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BEFORE

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EMERGING THREATS AND CAPABILITIES SUBCOMMITTEE

DEFENSE WIDE RESEARCH AND DEVELOPMENT

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Mr. Chairman and Members of the Subcommittee

We appreciate the opportunity to appear before you today to report on a wide range of research and development issues. Before taking your questions, we would like to spend a few minutes giving you our perspective on where we are today in providing our forces with the best equipment and support possible, where we want to be -- both in the near future and within the next 10 or 20 years -- and how research and development plays a key role in that future.

For ease of reference, we have divided this report into 9 major sections:

RESPONDING TO NEW THREATS

The 1997 Quadrennial Defense Review outlined the prospect of continued global dangers and established our strategic goals for meeting projected threats in the early 21st century. It is our strategy to promote regional peacekeeping efforts; to prevent or reduce conflicts and threats; to deter aggression and coercion; and to respond to the full spectrum of potential crises. In order to carry out this strategy, the U.S. military must be prepared to conduct multiple, concurrent, contingency operations worldwide. It must be able to do so in any environment, including one in which an adversary uses asymmetric means, such as nuclear, biological, or chemical weapons. Our combat forces must be organized, trained, equipped, and managed with multiple missions in mind.

The security environment in which we live is dynamic and uncertain, replete with a host of threats and challenges that we have the potential to grow more deadly. We are not facing a few disorganized political zealots armed with pistols and hand grenades. Rather, we must defend against well-organized forces armed with sophisticated, deadly weapons and access to advanced information and technology. They represent a different and difficult challenge to forces organized and equipped around traditional missions (particularly when we must also continue to expend significant resources to be equally prepared for potential, more traditional missions.

Future, hostile forces are unlikely to attempt to match overwhelming U.S. superiority on a plane-for-plane, ship-for-ship, or tank-for-tank basis, but are more likely to use asymmetrical strategies against us -- including weapons of mass destruction,

"information warfare", and large quantities of relatively low-cost cruise and ballistic missiles. They can also utilize commercial navigation, communications, and imagery satellites.

The Defense Science Board, in its 1998 Summer Study Task Force Report on our response to transnational threats, warned that, today, even an adversary with a relatively small defense budget can become a significant regional threat and, increasingly, can project (or threaten to project) this threat worldwide. It noted that this smaller adversary can present a non-traditional military force as deadly and destructive as large conventional forces. Military conflict is being dramatically transformed by the rapidly-changing nature of modern technology.

Of course, this is nothing new. Throughout history, advances in technology have directly and indirectly transformed the course of warfare. From spear and longbow, to the invention of gunpowder and dynamite, to the use of aircraft and the machine gun, and on to chemical, nuclear, and biological weapons, as well as the current information age, we have seen how revolutionary advances in weaponry have influenced the nature and extent of combat.

THE REVOLUTION IN MILITARY AFFAIRS AND BUSINESS AFFAIRS

How do we counter these changing threats and keep ahead of accelerated modernization by the new adversaries facing us in the early 21st century? Clearly, we must

perform better than they do and retain our vast superiority in the quality of our personnel and in our force's mobility, global projection, and weapon technology. These, combined with "information superiority", will assure our nation's future security posture.

Revolution in Military Affairs

Our vision for the 21st century is a warfighting force that is fast, lean, mobile, and prepared for battle with total battlespace situation awareness and information assurance. Our military strategy, as stated in the Joint Chiefs of Staff "Joint Vision 2010" posture statement, is to be based on Information Superiority -- real-time intelligence from "sensor to shooter". When combined with precision weapon delivery, this is the backbone of the "Revolution In Military Affairs" that will allow us to achieve total battlefield dominance.

Dominance of the 21st century's digital battlefield will come only to those able to "see" clearly across all intelligence disciplines and maintain a constant stream of information to decision makers, warfighters, and to a new breed of "brilliant" weapons. Modern, so-called "reconnaissance/ strike" warfare (often referred to as the essence of the "Revolution In Military Affairs") is based on real-time, all-weather, accurate and secure information systems, combined with long-range, unmanned, "brilliant", highly-lethal weapons designed to achieve precision kills. Put more simply, we must be able to <u>find</u>, <u>follow</u>, and <u>engage</u> the enemy with lethal force using weapons that allow us the flexibility to quickly modify the mission parameters. The digitized battlefield will provide commanders at all levels the information needed for complete situational awareness, and it will allow the acquisition, exchange, and employment of information to support planning and execution

in a joint network-centric battlespace. Moreover, the cornerstone of this network-centric warfare is the use of satellites, ground terminal equipment, and modern radios that provide the sensor-to-shooter links so vital to the future warfighting.

