPA should significantly

expand its investments: chemical and biological warfare defense, assured information dissemination and management, counter transnational threats, underground facility characterization and negation, affordable stand-off precision target engagement, and unmanned and robotics warfare.

Selectively demonstrate major innovative projects and technologies. DARPA needs to avoid requiring Service endorsement or financial support at the outset of a program. The Agency must not allow near-term military deficiencies and the need for immediate military acceptance of its research and development programs to bias the portfolio mix. This must not exclude, on a case-by-case basis, the ability to address critical warfighting needs that require short-term investments, but these should be the exception not the rule. DARPA should continue to use and pioneer innovative contracting vehicles for prototype development and the same authority should be extended to the military sources to allow for seamless transition of DARPA-developed systems to military-led acquisition programs.

Recruit highly qualified Program Managers from the public and private sector. DARPA's rotation policy enables the Agency to maintain a staff that is constantly at the cutting edge. DARPA must be able to hire the most qualified Program Managers from the public and private sector as well as military officers. The use of the Interagency Personnel Act (IPA), direct hiring from the private sector and enough joint billets to attract the very best military officers are all important capabilities to ensure Program Manager quality. To ensure that they are effective in managing DARPA's programs, the Agency should develop a program to provide mentoring, corporate knowledge, and program management skills. A mentoring process should be established that helps new Program Managers become familiar with threats and challenges that U.S. military forces face and will face in the future.

Create a structure for program management that addresses the needs of longer-term programs. Flexibility in Program Manager rotation policies that allows for a mix of short-term and selective "term extended" Program Managers, at the discretion of the DARPA Director, can bridge gaps in oversight due to rotations, and provide continuity and corporate history. Along with this flexibility, DARPA needs to develop a systematic project hand-off process to maintain program continuity and an explicit mechanism for technical exchange and collaboration among Program Managers and across Program Offices.

Be cognizant of the external environment, developing and maintaining strong relationships with the military, intelligence community, Congress, and the private sector. DARPA cannot be successful if its agenda does not support and is not supported by the external community. Today's environment requires DARPA to build and maintain these relationships with greater urgency in order to gain an understanding of priorities, research and development agendas, investment plans, and requirements. Visibility into private sector research and development will enable DARPA to establish priorities for investments in technology areas critical to DoD that are either not being pursued in the private sector or can be exploited from that sector in support of national defense.

DARPA has been highly successful throughout its history. The end of the Cold War has evolved into an era that will be defined by adversaries both capable and different and will be defined by how the United States chooses to deal with this new range of threats. DARPA is already developing an investment strategy to address this new era. By taking additional steps, the Agency can enhance the success of that strategy, and, in doing so, will remain a leader in defense technology innovation. Effective leadership - in establishing an investment strategy, maintaining an effective staff, and developing and maintaining relationships with the outside community - is the key to ensuring that DARPA remains a leader well into the future.

CHAPTER 1: INTRODUCTION

At the request of the Under Secretary of Defense for Acquisition and Technology (USD(A&T)), the Defense Science Board (DSB) formed a Task Force to examine the investment strategy of the Defense Advanced Research Projects Agency (DARPA). DARPA has long maintained an ability to redirect its investment portfolio with great agility. The past two decades are particularly illustrative of the Agency's changing mix of advanced technology research and development (R&D).

During the mid- to late eighties, DARPA placed emphasis on developing and incorporating newly developed advanced microelectronics and data processing technologies into weapon systems designed to meet the tactical and strategic military threat of the Soviet Union. After the demise of the Soviet empire, the Agency turned its attention to dual-use technologies that are both critical to military systems and also have commercial potential. This emphasis was accentuated by concerns in Congress over a decline in U.S. competitiveness in the global high-technology market.

By the mid-1990s, the United States had regained its position of global superiority in high-technology areas. Consequently, DARPA shifted its focus back to military capabilities, emphasizing information technologies, particularly those that promised to enable enhanced situation awareness on the battlefield, and biotechnology.

The evidence suggests that DARPA's overall portfolio changes continually as old projects are concluded, freeing up resources for new pursuits. In addition, the overall objectives of the Agency are influenced by the goals and philosophy of each individual Director. However, recent controversy has arisen over DARPA's current direction, with specific concern by some observers that DARPA has developed an investment bias that favors near- and long-term projects – that is, those projects with a payoff either within two years or beyond 10-15 years. This perceived bias might create an investment gap in mid-term technologies that offer potential yield within five to seven years and are important to maintaining commercial economic vigor in the United States.

In response to these concerns, the Task Force specifically focused on assessing DARPA's investment mix of near-, mid-, and far-term technologies.[1] In particular, the Task Force addressed the following questions:

1. Is there an imbalance in the current investments toward technologies with near- and far-term payoff and away from technologies with a yield in the mid-term?
2. Is the current mix of the DARPA investment portfolio appropriate given directions, capabilities, and resources of industrial research and development?
3. How does DARPA maintain a knowledge base on commercial technology?

[1] Annex A contains the complete Terms of Reference for the Defense Science Board Task Force on Investment Strategy for the Defense Advanced Research Projects Agency.

4. What is the strategy for DARPA taking advantage of technologies with strong commercial investment?
5. How should DARPA strengthen its relationship with the commercial and defense-oriented industry?
6. How should DARPA strengthen its relationship with military customers and the intelligence community?

To address these questions it was important to draw Task Force members from a broad spectrum of communities. The team included representatives from large defense contractors, small businesses, not-for-profit research companies, universities, government laboratories, and federally funded research and development centers.[2] This diverse group brought a wide range of technical and operational disciplines to the Task Force effort, enabling rich debate and perspective. It was understood at the outset of this study that the questions posed in the Terms of Reference would not likely be answered through quantitative analyses. Rather, a broadly based set of individuals familiar with DARPA would be necessary to form a collective set of judgements to address the issues raised.

As background for its work, the Task Force heard a variety of briefings from current DARPA Office Directors, former DARPA Directors, and individuals in the DoD science and technology community. DARPA's six Office Directors each described the current investment portfolio for their office and the process that they used for making decisions on the areas in which to start new programs.

Other briefings provided insight into DARPA's past operations, how DARPA's investments fit within the Department's overall science and technology investment strategy, and the needs of the Agency's potential customers.

The Task Force also met with Senator Lieberman's staff; DARPA Director, Dr. Frank Fernandez; and the DARPA Deputy Director, Dr. Jane Alexander, to better understand their goals for the Task Force. With this background, the Task Force began its assessment.[3]

The chapters that follow present the results of the Task Force deliberations. Chapter 2 begins with an overview of DARPA's history – its mission, culture, organization, and accomplishments. The next three chapters examine and evaluate DARPA's investment portfolio, focusing in Chapter 3 on the post Cold War environment, in Chapter 4 on an investment strategy for the future, and then in Chapter 5 on DARPA's critical relationships with the external environment. The overall findings and recommendations are discussed in the final chapter.

[2] A list of Task Force members is in Annex B.

[3] Annex C contains a list of the briefings to the Task Force.

CHAPTER 2: OVERVIEW OF DARPA

DARPA was established as an agency within the Department of Defense, in response to the Soviet Union's launch of Sputnik, for the purpose of initiating unique research and development programs in often high-risk areas, that would, if successful, offer significant impact on the Department's military capabilities. The goal of these efforts is to help maintain U.S. military technological superiority and to guard against unforeseen advances by potential adversaries. DARPA responds to tasks and guidance from the Office of the Secretary of Defense to establish an independent research agenda that is relevant to national security needs. DARPA is an "idea" agency, able to reach beyond today's technological frontier to develop what is needed by America's military in the future.

Based on its mission, DARPA focuses on revolutionary initiatives with high technical risks - a mission that differs from the typically evolutionary efforts appropriate to the research and development programs of the individual military Services. DARPA has been uniquely positioned to address technology developments that cut across all the Services or respond to joint-Service needs within the Department of Defense.

The Service research and development establishments provide focused technology solutions that are driven by specific Service requirements. The Service laboratories also provide a path by which to transition DARPA-developed technologies for insertion into military systems. Together DARPA and the Service research and development communities provide DoD with both radical and incremental approaches required for defense innovation. Figure 1 compares the different roles of DARPA and the Service laboratories.

The culture at DARPA has been instrumental to its success. Paramount is creative management that provides strategic guidance for the Agency, while embracing risk-taking and recognizing the possibility of failure. The DARPA environment minimizes bureaucracy, allowing motivated Program Managers to aggressively tackle the hardest technical challenges in a timely manner. The culture is supported by the Agency's goal to foster the growth of new ideas and gain visibility into the private sector. It achieves this goal through a rotation policy for Program Managers, with turnover typically every two to four years. The resulting environment places strong emphasis on good ideas that provide high potential payoff to critical needs but are too risky to pursue within the Service R&D organizations. DARPA's constantly changing research agenda is driven from the bottom to address tomorrow's critical challenges.

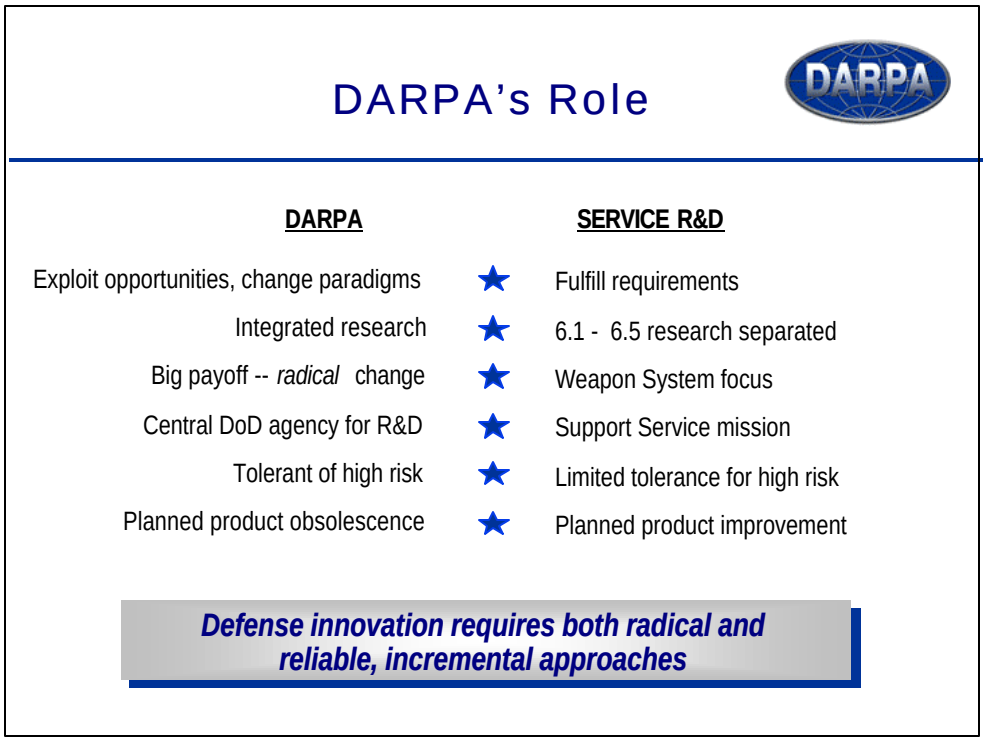


Figure 1. DARPA and Service R&D Approaches – A Comparison

DARPA'S BUDGET AND PROJECTS

A look at DARPA's budget history shows resource levels that have fluctuated over the past 40 years both in response to technological surprise from America's adversaries and to technological gaps that the Services need to have filled. Figure 2 highlights the events that precipitated some of the most significant fluctuations, beginning in the early years with a response to the Soviet space program and more recently with the Technology Reinvestment Project. In certain cases, DARPA's budget has declined as programs have been transferred to other organizations for implementation. The transfer of Project Defender to the Army in the late 1960s and the transfer of the Ballistic Missile Defense programs to the Strategic Defense Initiative Office in the mid 1980s are two examples.

Examining DARPA's core mission, as depicted in Figure 3, also illustrates how the organization has responded to internal DoD requirements while maintaining a strategy that balances among basic research, applied research, and advanced technology development (budget categories 6.1, 6.2, and 6.3). In recent years there has been concern that advanced concept technology demonstrations (ACTDs) have had undue influence on DARPA's core research. In fact there have been only minor perturbations from the Agency's core portfolio. A greater impact has instead come from commercial influences such as the Technology Reinvestment Project, which attempted to have DARPA and other DoD R&D organizations focus on developing technology with both military and commercial applications.

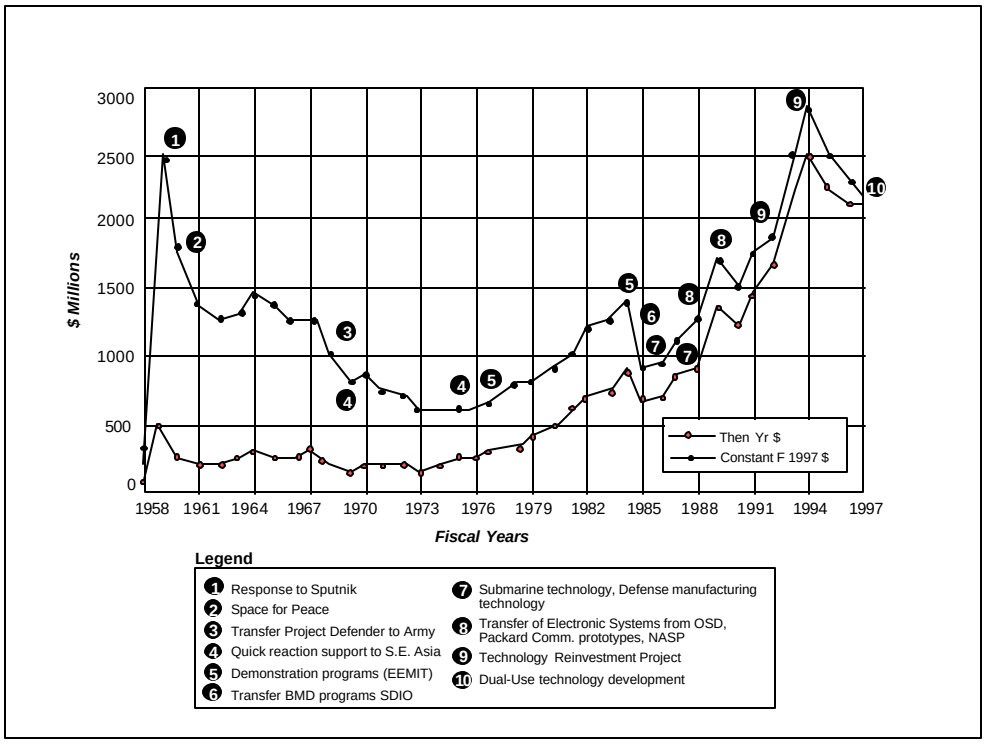
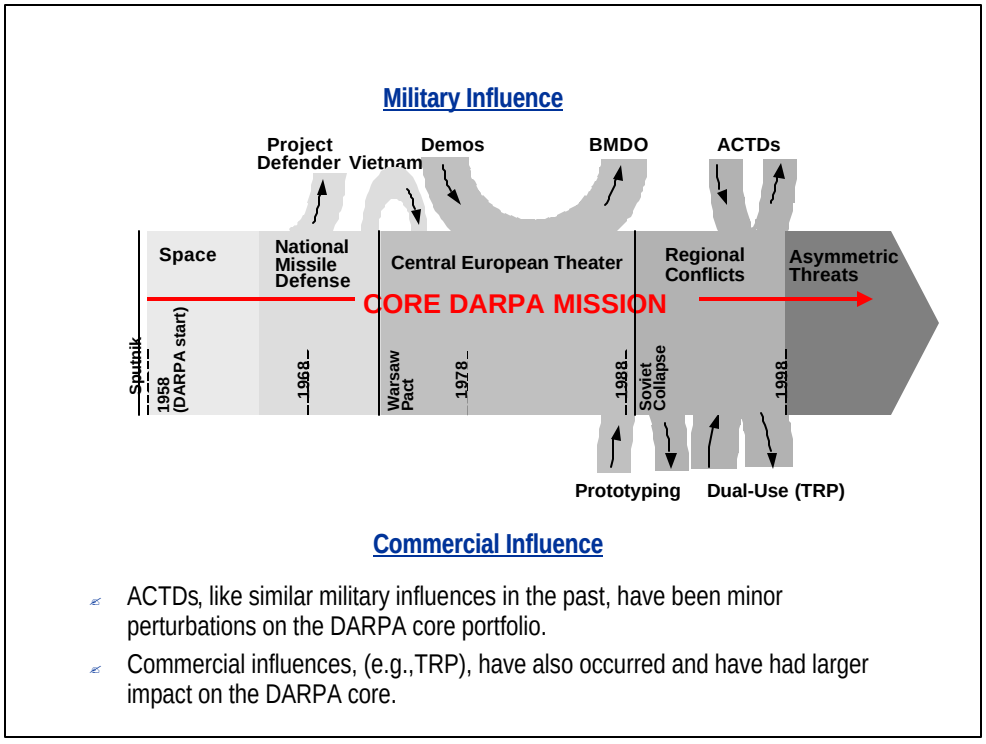


Figure 2. DARPA's Budget History



- ACTDs, like similar military influences in the past, have been minor perturbations on the DARPA core portfolio.
- Commercial influences, (e.g.,TRP), have also occurred and have had larger impact on the DARPA core.