The 21st century battlespace will also require an entirely new generation of advanced technology on the battlefield -- from improved sensor technology to an increased ability to identify moving targets, to far better systems-of-systems integration, not to mention a renewed examination of remote piloted vehicles as platforms for both delivery and observation. Many of these requirements are of course already the targets of our research and development efforts: for instance, hyperspectral imaging will provide us a new resource for "nowhere to hide" capability, including characterization of hardened and deeply buried targets.

Revolution in Business Affairs

To help pay for this Revolution in Military Affairs, Secretary Cohen announced, in November of 1997, the Defense Reform Initiative. The DRI, as it is called, is a basic restructuring of the way the Department does business. It calls for a "Revolution In Business Affairs". Although our military is unquestionably the strongest in the world, our defense establishment has labored under outdated and outmoded policies, procedures, and infrastructure -- designed to deal with a Cold War threat -- many of which are at least a decade out of date and far behind the private sector which, restructured and revitalized, is now competing strongly in a dynamic global marketplace.

Our technological advantage is quickly lost unless we keep at least two steps -- and several technological generations -- ahead of the enemy. This requires us to reduce cycle times in the development, procurement, and updating of new and modified weapon systems. In order to meet the demands for such vastly reduced cycle times, we determined that we needed to abandon traditional methods of acquiring advanced technology. We must accelerate, broaden, and institutionalize our acquisition reform -- thus shifting resources from infrastructure and support to combat and more effective modernization. This deals with the Business Revolution in its broadest context: from competitive sourcing of all work that is not inherently governmental; to privatization of housing; and, of course, continuation and full implementation of the weapons acquisition reforms begun and expanded over the last few years. If we are to produce affordable systems quickly, (which is required to keep up with the new technology cycles), we clearly must pursue non-traditional approaches; such as maximum use of commercial equipment, as well as significant design process changes, and, (in the production area), use of integrated -- commercial and military -- assembly lines for defense-unique items, taking maximum advantage of the potential offered by flexible manufacturing and "lean" design and production techniques.

Clearly, many -- if not most -- of our future conflicts will require ground forces. But, in general, our approach will be to replace massed <u>forces</u> with massed <u>firepowe</u>r, precisely placed on targets. Our reaction to new forms of aggression must be swift and decisive. The first few days, if not the first few hours, can easily determine the outcome. Our response

must come within hours, with sustainability in place in days -- not in weeks or months. Such responsiveness requires a significant change in doctrine, tactics, organization, equipment, and, particularly, decision making -- a task made far more challenging in a coalition environment. Each of the Services and each of the CINCs are now going through such transformations.

Just a few years ago, performance was our benchmark for developing new weapons systems; today it is performance at affordable cost -- specifically, at a cost that will allow us to obtain the quantities required. Today, "cost" is a requirement that must be considered at every stage of our acquisition process -- while still continuing to enhance weapons' performance.

We know we must look across the spectrum in our decision making process. The Army has developed a simulation based acquisition system know as "SMART" – Simulation and Modeling for Acquisition, Requirements, and Training. The vision for SMART is a process that capitalizes on modeling and simulation (M&S) tools and technology to build high quality weapon systems and equipment in a cost effective and efficient manner. The Crusader program is currently in development and provides a good example of SMART application and the benefits that result. This howitzer and its resupply vehicle will give the Army, for the first time in decades, a system for providing close artillery fires that match and exceed the capabilities of potential enemies. Crusader will be the premier cannon system in the world, with significantly enhanced mobility, range, rate of fire, and survivability. Using the virtual prototype, a physical interference with the two

automatic munitions loading arms was discovered. Engineers were able to redesign the prototype and verify that a single arm loader resolved the interference problem and still met weapon system specifications and criteria. This design flaw would have been costly to the program had it not been discovered and resolved early, before the system went into production.

The leadership of the Department of the Navy signed out its first ever *DoN Business Vision and Goals* (BVG) in July of 1999. The Navy Revolution in Business Affairs is a broad business vision, a set of business goals, and a series of initiatives focused on moving toward that vision. There are many on-going programs and initiatives that fit into the business vision. The Navy's SMART WORK Program is committed to improving the quality of the work environment. It focuses on the fact that people are our most important asset. We are therefore funding many SMART WORK initiatives focused on achieving efficiencies and relieving our personnel of burdensome or unnecessary work: advanced paint coatings and contractor preservation teams to more effectively and efficiently maintain our ships; automating fuel fill control systems to reduce oil spills; and other initiatives to reduce repetitive maintenance for our personnel. The Navy is also instituting an "Enterprise Resource Planning system which will allow the entering of financial and inventory information just once. It will permit everyone from the Secretary of the Navy to the youngest seaman recruit to work from a common database. Last year, Congress designated the Department of the Navy as the executive agent for implementing SmartCard throughout DoD. They have already issued a SmartCard to every recruit at Great Lakes

"bootcamp" and by this summer, should have SmartCard installed on four battle groups and amphibious readiness groups.