Figure 3. DARPA's Core Mission

DARPA's efforts have led to the development of numerous successful technologies and systems over the years, some of which were witnessed by weaponry used in conflicts such as Desert Storm, Bosnia, and Somalia (particularly stealth aircraft and JSTARS). Furthermore, much of the Strategic Defense Initiative technology, particularly in surveillance and directed energy, was a product of the Agency's research efforts. Other successful developments in recent decades include the Javelin seeker, armor/anti-armor, unmanned underwater vehicles, acoustic-quieting techniques, endurance unmanned air vehicles, and missile launching systems.

Some of DARPA's successes have also found their way into the civilian sector, perhaps the most far reaching of which is today's modern Internet systems which grew from DARPA's pioneering work on ARPANET. Figure 4 provides a partial listing of DARPA's successes throughout its history.

Late 50s

- Saturn space launch vehicle, Centaur RL-10 engine
- Vela Hotel satellites

Early 60s

- Foundations of BMD (Defender Project PRESS, KREMS)

Vietnam Era (late 60s, 70s)

- M-16 Rifle (AR-15)
- Ground surveillance radars (Camp Sentinel Radars)
- SURTASS, Acoustic Research Center (Illiac)
- Transit satellites
- UAVs (Praerie, Calere)
- ROTHR

Early 80s

- Much of SDI technology (surveillance and directed energy)
- AMOS satellite imaging and adaptive optics

Modern Network Systems (ARPANET)

1980s

- Interactive simulation systems (SIMNET)
- Javelin (Tankbreaker); Armor/Anti-Armor
- Non-penetrating submarine periscope
- Unmanned underwater vehicles; acoustic quieting tech
- LPI/LO radars
- Endurance UAVs (Condor, Amber)
- Pegasus, Taurus launch vehicles

Display of Weaponry in Desert Storm

- JSTARS (Assault Breaker, Pave Mover)
- ATACMS (Assault Breaker)
- F-117 (Have Blue), B-2 (Tacit Blue)

Bosnia, Somalia

- Predator (Amber)
- Soldier 911
- Personnel and vehicle armor
- Bosnia C3 Augmentation System
- Natural Language

Figure 4. DARPA Successes

DARPA has also experienced unsuccessful programs, as would be expected from an agency involved in high-risk research and development. However, even though expected, it is important to examine and learn from the reasons for such outcomes. The Task Force observed two primary causes of unsuccessful programs. On the one hand, some programs end in failure due to technical risk – lack of technical maturity, a problem that is simply "too hard," a requirement that is no longer needed, or other technological solutions emerge. These are "acceptable failures" – a normal and expected part of the process of advanced technology research.

On the other hand, DARPA experiences program failures due to program management – an issue of concern to the DSB Task Force. Cases of inconsistent and changing program objectives, a tendency to press for early demonstrations and programs that proceed with no clear exit criteria are evident. While the Program Manager rotation policy allows for the infusion of fresh ideas and a staff familiar with the cutting edge of technological developments, it also causes program objectives to shift when research efforts are handed off from one Program Manager to the next. Well-defined exit criteria, important on their own merit, can also help to minimize the impact of changing Program Managers. *DARPA needs to set in place a process for capturing, understanding, and learning from project failures*. The lessons that are learned need to then be institutionalized in new behavior and passed on to new Program Managers.

PROGRAM MANAGERS

DARPA's Program Managers in large measure drive the character of the institution. These individuals must be highly motivated visionaries who are successful at both management and technology. They must be experts in their field, but, importantly, they must "think outside the box" and they must be willing to take risk. To maintain a staff that is constantly on the cutting edge, DARPA Program Managers are brought to the Agency for temporary assignments, typically lasting two to four years. Its Program Managers come from industry, the military Services, academia, not-for-profit research companies, federally funded research and development centers, and the national laboratories.

DARPA has traditionally used the 1971 Interagency Personnel Act (IPA) as a mechanism to bring in program managers. The IPA allows non-profit organizations, such as universities, to temporarily loan scientific and engineering personnel to DoD agencies and the Services. However, the IPA Act does not permit temporary loan of personnel from private sector profit-making organizations. DARPA has recently been given authority to hire Program Managers directly from private sector firms. The Task Force is very supportive of this change. DARPA access to high-quality Program Managers from within the military was limited a few years ago by the decision not to grant joint billets to DARPA. The impact of this decision has made a tour at DARPA less attractive to many military officers at a point in their career where a joint assignment is critical to career growth. The Task Force believes that DARPA should be assigned a number of joint billets to allow access to a broader cross section of military officers.

While an important part of DARPA's culture, the rotation policy also brings a unique set of problems. The Task Force is concerned that Program Managers lack sufficient training and mentoring about the goals of the agency and the defense community. New Program Managers need to be educated, as early as possible, on the latest thinking on threats to the national security

and the resulting DoD requirements to meet these threats in order to better focus their research on DoD's needs. While the DARPA research agenda is not tied to military requirements, per se, if its research is to be most beneficial to DoD, it needs to address the nation's security needs.

The rotation policy also tends to create a short-term focus by the Program Managers, who bring with them an inherent desire to accomplish a vision or goal within their tenure. Related is the fact that long-term programs can experience a gap in oversight and direction while Program Managers get settled into their jobs and learn new programs. DARPA needs to address this concern to ensure that there is continuity within the organization. Flexibility in Program Manager rotation policies that allows for a mix of short-term and a few "term extended" employees can bridge such a gap, with the more permanent employees providing continuity and corporate history on individual programs, as well as experience within the Department of Defense establishment. This tenure policy needs to be augmented with a systematic project hand-off process to maintain program continuity, such as an effort to provide for overlap between rotating Program Managers.

The rotation policy also has a tendency to suppress collaboration and technical exchange among Program Managers, particularly across offices. Collaboration is a hit-or-miss exchange, driven primarily by Program Manager personalities rather than by programmatic needs. Where natural collaborations tend to evolve through longer-term interactions among staff, DARPA needs an explicit mechanism for technical exchange that accommodates for the shorter-term relationships that evolve with Program Managers continually rotating in and out of the organization.

STRATEGIC PLANNING

The Task Force believes that DARPA needs to strengthen its approach to strategic planning. The Agency identifies thrusts and focus areas to direct its research but has no systematic process for deliberately planning for the future. The process is decentralized, leaving the Office Directors and Program Managers to define their own research portfolio. Moreover, DARPA fails in communicating its plans both within the organization and outside. This creates the impression that Program Managers are pursuing agendas that may be disconnected from the Agency's long-run goals. It also leaves the organization vulnerable to uninformed criticism regarding their programs and plans. DARPA's strategic planning process should be a collaboration between the Director's Office and the Office Directors. The resulting plan must be communicated to DARPA Program Managers as well as the USD(A&T), Director, Defense Research and Engineering (DDR&E), the Joint Staff, and Congress.

The strategic planning process should assess the current portfolio using criteria that assesses risk versus military utility. This process should establish long-term Agency goals and identify emerging investment opportunities in technologies and programs where there is limited private sector investment but the potential for significant military payoff. The Task Force believes that the new DARPA management has initiated this process and has established a set of programmatic themes (discussed in Chapter 4 and highlighted in Figure 10) that address important military issues that will dominate defense needs in the next century.

To be successful in implementing its research agenda, DARPA must foster relationships with a variety of communities external to its organization including the Office of the Secretary of Defense (OSD) and the military Services, the intelligence community, Congress, and the private sector. It is critical that this communication be two-way, with DARPA maintaining visibility into the research and development efforts ongoing in DoD, the intelligence community, and the private sector, as well as providing visibility for these communities into DARPA's own research agenda. By maintaining critical external relationships, DARPA will strengthen its basis for establishing priorities on which to base its future portfolio investments. Chapter 5 provides a more detailed discussion of the external environment.

CHAPTER 3: THE POST COLD WAR ENVIRONMENT

The end of the Cold War led to a steady decline in the Department of Defense budget, which only in the past few years has begun to stabilize. The overall budget decline in turn has caused significant reductions in the Service Total Obligation Authority. To compensate for this reduction, the military Services have redirected funds from their science and technology budgets to provide needed resources for maintaining readiness and addressing issues associated with personnel retention and morale.

DoD's total budget for science and technology research was $7.2 billion in fiscal year 1998, down from a high in 1993 of over $9 billion. Figure 5 shows the history of the Department's science and technology budget from 1978 to 1998 and illustrates two important points. First, the military Services have each reduced science and technology funding since the end of the Cold War. Second, DARPA and the other Defense Agencies – predominantly the Ballistic Missile Defense Organization – now represent approximately half of the overall DoD science and technology budget.

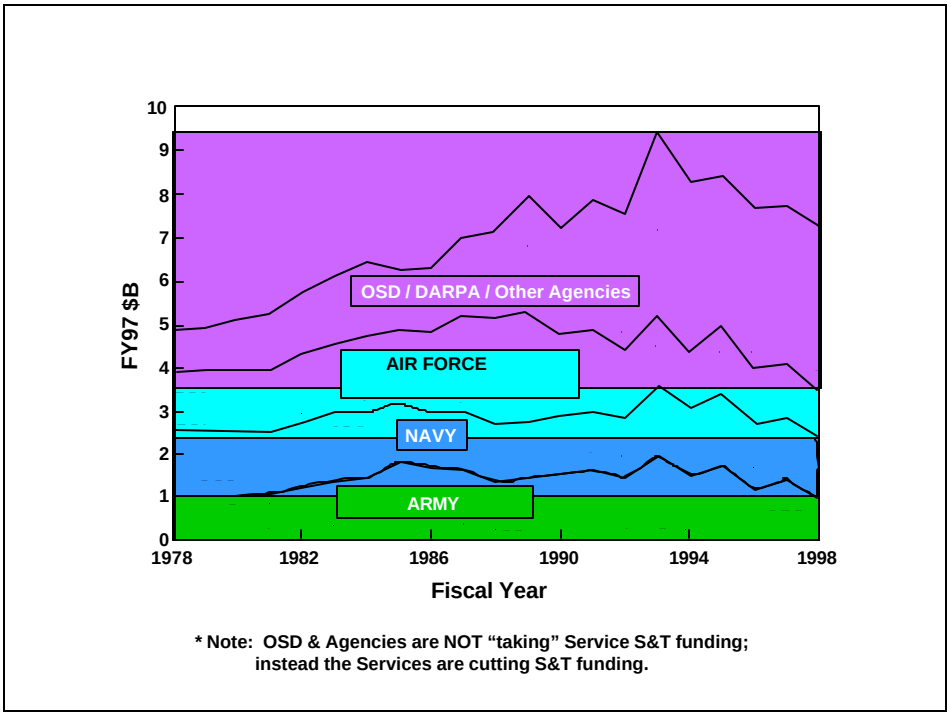


Figure 5. Defense-wide and Service Funding of Science and Technology

Moreover, the Services not only have reduced their overall investments in science and technology, but also have directed much of their funding priority toward modernization. Technology advances for next-generation aircraft, precision munitions, ground combat vehicles,

helicopters, transport aircraft, new ship concepts, automation to reduce ship manning, and battle group defenses are only some of the domains that require Service technology developments to meet future needs.

For the United States and its NATO allies, the Cold War was a period when military weapons and systems were designed to defeat the Soviet Union – America's primary adversary – and to support a confrontation with the Warsaw Pact, the logical military operational scenario. U.S. forces and weapon systems were primarily forward deployed, large, heavy, and static. Intelligence, reconnaissance, and surveillance assets, designed for an Eastern Europe conflict, resulted in fixed communications, command and control systems that were well understood, and individual Service missions and responsibilities that were well defined.

To respond to the desert crisis in 1990, the United States transported a primarily Cold War-focused set of military systems to Saudi Arabia over a six-month period and subsequently used these systems against Iraq in Operation Desert Storm. While Operation Desert Storm was a military success, post conflict assessments identified a number of deficiencies and fundamental limits in U.S. military capability, particularly in the area of communications.

Desert Storm provided an assessment of joint Service operations and highlighted deficiencies in command, control, communications, computers and intelligence, surveillance, and reconnaissance (C^4ISR). Limitations in available communications bandwidth, communications to support command and control on the move, wide area surveillance, target identification, planning tools, logistics management, sensor-to-shooter connectivity, situation awareness, and the ability to manage and disseminate timely intelligence and reconnaissance information to joint forces in theater were some of the deficiencies identified. Thus, pressure mounted from DoD and Congress to focus post-Desert Storm science and technology investment strategies on addressing these shortfalls. DDR&E made joint C^4ISR a major priority within the science and technology budget and looked to DARPA to help solve these problems.

In addition, the Defense Airborne Reconnaissance Office was created to address tactical surveillance needs and the Deputy Under Secretary of Defense for Advanced Technology pursued ACTDs as a means to quickly improve U.S. C^4ISR capabilities. Typically short-term programs, ACTDs integrate existing technologies into systems that can be "tried out" by military users to assess, experiment with, and ultimately provide direct military utility. Many of these programs have focused on C^4ISR issues. Despite the emphasis on ACTDs during this period, funding for these programs has never been a particularly large portion of the DARPA budget, as many have suggested. As shown in Figure 6, funding on ACTDs represented less than five percent of the DARPA budget over the past five years.

					97-99 Change	
	FY 96	FY 97	FY 98	FY 99	Category Total	% DARPA Total
6.1 Basic Research	76.459	90.701	76.009	80.936	-11%	-0.45
6.2 Applied Research	754.21	710	827.87	928	31%	10
6.3 Adv Tech Dev	1358.4	1298.7	1256.6	1216.7	-6%	
Agency Total	2269.2	2140.4	2204.4	2271.9	6%	

ACTDs	FY 96	FY 97	FY 98	FY 99	FY 00
High Altitude Endurance UAVs	$22M	$13M	$5M	$0M	$0M
Synthetic Theater of War		$12.9M	$12.6M	$0M	$0M
Battlefield Awareness and Data Dissemination		$28.9M	$43.8M	$14.5M	$7.4M
Semi-Automated IMINT Processing		$24.9M	$23.9M	$13.6M	$4.5M
Joint Logistics			$9.8M	$9.6M	$9.72M
Miniature Air Launched Decoy			$17.9M	$9.0M	$2.0M
Combat Vehicle Survivability			$6.6M	$6.3M	

Figure 6. DARPA Investment, Fiscal Years 1996-2000

Figure 6 shows the distribution of DARPA investments in basic and applied research (6.1 and 6.2) and advanced technology development (6.3). These data show no evidence that DARPA programs have become focused on near-term military deficiencies. The Task Force believes that many subjective factors have led to a near-term focus on demonstrations. First, as previously discussed, DARPA increased its focus on solutions to meet the near-term needs established within the joint Service C^4ISR community. Second, DARPA Program Managers have been required to solicit early buy-in for their programs from a military Service and to define technology transition plans and Service funding profiles for that transition early in a program. In order to secure Service support and buy-in, Program Managers are pushed to have early demonstrations of particular technologies or systems. These factors, along with the reduced Service funding for science and technology investment, have brought about a near-term focus for a large fraction of DARPA's investment portfolio.

During this period, DARPA also took steps to remain technologically current by enforcing a four-year rotation cycle for its Program Managers and significantly increasing the number of Program Managers from universities, not-for-profit research corporations, federally funded research and development centers, and government laboratories. While this policy change was important, it did create incentives for Program Managers to define programs that had at best a three-year horizon. DARPA has a very limited training or mentoring program for new Program Managers and thus it may take as long as a year for new Program Managers to establish a set of programs. Moreover, the high quality, innovative, and competitive characteristics found in DARPA's best Program Managers do not support a great deal of collaboration between Program Managers or the likelihood for programs to smoothly transition from one Program Manager to another. The fundamental character of a successful DARPA Program Manager as an innovator, an individualist, and an "anti-bureaucrat," will create a culture in which a manager establishes his/her own agenda and programs.

Together, this complex set of factors has resulted in a DARPA program portfolio in the post-Desert Storm era that has many programs focused on near-term demonstrations. This result did not happen by accident. It is consistent with the DARPA charter and the DDR&E and DARPA strategy to solve the deficiencies in joint-C^4ISR capabilities.

Consequently, the Task Force believes that DARPA's current portfolio does not have enough high-risk, high-payoff programs. This situation should now be addressed. With stabilization of the defense budget and the establishment of warfighting laboratories within the Services and the Joint Experimentation Organization at the U.S. Atlantic Command, the burden of near-term demonstration of C^4ISR systems can be shifted from DARPA to the military Services. DARPA funding for ACTDs will be near zero in FY 2000. Also, most importantly, the new DARPA management has taken this opportunity to redefine their overall objectives and portfolio mix and characteristics.

The Task Force attempted to address the portfolio imbalance hypothesis through a more analytic process, but was unsuccessful. DARPA senior management provided data based on a subjective judgement of the characteristics of the current portfolio, which indicated a bias favoring near-term, low-risk programs which had significant utility for military operations. The Task Force attempted to replicate this judgement by asking each DARPA Office Director to provide an assessment of the level of risk associated with each program and the time required for the program to provide a useful military capability.

These attempts at a quantitative analysis of program focus, along with an examination of the DARPA Science and Technology investments presented in Figure 6, did not result in a definitive set of data to address the question of portfolio mix. The Task Force concluded that an assessment based on near-, mid- and far-term focus was not an appropriate methodology to assess the DARPA portfolio mix. Instead the Task Force accepted a characterization that measured technological risk versus military utility and believes that the DARPA portfolio should be biased toward high-risk, high-payoff programs. This characterization and the recommended distribution within the portfolio are discussed in Chapter 4.