Our defense industrial base has undergone necessary consolidation; and we, in turn, must capitalize on the lessons learned from the successful commercial transformation -- how to adopt modern business practices; consolidate and streamline; embrace competitive market strategies; and eliminate or reduce excess support structures. Our future direction must include greater competition; greater civilian/military integration; and strengthened global links, in order to achieve the full potential of our defense industrial base.

Unfortunately, potential adversaries are able to rapidly capitalize on modern technology, for example: commercial communications/navigation/earth surveillance satellites, low-cost biological/chemical weapons, cruise and ballistic missiles, etc. If they can't develop them, they can purchase them -- and the skills to use them -- on the world arms market. Therefore, we must develop effective countermeasures to this technology; for example: information warfare defenses, vaccines and special medical agents to counter biological and chemical weapons, defenses against ballistic and cruise missiles, and the ability to destroy hard and deeply buried targets. In some respects, we have become the victims of our own technological advances. Our successes in using new technology to our advantage in operations such as Desert Storm and Bosnia have made those technologies an object for acquisition by all.

Yet we have no choice. We must develop the defenses and we must do so in a coalition context. For example, ballistic missile defense -- essentially hitting a bullet with a bullet -- poses a particularly difficult challenge; and deploying an integrated coalition theater missile defense system -- one that collectively hits all the incoming missiles instead of all of us going for the first one coming at us -- is an even more demanding technical and management problem. Unless all systems -- weapons communications and command and control -- are fully interoperable, the complex job of theater missile defense cannot be effectively achieved.

In addition to developing and deploying countermeasures to our adversaries' use of advanced technology (weapons of mass destruction, information warfare, etc.), perhaps the most important implication of the revolution in technology and its global spread is the need for the acceleration of advances in technology, in order to maintain superiority on the battlefield.

RESEARCH AND DEVELOPMENT GOALS

From a Research and Development perspective, to accomplish this, we must ensure that the warfighters today and tomorrow have superior and affordable technology to support their missions, and to give them revolutionary war-winning capabilities. Our number one acquisition priority is providing the weapons and equipment our combat forces and our allies will need to meet our strategic objectives in 2010 and beyond. One of the difficulties is that we must always be looking with one eye to the day ahead and another

eye to the distant future -- ten or twenty years down the line. What do we need to serve the warfighter in 2010 and insure our national security well into the 21st century? There are five weapons-oriented goals we are working to address:

- **First, in the information area, to achieve an interoperable, integrated, secure, and "smart" command, control, communications, computer, intelligence, surveillance, and reconnaissance (C^4ISR) infrastructure that encompasses both strategic and tactical needs.**
- **Second, in the "strike" area, to develop and deploy -- in sufficient quantities -- long-range, all-weather, low-cost, precise, and "brilliant" weapons for both offensive and defensive use.**
- **Third, to achieve rapid force projection, global reach, and greater mobility for our forces. With uncertainty over where they will be required, and the need for extremely rapid response to a crisis anywhere in the world, this capability -- when combined with the first two elements -- will provide us with overwhelming military superiority.**
- **Fourth, to develop and deploy credible deterrents and, if necessary, military defense against projected, less traditional early 21st century threats -- which include: biological, chemical, and nuclear weapons; urban combat; information warfare; and large numbers of relatively low-cost ballistic and cruise missiles. These threats represent priority issues for our resources -- even if it means impacting some of our more traditional areas.**
- **Fifth and finally, to achieve not only inter-service jointness, but also interoperability with our Allies. This is essential for coalition warfare and even more important given**

the realization that coalition-driven operations will become the norm, rather than the exception, in the future. We must insure that our allies' technologies complement those of our overall forces. To accomplish our goal of information superiority, we are taking steps to make certain that the C^4ISR systems and advanced weapons -- such as theater missile defense systems – of ourselves and our allies are fully interoperable.

BUDGET OVERVIEW

The overall Defense budget can be viewed as a balance between funding for today's forces ("readiness"), funding to recruit, retain, and equip the next force, and funding to develop the technology for the force after next (the latter two making up the DoD's short term and long term "modernization" accounts). The Services' request in FY 2001 for readiness (pay of personnel, training, maintenance of equipment, etc) represents 78% of the Army's budget, 62% of the Navy's budget, and 60% of the Air Force's budget. The funding required for short term modernization, for the next Army, the next Air Force, and the next Navy, consists of both procurement and test and development dollars. It also provides for the full-scale engineering development of new systems, for system upgrades, and for procurement of follow-on systems (so called "weapon modifications").

Overall, the combined modernization funding consists of procurement, as well as research, development, test, and evaluation (RDT&E). In RDT&E, 20% is science and technology (S&T) with the remaining 80% spread as 33% for Operational System

Development, 23% for Engineering Manufacturing Development, and 18% for Demonstration and Validation. The remaining 6% is management support.

This year the Department is requesting approximately $38B in Research and Development; of that amount, the science and technology request is $7.57B.

In the FY 2001 budget request, after inflation (i.e. in real dollars), we increased our readiness accounts by +4%, our total research and development +8% and our procurement by +12%, over the FY 2000 request. In the procurement area we meet our goal of $60B, and with our R&D we insure our long-term modernization – all while satisfying our critical short term readiness issues.

RESEARCH AND DEVELOPMENT PROGRAMS

The Research and Development goals described above, form the platform of the Revolution in Military Affairs. To pay for these new systems, as we said, we are engaged in an equally important Revolution in Business Affairs. There is no question that the way the DoD does its business is significantly different today than it was five years ago, and even just one year ago. We still have a long way to go, but, on most fronts, we can report progress and substantial successes in transforming the way the Department does its business, in areas such as use of commercial practices and distribution systems to satisfy materiel acquisition and support requirements; more competitive sourcing of current in-house work; and greatly expanded purchase of common-use, commercially available, goods and services. We have highlighted below some of our key major programs that are in the

FY 2001 R&D funding request. These programs have capitalized on both Revolutions -- providing the needed mission capabilities at lower cost.

Joint Strike Fighter

Modernization of aviation forces includes DoD's largest acquisition program: the Joint Strike Fighter (JSF). The JSF program will develop and field an affordable, highly common family of next generation strike fighter aircraft. The conventional takeoff and landing (CTOL) variant replaces the F-16, the A-10's, and complements the F-22 in the USAF (1763 total). The short takeoff and vertical landing (STOVL) variant replaces USMC F/A-18A/C/D and AV-8B (609 total). The carrier based variant (CV) provides stealthy strike aircraft to complement the Navy F/A-18E/F (480 total). An evolutionary acquisition strategy is planned for the JSF, which will ensure it is updated with the latest technologies to aid the warfighters. In FY 2001 this program is funded at $859M in RDT&E.

F-22

The F-22 will replace the F-15C/D in the air superiority role and have substantial air-to-ground capability as well. The F-22 aircraft will provide the warfighter with a platform that will be the premier air dominance fighter in the world. It will dominate the vertical battlespace of the 21st Century with its revolutionary combination of stealth, supercruise, maneuverability, and integrated avionics. Armed with the AIM-9X infrared

short-range air-to-air missile, an improved AIM-120 AMRAAM missile, and the 1000 lb Joint Direct Attack Munition (JDAM) the F-22 will be able to destroy threats to our forces in the air and on the ground. The revolutionary F-22 is optimized for the air-to-air environment, providing air dominance across the future battlespace using a combination of stealth, supercruise, agility, and integrated avionics. This deadly combination allows the F-22 to penetrate and suppress the most lethal ground-based and airborne systems of the next century. The total buy is planned at 333 aircraft with the last aircraft being delivered in 2013. In FY 2001 this program is funded at $1,412M in RDT&E.

Future Combat Systems (FCS)

This is the objective family of vehicles for the "transformed" Army combat forces, which are planned for post-FY 2012. Prior to the availability of the Future Combat Systems (FCS), the Interim Armored Vehicle (IAV), afamily of highly mobile and transportable vehicles is planned to fill all or most of the combat vehicle roles in the Army's "transformed" units. Like the IAV, the FCS vehicles will be in the C-130 transportable weight class (less than approximately 20 tons each). However, the technology leap-ahead capabilities of the FCS in lethality and survivability will permit the FCS-equipped forces to be dominant all along the spectrum of conflict, including the intense close combat of a Major Theater War. The combined IAV and FCS funding for FY 2001 (from both the Army and DARPA) is $213.7M in RDT&E.

DD 21

The transformation of U.S. forces is exemplified by the Navy's new DD 21 destroyer. It is the first in the family of SC 21 ships, its design will emphasize stealth, lower operating costs, and will be a multi-mission surface combatant tailored for land attack and maritime dominance. The DD 21 will provide offensive land attack capability, forward presence and deterrence, and operate as an integral part of joint and combined expeditionary forces. To ensure effective operations in the littoral, DD 21 will feature full-spectrum signature reductions, active and passive self-defense systems, and cutting-edge survivability features, such as in-stride mine avoidance. DD 21 will be the Navy's first class of ships to have a fully integrated electric power system, including electric drive. This revolutionary electric-drive propulsion system will save space, cut noise, and economically deliver abundant power. DD 21 will also introduce revolutionary advances in surface ship technology including: integrated power system, total ship computing, multi-function radar, volume search radar, advanced gun system, and advanced land attack missile. Key cost and manning objectives include: reduced production cost objective ($750M each), 70% reduction in O&S cost from a DDG 51, and a crew of only 95 personnel (significantly reduced from that of a DDG 51 which uses a crew of 325). It is intended to replace the FFG 7s and DD 963s. In FY 2001 the funding proposed is $555M in RDT&E.