CHAPTER 4: THE FUTURE

As the 21st century approaches, it is evident that DoD needs to develop warfighting qualities and technologies to reach beyond the C^4ISR deficiencies identified by the Desert Storm experience to a more far-reaching and complex set of capabilities. These capability requirements are driven by the emergence of new asymmetric threats and new and diverse missions that the military forces have been called upon to execute – such as peacekeeping and humanitarian missions in Bosnia, Haiti, and Somalia and drug interdiction. They are also driven by the overarching strategy embodied in Joint Vision 2010 that calls for military dominance made possible by establishing information superiority for U.S. military forces.

This national security environment, which is expected to dominate into the next century, and the asymmetric threats that the U.S. military must be prepared to address within this new environment are illustrated in Figures 7 and 8.

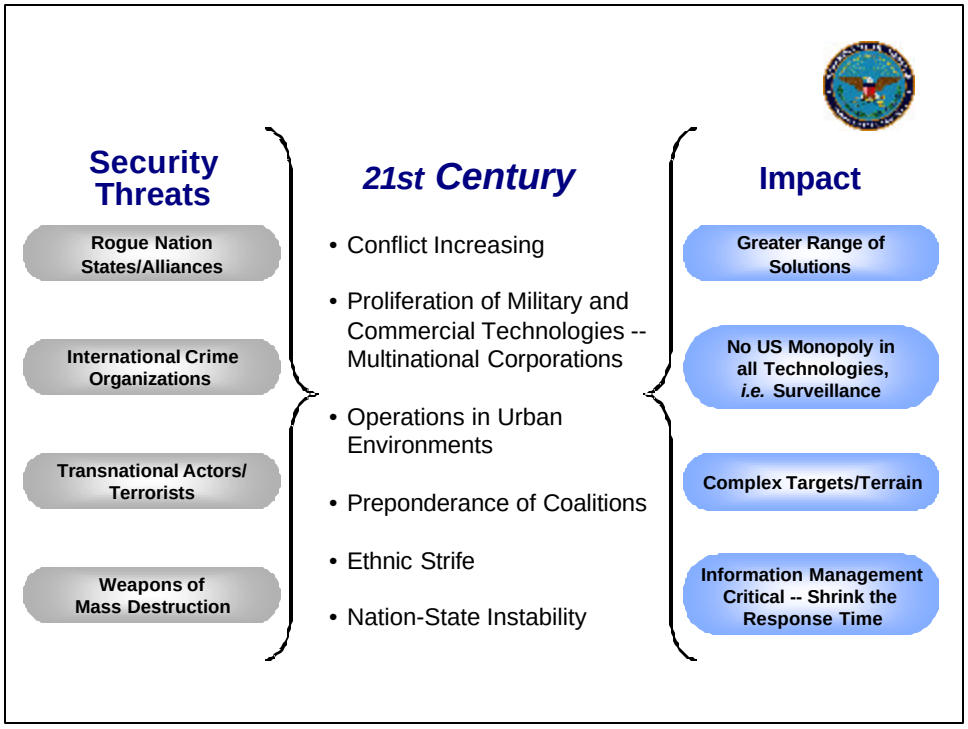


Figure 7. Changing Security Environment

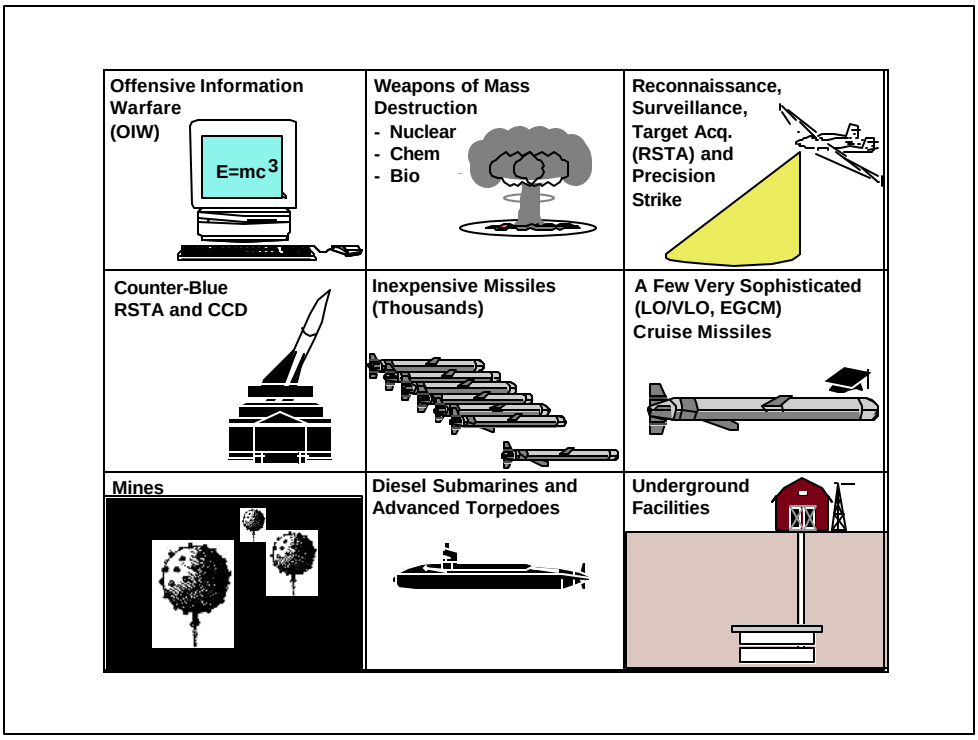


Figure 8. 21st Century Threats to the United States

The United States faces a highly dynamic international environment within which its military forces will operate. Whereas the Cold War period was a bipolar alignment between superpowers, today and in the future the situation will be far more complex. America's adversaries are more diverse and might include the potential emergence of either a regional or world peer or coalition. While wars in the traditional sense may be decreasing, conflicts are increasing. America's adversaries have increasing access to threatening asymmetric capabilities to offset U.S. and coalition military prowess. The U.S. military will operate alongside coalition partners in diverse environments including the urban battlefield and its unique set of challenges.

While the United States has been modernizing its forces to address this wider range of missions and adversaries, these adversaries have also been modernizing their forces to discourage the United States and its coalition allies from influencing their foreign policy. They have learned from Desert Storm. Their military modernization has included the purchase of large numbers of missiles and mines; some submarines with high-speed torpedoes; the construction of underground facilities; and development of capabilities for weapons of mass destruction including biological and chemical weapons. Further, potential adversaries can now use the global information infrastructure, including the Global Positioning System and commercial imagery satellites, as their C3I system, which in turn can use the worldwide, robust commercial infrastructure to project "force" anywhere, anytime. Even a small nation with a modest budget can afford such modernization – a military capability as potentially deadly as large conventional forces.

Together, this picture suggests that the DoD's science and technology agenda must be reassessed and a new investment strategy established. This new strategy should include a mix of investments in technologies and system-level technology experiments to support the new and evolving warfighting concepts. This will require a shift in emphasis from near-term science and technology initiatives to a more balanced portfolio that includes mid- to long-term initiatives as demanded by the emerging threats. Within this strategy, however, there must be retained the ability to address critical warfighting needs, on a selective basis, that require short-term investments.

As part of the future science and technology strategy, the USD(A&T), DDR&E, and DARPA leadership must jointly reaffirm DARPA as the corporate research and development agency for DoD. DARPA's investment portfolio must address potential threats to America's national security in the 21st century and must focus on high-risk projects with high military relevance and operational payoff. However, DARPA must be careful not to allow near-term military deficiencies and the need for immediate military acceptance of their research and development programs to bias the portfolio mix. High-risk programs are not likely to gain early military buy-in, but these are the type of projects DARPA was created to pursue. Accomplishing these goals will require deliberate planning for the future.

Figure 9 describes the distribution and type of programs that should comprise the DARPA investment portfolio in coming years. The majority of the portfolio should focus on programs with high-risk and high military payoff (H,H). Lesser investments should be made in longer-term research and development (L,H) and near-term programs with lower risk but high military utility (H,L). DARPA management has recently suggested a distribution of 60 percent, 20 percent, and 20 percent respectively. The Task Force agrees with this baseline portfolio distribution, but recognizes that, as occurred in the period following Desert Storm, DARPA must be prepared to sporadically increase the investment in near-term, high-utility programs in response to military needs to counter a specific problem the Service R&D establishment cannot address.

DARPA management has recently identified areas of interest that will guide future program development, as shown in Figure 10. The nine focus areas respond to challenges in national security, surveillance and targeting, and military operations. The Task Force agrees with the general approach in this chart but suggests several important changes. First, DoD should not ignore the chemical agent threat; thus DARPA should address chemical as well as biological warfare defense. Second, the concept of information warfare defense should be broadened to encompass assured information dissemination and management. This would incorporate information security which is integral to the ability of the future Integrated Information Infrastructure (DSB 1998 Summer Study "Joint Operations Superiority in the 21st Century") to manage the dissemination of crucial military information and assure the integrity and reliability of that information. The panel also recommends that DARPA focus on underground facility negation technologies in addition to technologies necessary for their characterization.

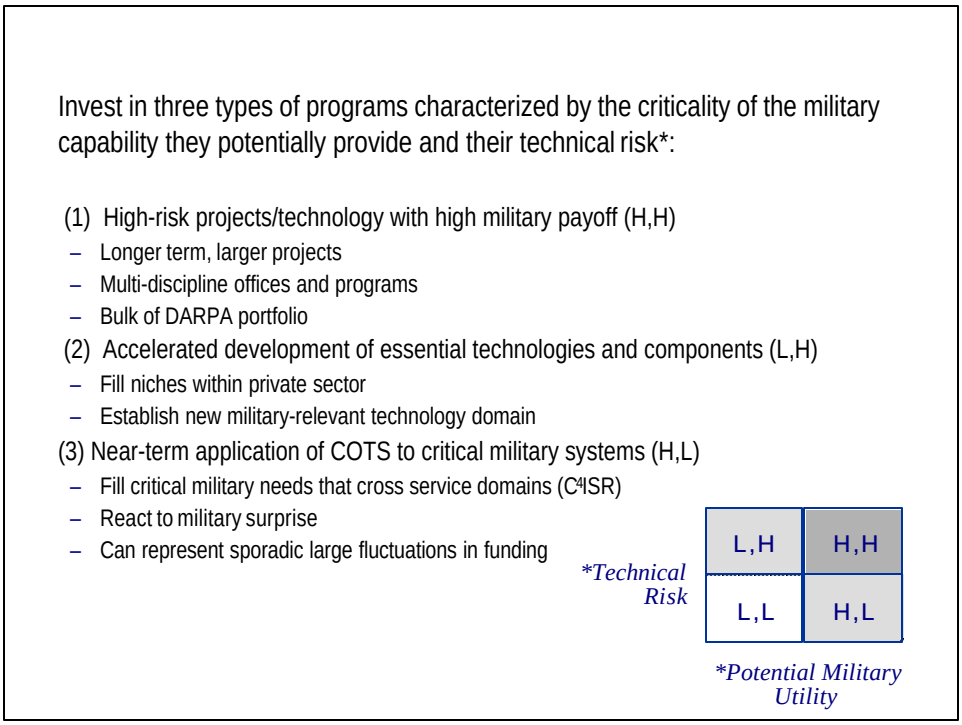


Figure 9. DARPA Investment Prospectus

Figure 10. Current Areas of Interest

The Task Force believes that six of the focus areas, indicated by checks in Figure 10, are areas where DARPA should significantly expand its investments. To carry out this investment strategy, the Task Force recommends that DARPA establish a number of thrusts in each area that address shortcomings to successfully counter these emerging asymmetric threats. Example thrusts might include chemical and biological defense, counter transnational threats, underground facility characterization and negation, and unmanned and robotics warfare. These thrusts should include a number of individual projects and programs supported by multi-office and multi-Program Manager participation. The thrust areas will consist of programs focused on both advanced technology development as well as system integration and demonstration.

Addressing these challenges will require longer-term programs and investments and will necessitate careful attention by DARPA management to Program Manager turnover, collaboration, and mentoring. To define and launch such thrusts, the Task Force believes that DARPA needs a more deliberate strategic planning process. DARPA's Director and Deputy Director should work closely with the Office Directors in establishing and implementing the Agency's long-term strategic vision. An integral part of the process will be to communicate that vision to individual Program Managers, USD(A&T), DDR&E, the Joint Staff, and Congress. It is critical that DARPA be supported by both DoD management and Congress as the Agency addresses the demanding technological challenges imposed by the military missions and threats that will be critical in the 21st century.

CHAPTER 5: THE EXTERNAL ENVIRONMENT

Throughout its history, DARPA has had to manage its relationships with communities outside the organization. Today's environment requires DARPA to place even greater emphasis on building and maintaining these relationships – with customers, constituents, and suppliers. Facing complex problems with fewer resources, there is a need to gain understanding of the priorities, research and development agendas, investment plans, and requirements internal to those communities. Ultimately DARPA cannot be successful if its agenda does not support and is not supported by the external community. DARPA's most important partners within DoD include the Office of the Secretary of Defense, Joint Staff, and military Service communities. Outside DoD, DARPA's partners include the intelligence community, Congress, academia, and the private sector, including both defense and commercial industry.

DARPA must maintain close ties with the Office of the Secretary of Defense and the Joint Staff to ensure a common vision for DARPA's programs. The USD(A&T), DDR&E, and the Joint Chiefs of Staff must develop a common understanding of the national imperatives and priorities that DARPA's programs should support and within which its programs should be framed. DARPA's relationship with other DoD components is also important in order to coordinate research priorities among the Service laboratories to avoid duplication and, more importantly, to facilitate technology transition. DDR&E's active participation in technology transition could help eliminate some of the transition bottlenecks that hinder moving DARPA-developed technology to the military Services.

DARPA must continue to collaborate with the military Services in order to maintain an understanding of the operational needs of the military and, in the long run, develop Service support for DARPA's efforts. The new joint and Service experimental laboratories should provide an opportunity to evaluate DARPA technology, help to determine program priorities, provide early feedback, help define meaningful experiments and demonstrations, introduce DARPA to CINC warfighting needs, and help to develop constituencies and realistic transition plans. Gaining an understanding of CINC needs and gaining endorsement from the CINCs will help to ensure that there is continuity in program development after DARPA investments end. DARPA must, however, resist requiring early military buy-in for its higher-risk programs as that requirement will inevitably drive program objectives towards near-term solutions and demonstrations. Feedback from the military community also helps to ensure that concepts are sufficiently mature to enter into the next stages of the development and acquisition process. DARPA has pioneered the use of innovative contracting within DoD. After obtaining legal authority to enter into "other transactions" in 1989, DARPA has entered into hundreds of flexible agreements with commercial firms and consortia as well as traditional defense contractors. These agreements initially involved cost sharing and were primarily useful in supporting dual-use technologies. In 1993, DARPA received additional authority to conduct prototype projects outside the traditional contracting statutes. This authority has been used to develop a number of new innovative system prototypes as well as a variety of sub-systems and components. Both these authorities have facilitated commercial business practices, unique teaming and management arrangements, and have attracted participation by companies and organizations that

do not traditionally do business with DoD. With the shrinking defense industrial base and new threats requiring DoD to deal with the bio-technology and pharmaceutical industries, among others, these authorities are vital to DARPA's future. If DARPA is to successfully and seamlessly transition prototypes developed under these authorities to the Military Services, the Services will need authority to conduct emerging model development and production programs with the same flexibility available to DARPA in its prototyping efforts. This will require legislative action.

The intelligence community is another important partner for DARPA. This partnership has lapsed in recent years and must be reestablished in order for DARPA to maintain awareness of emerging national security threats and intelligence community technological needs. Many of DARPA's current thrusts – such as biological warfare defense, information warfare defense, counters to transnational threats, and underground facilities characterization – are closely tied to intelligence community concerns. Understanding how the intelligence community is approaching the assessment of these threats can be valuable and helps to ensure that DARPA's programs remain relevant to the future. The intelligence community can also be a valuable partner in technology and system development, providing early evaluation of DARPA-sponsored technology, as appropriate.

DARPA's relationship with Congress has been uneven over the years, with DARPA largely playing a reactive role to Congressional direction. DARPA tends to deal with Congress largely from the Director's Office with interaction at the Office Director level occurring only sporadically. A more consistent approach to this relationship, reaching deeper into the DARPA management structure, would be valuable. DARPA should initiate regular meetings with Congress to share the Agency's priorities and programs as well as understand Congressional concerns and priorities. DARPA's Director must proactively provide Congress with a strategy and overall rationale for shifts in its investments – whether among thrust areas, levels of risk, or time horizon of investments. The Office Directors should also participate in this process by providing program-level specifics including information on new program initiatives, program goals, risks, milestones, and alternatives. Such an approach would greatly improve DARPA's relationship with Congress, creating a partnership that can lead to consensus building on funding priorities. DARPA, through its strategic planning process, will have enunciated its long-range R&D plans to the USD(A&T), DDR&E, and the Joint Staff. High-level DoD support for the DARPA portfolio will allow coherent response to Congressional concerns and issues.

Perhaps the most important relationship for DARPA to foster in the decades ahead is its interaction with the private sector, including both defense and commercial industry. This will be essential to establishing an appropriate investment strategy for the Agency. Consolidation in the defense industry is resulting in a reduction in internal research and development (IR&D) spending by defense companies as well as a reduction in the competition that drives technology development. IR&D spending on advanced technology has been reduced by 50 to 75 percent. DARPA needs to be better informed about where private industry is investing its resources to better leverage these investments.

To enhance its insight into commercial technology development, DARPA should hire Program Managers with established connections to commercial companies. The Agency should reach out to the private sector research community by conducting and attending seminars and symposia to assess private sector technology trends. Another outreach program would be to

establish regular meetings with Chief Technical Officers in specific technology domains to assess trends, gaps, and shortfalls in private sector technology roadmaps and plans. Through these avenues, DARPA can begin to create an environment of trust and collaboration with this community.