National Missile Defense

The FY 2001 budget provides the funding needed to deploy a National Missile Defense (NMD) system to defend all 50 states against a limited ballistic missile attack from states that threaten international peace and security. Later this year the President is expected to determine in 2000 whether to deploy limited national missile defense against ballistic missile threats to the United States from rogue states. The Administration's decision will be based on an assessment of the four factors that must be taken in account in deciding whether to field this system: 1 whether the threat is materializing, 2. the status of technology based on an initial series of rigorous flight tests and the proposed system's operational effectiveness, 3. whether the system is affordable, and 4. the implications that going forward with NMD would have for the overall strategic environment and our arms control objectives, including efforts to achive further reductions in strategic nuclear arms under START II and START III. The budget for FY 2001-2005 includes $10.4 billion in NMD funding to both achieve a 2005 initial capability, and expand that capability in 2006-2007, if deployment is ordered. The budget will allow DoD to upgrade early warning radar facilities, build a x-band radar complex, provide 100 ground based interceptors, and fund additional systems testing. When fully deployed in 2007, this system will be capable of defending the United States against a launch of a few tens of warheads with simple countermeasures. The follow-on architecture will provide additional capability to defend the United States against a launch of a few tens of warheads with complex countermeasures. The funding proposed for NMD in FY 2001 is $1.740B in RDT&E.

Theater Missile Defense

Our efforts continue on a strong theater air and missile defense program that can protect forward-deployed U.S. forces, as well as allies -- aimed at meeting current and near-term regional threats. Our lower-tier programs, Patriot Advance Capability-3 (PAC-3) and Navy Area Defense (NAD), are focused on short-range, tactical ballistic missiles. PAC-3 and NAD will greatly improve protection of defended assets by using hit-to-kill intercept technology that destroys weapons of mass destruction and prevents the missile content from falling on the protected area. To meet the medium-range ballistic missile threat, we are pursuing two Upper Tier Theater Missile Defense programs: Theater High Altitude Area Defense (THAAD) and Navy Theater Wide (NTW). THAAD's schedule supports a FY 2007 First Unit Equipped (FUE) date. NTW plans to deploy its capability in blocks. A capability using a reconfigurable ship can reach FUE in 2008, and a capability that fully meets operational requirements can be available in 2010. Both Upper Tier programs should proceed based on demonstrated success. While we have funded THAAD adequately in the Future Years Defense Program, funding for NTW will be dependent on successful flight-testing occurring between now and FY 2002. Finally, to gain greater mobility for our forward-deployed troops we are jointly developing – with our German and Italian allies – the MEADS program. The total RDT&E funding for TMD (PAC-3, NAD, THAADS, NTW, MEADS and the Family of System Engineering and Integration) in FY 2001 is proposed at $1.582B.

In addition to these Ballistic Missile Defense Organization-managed programs, we are pursuing the Air Force's Airborne Laser Program for boost-phase intercept and a joint Air Force-BMDO effort on Space Based Laser targeted for an Integrated Flight Experiment in FY 2012. These longer-term programs aimed at (defeating) hostile missiles during their ascent phase.

SOFTWARE INTENSIVE SYSTEMS

Software is at the heart of the nation's warfighting capability, as more weapon system developments and upgrades increase reliance on software to provide the flexibility to meet future unknown requirements. In Kosovo, for instance, rapid response to threat changes was only possible with weapon system software updates sent in real-time, via secure web technology, to the field.

However, the acquisition, development and sustainment of software-intensive systems has had significant problems, with almost all large efforts undergoing major cost and schedule overruns. The Department of Defense has had several initiatives to improve software productivity and quality, but they have not been coordinated in the past. In addition, lessons learned by industry for process improvement have not been widely adopted by DoD programs.

We recently initiated an effort to leverage current software improvement activities to provide synergy among the department's independent initiatives. The effort applies

software process discipline to all major weapon system procurements by requiring Software Engineering Institute (SEI) Capability Maturity Model Level 3 compliance, or an equivalent level from other approved evaluation tools.

This effort coordinates work done by over 30 defense and service software engineering expert organizations. We will work with the Services to provide software acquisition management training for all major system Program Managers and their key staff.