Understanding the private sector's investment strategy in technology areas where there is both defense and commercial interest is an important basis for identifying appropriate DARPA investments in these technology areas. In addition to understanding private sector investments, DARPA must understand the nature of the military's needs as well, identifying the investment areas that would prove most valuable for the Department. In areas where private industry is investing heavily in technology development, DARPA should become a niche player, extending the available technology where necessary to meet unique DoD needs.

Where there are limited private sector investments in technologies critical to DoD, DARPA should take a leadership position in developing a technology base. These investments should focus, however, on developing technology to meet national security needs and not on establishing a private sector industrial base. As technology development shifts from DoD to private sector dominance, DARPA must establish an exit strategy to transition from a position of technology leadership to one of a niche player. Once DARPA identifies a strategic plan for technology investment, these plans should be communicated to the private sector.

Semiconductor technology is an excellent example of how DARPA successfully made the transition from technology leader to niche player, as the case of integrated circuits in Figure 11 illustrates. In the early 1970s, the Department of Defense was a major consumer of integrated circuits. DoD played a major role in semiconductor development, with state-of-the-art integrated circuits driving the performance of defense systems and vice versa. However, the private sector's demand for semiconductors increased dramatically over the next two decades, resulting in DoD representing only 1.1 percent of worldwide semiconductor production, limiting DoD's influence in the market's product development. During this period DARPA shifted from a role of technology leader to niche player.

The case of advanced lithography technology is another example of how DARPA's investment strategy can complement commercial sector investments in a technology important to both sectors. DARPA has invested significantly in lithography technology, financing work in both deep ultra violet and x-ray lithography. There has been significant pressure from commercial industry and Congress for DARPA to continue and expand its investments in these technologies to augment the current programs being conducted within the commercial sector. The Task Force does not believe it is appropriate for DARPA to continue to invest in projects that represent an evolutionary improvement to existing deep ultra violet or x-ray capabilities. Rather DARPA should focus its investments in leap-ahead technologies – specifically on innovative research projects in unique, new methods of lithography. The Task Force supports the recent Broad Agency Announcement (BAA) from the DARPA Electronic Technology Office that focuses on innovative approaches to advanced lithography.

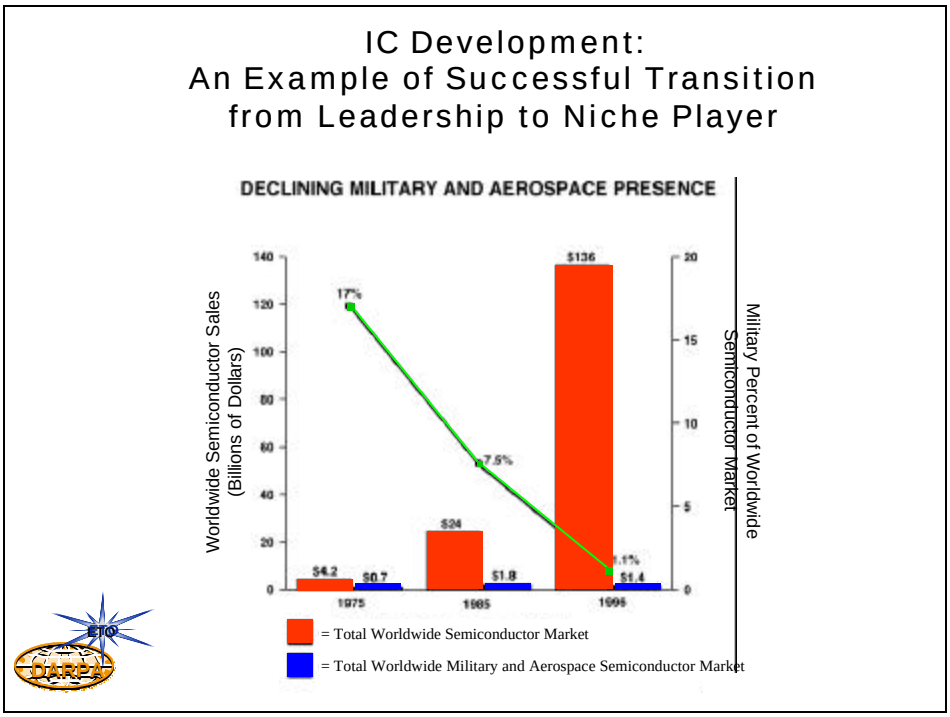


Figure 11. Integrated Circuit Development

The Task Force believes that DARPA should not provide stop-gap investments in areas where there is commercial utility but where the commercial sector is under investing. Nor should DARPA provide stop-gap investments to fill Service needs. DARPA's strategy should focus on identifying the key technology areas that will provide a distinct advantage for the Department in establishing and maintaining enduring superior military capabilities. In some cases this will require DARPA to take a leadership position in technology investment; in other cases it will be more appropriate for DARPA to be a niche player. An ongoing awareness of private sector investment strategies will enable DARPA to most effectively invest its own resources and to change its role when appropriate.

In order to maintain leadership in the science and technology community, the Task Force believes that DARPA needs to strengthen and tend to its external relationships on an ongoing basis. Only by working effectively with these communities can the nation's resources for science and technology development be most effectively invested and DARPA's investment strategy successfully implemented.

CHAPTER 6: FINDINGS AND RECOMMENDATIONS

DARPA has been highly successful throughout its history in providing the Department of Defense with science and technology research and development that has led to technological superiority in the country's military forces. Further, DARPA's leadership in technology development has led to the establishment of entire commercial industries. Over the decades of its existence, the Agency's research portfolio has changed – both in subject and in the time horizon of its efforts – in response to both external pressures and internal Department requirements.

In the recent past, DARPA has focused a significant fraction of its investments on near-term C^4ISR programs largely in response to deficiencies illuminated in Operation Desert Storm. Many of these investments have paid off and much of this work has matured and is being transitioned to the Services to support the acquisition of new C^4ISR systems. This emphasis during the mid-1990s was appropriate and responded to science and technology research priorities established by the Department's senior leadership.

DARPA is now at an important transition point as it moves into the 21st century. The adversaries of the future will be both capable and different, capitalizing on asymmetric responses to America's arsenal of forces and weapons. These asymmetric threats call for a new response and a new investment strategy. This strategy will require transition from a portfolio biased toward programs that address deficiencies in C^4ISR capabilities to one that addresses emerging asymmetric threats and the far more diverse missions that America's military forces will be called upon to execute.

As an agency, DARPA is capable of meeting this challenge. But it will require improvements in a number of areas, including setting objectives and strategy, personnel, program management, portfolio management, and awareness. The following summarizes the key Task Force findings in these areas.

Objectives and Strategy. DARPA should establish a systematic approach to strategic planning that provides clear definition of long-term Agency objectives in support of evolving national defense threats. Further, the planning process should incorporate increased awareness of intelligence, Department of Defense, and private sector needs and investments.

Portfolio. DARPA's current portfolio has many programs with short-term focus. An increasing fraction of the projects appear risk averse, with fewer high-risk and high payoff, longer-term program thrusts. Moreover there is a tendency to focus too much on early demonstrations and military acceptance. Today's portfolio has evolved largely in response to the Department's emphasis on C^4ISR deficiencies identified after Desert Storm.

Personnel. DARPA currently provides new Program Managers insufficient training, mentoring, corporate knowledge, and insight into military needs. Program Managers need to quickly come up to speed on DARPA's goals and objectives and the

Department's threats and requirements. Moreover the rotation policy, when strictly adhered to, results in a short-term focus for many programs.

Program Management. DARPA has difficulty executing larger, multi-office and multi-discipline programs. Programs can experience a gap in oversight and direction while new Program Managers focus on developing new programs; this is exacerbated by the lack of clear program objectives and exit criteria for many existing programs. There is limited collaboration and technical exchange among Program Managers, particularly across offices.

Awareness. DARPA needs to strengthen its interaction with external communities. Ties to the intelligence community have lapsed in recent years. The Agency's interaction with Congress has become largely reactive. There is no formal process for understanding emerging military needs. Further, DARPA needs to augment its means for understanding private sector plans, technology shortfalls, and investment gaps.

To address these concerns, DARPA must take the following steps:

Plan deliberately for the future. DARPA needs to strengthen its approach to strategic planning. The strategic planning process should be a collaboration between the Director's Office and the Office Directors. The resulting plan must be communicated to the Agency's Program Managers as well as the USD(A&T), DDR&E, Joint Staff, Congress, and the private sector. Caution should be taken not to make the process too bureaucratic, and resource flexibility must be maintained to be able to address emerging opportunities. DARPA's culture and approach to R&D management is unique and draws its strength from the independence and quality of its Program Managers. While DARPA management should regularly communicate their strategic plans, program composition, and research goals to DDR&E, care should be taken to not burden DARPA Program Managers with the TAP and TARA review processes that are used by DDR&E to coordinate the overall DoD S&T investment portfolio.