SCIENCE AND TECHNOLOGY

The Department's Science and Technology Program ensures that the warfighters today and tomorrow have superior and affordable technology to support their missions, and to give them revolutionary war-winning capabilities. In short, this is the foundation of the Department's RDT&E program. It provides the technological edge that deters aggression and minimizes the endangerment of our young men and women in battle when deterrence fails. As mentioned earlier, the science and technology RDT&E request budget for FY 2001 is $7.54 billion.

I would like to take a moment to address the requirements of Section 212 of the NDAA for FY 2000. That Section requires us either (1) to increase for the S&T programs by 2% in real growth over the budget for the proceeding year or (2) to certify to the Congress that the budget does not jeopardize the stability of the defense technology base or increase the risk of failure to maintain technological superiority in future weapon systems.

We will present you shortly with a complete certification addressing that issue. However in the meantime I would like to make a few points.

We believe the DoD S&T program is indeed adequate to protect the stability of the defense technology base and to maintain technological superiority in our future weapon systems. We did not meet the 2% real increase goal for FY 2001. However, we have provided zero real growth plus $48 million over the FY 2000 budget request level. In addition to the FY 2001 request after inflation we increased total research and development by 8% and procurement by 12% over the FY 2000 request. This was done to meet our goal of a $60 billion procurement to ensure that acquisition programs in final development are ready to transition. In fact we believe when compared with S&T funding levels a longer period of years, the President's Budget funding request for FY 2001 will be seen to be quite respectable.

What follows are the roles of important pillars of our science and technology program and a brief discussions of the priorities of that program.

OVERALL SCIENCE AND TECHNOLOGY PARTNERSHIPS

The Department's investment in Science and Technology is executed through a partnership among our Defense agencies, Service laboratories, universities, industry, and international partners. Each "member" of this partnership provides different capabilities and strengths.

Defense Advanced Research Projects Agency

DARPA is the Department's technical enabler for radical innovation in support of national security. DARPA's budget ($1.95B) represents 25 percent of the Department's FY 2001 science and technology program. The Agency's investment strategy is three-pronged, focusing approximately 15 percent of its FY 2001 resources on technical solutions to the national concerns of protection from biological warfare and information warfare attack. The balance of the DARPA investment portfolio is divided approximately equally between the Agency's two other mission areas -- providing technologies and systems to give the U.S. military dominance across all types of operations with minimum risk to our warfighters, and developing and exploiting disruptive, high-risk, high-payoff core technologies. The operational dominance programs include technologies and systems for affordable, precision moving target kill and for maneuver warfare capabilities for small, early-entry forces. Other programs in this area include systems to provide dynamic command and control capabilities, correctly classify hard and deeply buried targets, and provide near-real-time logistics planning and replanning capabilities. Lastly, DARPA is working directly with the Services on some of their most advanced warfare concepts – with the Air Force and the Navy on the Unmanned Combat Air Vehicle Advanced Technology Demonstration, with the Army on the Future Combat Systems program, with the Navy on the Submarine Payloads and Sensors programs and has underway a program to understand and use characteristics of the sensors in a dog's nose that may make feasible a universal chemical detection system. The Agency's investment in technologies and systems

for advanced military capabilities is balanced by its continued investment in the underlying enabling technologies that have formed the core of DARPA's technical expertise over the years -- information technology, microsystems technologies, materials technologies and mathematics. Added to this list in FY 2001 is the Agency's effort to combine biology with information technology, electronics, optoelectronics, sensors and actuators to bring tremendous new capabilities to far-future military systems.

Defense Threat Reduction Agency And Ballistic Missile Defense Organization

Our other Defense agencies, in conjunction with DARPA and the Services, provide a focus on special emerging threats. Current technology and operations are threatened by the specter of emerging chemical, biological and radiation threats, as well as theater and intercontinental missile delivery systems. Future technology will have to provide a broad spectrum coverage to respond to these emerging threats. Chemical and biological detection technologies, physical protection systems (e.g., masks) and medical countermeasures will exploit discoveries defining common chemical and biological principles in order to achieve a broad-spectrum coverage of threats.