Structure an investment portfolio and program that includes several major thrusts that address critical national security challenges of the 21st century. DARPA's investment portfolio should include a mix of investments in technologies and system-level technology experiments focused on new and evolving national defense threats and warfighting concepts. The Task Force highlights six focus areas where DARPA should significantly expand its investments: chemical and biological warfare defense, assured information dissemination and management, counter transnational threats, underground facility characterization and negation, affordable precision target engagement, and unmanned and robotics warfare.

Selectively demonstrate major innovative projects and technologies. DARPA must retain the ability to address critical warfighting needs and demonstrate new capabilities that require short-term investments, on a selective basis. However, the Agency needs to be careful not to allow these near-term military deficiencies and a desire for immediate military acceptance, endorsement, or financial support of DARPA's research and development programs to bias the portfolio mix. DARPA should continue to use and pioneer innovative contracting vehicles for prototype

development, and the same authority should be extended to the military sources to allow for seamless transition of DARPA-developed systems to military-led acquisition programs.

Recruit highly qualified program managers from the public and private sector. DARPA's rotation policy enables the Agency to maintain a staff that is constantly at the cutting edge. DARPA must be able to hire the most qualified Program Managers from the public and private sector, as well as military officers. The use of IPAs, direct hiring from the private sector, and enough joint billets to attract the very best military officers are all important capabilities to ensure Program Manager quality. To ensure that they are effective in managing DARPA's programs, the Agency should develop a mentoring program that provides context on national security and military needs, program management success and failures and that helps to transition longer-term research and development objectives.

Create a structure for program management that addresses the needs of longer-term programs. Flexibility in Program Manager rotation policies that allows for a mix of short-term and selective "term extended" Program Managers, at the discretion of the DARPA Director, can bridge gaps in oversight due to rotations, and provide continuity and corporate history. Along with this flexibility, DARPA needs to develop a systematic project hand-off process to maintain program continuity. The Agency also needs an explicit mechanism for technical exchange and collaboration among Program Managers and across Program Offices. In addition, there needs to be an increased emphasis on defining clear program objectives and exit criteria to ensure smooth transition when research efforts are handed off from one Program Manager to another.

Be cognizant of the external environment, developing and maintaining strong relationships with the military, intelligence community, Congress, and the private sector. DARPA cannot be successful if its agenda does not support and is not supported by the external community. Today's environment requires DARPA to build and maintain these relationships with greater urgency in order to gain an understanding of priorities, research and development agendas, investment plans, and requirements. Visibility into private sector research and development will enable DARPA to establish priorities for investments in technology areas with both defense and commercial application and to develop strategies to transition from a technology leader to a niche player as private sector investments shift.

DARPA has a well-deserved reputation as an institution that is dynamic and successful in defense technology innovation. By evolving to meet the challenges posed by future threats, DARPA's performance and reputation will remain strong. Effective leadership – in establishing an investment strategy, maintaining an effective staff, and developing and maintaining relationships with the outside community – is the key to ensuring that DARPA remains a leader well into the future.

ANNEX A: TERMS OF REFERENCE

THE UNDER SECRETARY OF DEFENSE
3010 DEFENSE PENTAGON
WASHINGTON, D.C. 20301-3010

ACQUISITION AND TECHNOLOGY

30 OCT 1988

MEMORANDUM FOR CHAIRMAN, DEFENSE SCIENCE BOARD

SUBJECT: Terms of Reference- Defense Science Board Task Force on Investment Strategy for the Defense Advanced Research Projects Agency (DARPA)

You are requested to form a Defense Science Board (DSB) Task Force to examine DARPA's Investment Strategy. The Task Force should focus particularly on an assessment of DARPA's mix of near, mid, and far term technologies. Throughout its history, DARPA has jealousy maintained its ability to redirect its investment portfolio with great agility. During the mid- to late eighties, central emphasis was placed on the development and incorporation of newly developed advanced microelectronics and data processing technologies into weapons systems designed to meet the tactical and strategic military threat of the Soviet Union. When the wall came down in the early nineties, DARPA turned a new attention to dual-use technologies, those technologies which are both critical to military systems which also have commercial potential with the goal of reducing costs. This emphasis was accentuated by concerns in Congress over the slippage of the U.S. in high technology global competitiveness.

By the mid 1990's the U.S. had regained its position of superiority in global high technology production and DARPA again shifted its focus back to military capabilities. But this time the focus was different-DARPA would emphasize information technologies, particularly those that promised to enable much enhanced battlefield situational awareness-and biotechnology with the difference that in both cases the commercial industry is technologically ahead of the military and the gap is widening. DARPA can shift focus, however, only by concluding old projects to free up resources for new pursuits. This means that the character of the overall portfolio changes continually.

Recently, controversy has risen over DARPA's current directions. Specifically, some important observers believe that they have identified a bias in DARPA's investment patterns which favors both very near-term (that is, with a payoff within two years) and long-term (with a payoff beyond 10-15 years). The concern is that DARPA has systematically abandoned very important, mid-term technologies which offer a potential yield within 5-7 years which are also very important to maintaining commercial economic vigor in the U.S. This issue, the so-called "mid-term" problem has been raised in numerous congressional hearings and committee reports.

This task force should address the following questions:

1. Is there currently a bias of DARPA investment to near-term and far-term technologies, and away from technologies with a yield in the mid-term?

2. Is the current mix (near, mid, and far) appropriate or inappropriate, given current directions, capabilities, and resources of commercial, high technology industry?

3. How can DARPA maintain a vision into technology developments within the commercial sector so that it does not duplicate what is likely to happen, commercially, anyway?

4. Where a technology is already receiving (or is about to receive) considerable commercial attention, what are the appropriate criteria that DARPA should use for assessing the probability that further Government investment will be influential?

5. How should DARPA strengthen its relationship with commercial technology developers to complement its relationship with defense developers?

6. What should be the relationship between DARPA and the military customer, as well as the relationship with the National Intelligence Community?

This study will be co-sponsored by USD (A&T) and the Director, Defense Research and Engineering (DDR&E). Mr. Vincent Vitto will serve as the Chairman of the Task Force. Dr. Bruce Gnade, Defense Advanced Research Projects Agency, will serve as Executive Secretary. CAPT Jim Lyons, USN will be the Defense Science Board Secretariat Representative.

The Task Force will operate in accordance with the provisions of P.L. 92-463, the "Federal Advisory Committee Act," and DoD Directive 5105.4, the "DoD Federal Advisory Committee Management Program." It is not anticipated that this Task Force will need to go into any "particular matters" within the meaning of section 208 of Title 18, U.S. Code, nor will it cause any member to be placed in the position of acting as a procurement official.

J. S. Gansler

ANNEX B: TASK FORCE MEMBERSHIP

CHAIRMAN

Mr. Vincent Vitto
Draper Laboratory

MEMBERS

Dr. Elliot Brown UCLA	Mr. Alan McLaughlin MIT Lincoln Laboratory
Dr. John Foster TRW, Inc.	Dr. Vincent Mrstik Toyon
Dr. Michael Frankel SRI International	Mr. Robert Stein Raytheon Company
Dr. John Hennessy Stanford University	Mr. Dale Von Haase Lockheed Martin
Dr. Miriam John Sandia National Laboratory	Dr. Robert Weiss Physical Sciences, Inc.

EXECUTIVE SECRETARY

Mr. Bruce Gnade
DARPA

DEFENSE SCIENCE BOARD MILITARY ASSISTANT

CAPT Jim Lyons, USN

STAFF

Ms. Marya Bavis
Ms. Barbara Bicksler
Ms. Julie Evans
Strategic Analysis, Inc.

ANNEX C: SUMMARY OF BRIEFINGS

OCTOBER 30, 1998

SENATOR LIEBERMAN'S OFFICE
Dr. Peter Rooney, Senior Fellow
Mr. William Bonvillian, Legislative Director and Chief Counsel

Dr. Frank Fernandez
Director, DARPA

NOVEMBER 11-12, 1998

DARPA OFFICE DIRECTORS
Dr. Noel MacDonald, Director, ETO
Dr. William Mularie, Director, ISO
Mr. James Carlini, Director, STO
Dr. Larry Dubois, Director, DSO
Dr. David Whelan, Director, TTO
Dr. David Tennenhouse, Director, ITO

Dr. Jane Alexander, Deputy Director, DARPA

DECEMBER 9-11, 1998

Mr. Dave Ream, Director, Standards of Conduct
Dr. Robert Kahn, President, CNRI
Dr. Delores Etter, DUSD, Science and Technology
Dr. Vic Reis, Department of Energy
Dr. Jeff Freidhoffer, Technical Director of Technology and Systems, NSA
Dr. Anita Jones, University of Virginia
Dr. Gary Denman, GRC International