The Defense Threat Reduction Agency (DTRA) was created on October 1, 1998. Established by the Defense Reform Initiative in November 1997, this Agency consolidates in one organization the bulk of DoD's arms control, cooperative threat reduction, technology security and weapons of mass destruction (WMD)-related research,

development, test, and evaluation (RDT&E) programs, and with OSD oversight has coordinating and budget execution responsibility for Joint Services Chemical/Biological (CB) Program. In addition to executing the current programs, DTRA was tasked to develop an overarching architecture for response to the threat posed by WMD, both to civil and military populations, and to become a stronger and fuller partner with the Department of Energy (DOE) in the maintenance of the physical and doctrinal components of nuclear deterrence. Today, DTRA is developing technologies that will support deterring the use of WMD, reducing the present threat, and preparing for the future threat. In order to prepare for the future, DTRA will be a key element in supporting the Hard and Deeply Buried Target Defeat Program, a newly established Joint Warfare Capability Objective to deny sanctuary to adversaries by developing end-to-end capabilities for detection, characterization, target planning, defeat, and combat assessment directed at deeply buried, tunnel, and other hardened high value facilities. DTRA supports the regional Commanders in Chiefs (CINCs) with technologies that allow CINCs to target WMD facilities or deal with WMD events directed at their troops and facilities. DTRA's Air/Sea Port of Departure (APOD/SPOD) analysis of the effects a chemically contaminated environment will dramatically alter the worldwide strategic movement of troops and supplies. For the Joint Chiefs of Staff, the Agency continues to execute the vulnerability assessment of U.S. military facilities while providing technology solutions that enhance force survivability. Working jointly with DOE, the FBI, and DARPA, DTRA is forming a consortium to pursue a "Smart Building" project. By coupling sensors for CB agents currently under development for both civil and military applications with decision-making software, meteorological sensors, and the controls for building air handling equipment,

DTRA shall be able to modify structures to minimize the consequences of external or internal releases of toxic or infectious agents. DTRA also has formalized a strategic partnership on consequence management with the Joint Forces Command and the Joint Task Force for Civil Support in the areas of exercise planning and execution, modeling and simulation, and operational and analytical support. In partnership with the US Strategic Command, DTRA has also developed the first edition of the Nuclear Mission Management Plan which will provide a comprehensive, end-to-end roadmap to lead DoD nuclear forces into the 21st Century. As part of an ongoing effort to examine the national level response to various WMD scenarios, the development of doctrine, and the establishment of national policy, DTRA's quality of work has enabled our government to advance itself by two years.

Finally, some highlights of the BMDO S & T program include developing the technology to more rapidly detect theater and intercontinental missiles against a cluttered background, as well as technology to improve the robustness and performance of the atmospheric interceptor missiles being developed throughout the Department.

Service Laboratories

The Service laboratories provide a stable, mission-oriented (Service specific) focus to the Defense science and technology program. These laboratories perform approximately 36% of the total DoD applied research program, as well as 24% of the advanced technology development program, in-house. The Service laboratory element of the partnership has brought the Department such advances as night vision from the Army, underwater

acoustics from the Navy, and much higher performance turbine engines, primarily from the Air Force. The Army is developing technologies necessary for both the Force XXI and Army After Next, and is focused on providing land warrior systems that will have increased lethality, survivability, tactical mobility, and energy efficiency. Examples of significant programs include the compact kinetic energy missile and the future Scout and Cavalry System light infantry vehicle. Within the Navy, the current focus is on reducing the logistics and manpower requirement of combatant ships and extending the littoral battlespace. Examples of significant programs supporting these areas include the Next Generation Destroyer (DD 21) Program, and Organic Mine Countermeasures. The Air Force science and technology program has placed particular emphasis on space and aircraft propulsion. The Air Force continues to maintain a strong and balanced enabling technology base, pursues core competency technologies that address warfighter needs and increases investment in space-related technologies. Finally, through the Reliance planning process (which we shall describe below), the Services also conduct longer-term, cooperative programs in support of joint capabilities, such as the tri-Service program to mature automatic target recognition systems.

Universities And Department Of Defense Basic Research Program

The DoD Basic Research (6.1) Program is the cutting edge of the Defense Science and Technology Program. Since the end of the Second World War the Department of Defense has relied upon its Basic Research Program to provide the long-range research into new phenomena that ultimately permits the U.S to maintain military technological

superiority. The DoD's Basic Research (6.1) is focused upon those areas of science and engineering that are viewed as likely to provide advances that will affect national security, and the program supplies new knowledge and understanding in science and engineering fields that underpin national defense. This investment stimulates the development of new technologies, creating opportunities to enhance capabilities of future military systems and to make them easier and less expensive to manufacture, operate and maintain.

The DoD's 6.1 investment complements programs of other Federal agencies because it is targeted at areas that have the highest potential for long-term military benefit. The DoD Basic Research Program provides support for research in twelve areas: physics, chemistry, mathematics, computer science, electronics, materials science, mechanics, terrestrial science, ocean science, atmospheric and space sciences, biological sciences, and cognitive and neural sciences. These areas are viewed as most likely to provide advances that will prove instrumental in the development of next generation military systems. Support for academic research in these areas is highly dependent upon the DoD. For example, even though DoD's total 6.1 funding is less than 7% of total Federal basic research funding, DoD provides more than two-thirds of total Federal support for basic research in electrical and mechanical engineering, almost half of all Federal support for metallurgy and materials science and engineering and almost half of all Federal support in computer science. DoD provides about 40% of the support for all engineering research. The DoD basic research program has been extremely successful and has provided the scientific and engineering foundations for many systems in use today, such as the Global Positioning System (GPS), satellite communications, etc. An indication of the success of the basic research program is

the fact that DoD has provided support for 69 Nobel Laureates for work that led to their award. The most recent awardee is Ahmed Zewail, the 1999 Nobel Award winner in chemistry for his work on the studies of the transition states of chemical reactions.

The Basic Research program relies on a mix of performers. Universities perform about 55 percent of the total 6.1 program. Basic research is a core competency of universities, and university research pays additional dividends through the associated training of the next generation of scientists and engineers in defense-critical disciplines. DoD and other Federal laboratories perform about 30 percent of the 6.1 program, with the balance performed by industry and nonprofit institutions other than universities.

The Basic Research program emphasizes excellence. Merit competition assures that we support research of the highest technical quality and with the greatest potential for generating technology to help future warfighters. Basic Research is a priority of the Department, and we urge that you support the full budget request.

Industry

The benefits of the Department's partnership with industry include enhanced innovation and technology transfer. In fact, industry executes nearly 50% of the Department's applied research, and almost 65% of the advanced technology development. The remainder is done in our Service Laboratories, Universities, and other non-industrial activities. This investment's primary contribution comes in developing more mature technology transitioning to warfighting systems. The Office of the Secretary of Defense

manages specific programs aimed at maturing Dual-Use technology, Manufacturing Technology, and the Commercial Operations and Support Savings Initiative (COSSI) -- each described below in more detail. For instance, the Department is involved in a 50/50 partnership with the automotive industry to develop an active braking system for medium weight trucks. When fielded in the Army's High Mobility Multipurpose Wheeled Vehicle, this technology will reduce life cycle costs, and increase safety of current vehicles. A final element of industrial partnership is with small businesses, through the "Small Business Innovative Research" (SBIR) program. In FY 1998, over 120 contracts were issued to small business as part of the SBIR program. Many of these addressed problems in emerging threat areas. For example, the accelerometer used to arm most DoD missile systems, including the Patriot Advanced Capability-3, comes from a SBIR set-aside development.

International Cooperation

Another partner for the DoD Science and Technology program is the international S&T community. We have individual bi-lateral and multilateral science and technology agreements with individual nations, and additional international collaboration comes through our involvement in the NATO Research and Technology Organization (RTO) and The Technical Cooperation Program (TTCP), a long-term alliance with Australia, Canada, New Zealand and the United Kingdom. Through these latter bodies, the Department has engaged in international cooperative research for over forty years. For example, the TTCP Weapons Group developed technology to compute and measure direct fire accuracy of

main battle tanks that will improve the quality of design and experimental methodology for all future direct fire systems. The TTCP Joint Systems and Analysis Group completed a project to support battlefield operations in Kosovo and elsewhere. The results provide field commanders and the units being deployed with more timely, more complete, and higher quality analysis of battlefield operations underway through the sharing of data, models, and techniques among coalition forces. Within the RTO, the Sensors and Electronics Technology Panel is completing an extensive effort that resulted in several models and analytical tools useful to sensor system designers. Though not complete, the Studies, Analysis and Simulation Panel is in the midst of a study that focuses on coalition warfighting lessons learned from Operation Allied Force. Although the U.S. has conducted its own thorough analysis, this RTO study is integrating all of the NATO viewpoints.

Planning And Assessment Process ("Reliance")

The S&T investment is planned and assessed through a cooperative initiative with the Services and Agencies in DoD called the Defense Reliance Process. The process enables us to integrate programs across the Services and Agencies to develop the capabilities needed to meet the goals of Joint Vision 2010. Through this process, we are able to avoid unwarranted duplication of efforts in the Services and Agencies, and to leverage the investments they make. The execution of our S&T program is based on four planning documents that we develop: The Defense S&T Strategy, the Joint Warfighting Science and Technology Plan (JWSTP), The Defense Technology Area Plan (DTAP), and the Basic

Research Plan (BRP). The assessment of the quality of the research in the S&T plan includes reviews by teams of independent reviewers from academia and industry.

S&T FOCUS AREAS

In developing the Department's Science and Technology program, we recognized the need to provide an additional focus on the technologies to acquire and use information to our advantage. Consequently, we have three interdisciplinary science and technology focus areas that are intended to allow the Department to more fully benefit from emerging capabilities.

Information Technology Initiatives

Information technology has been a core research area for the Department since the beginning of computing. This research area remains vital, and will be more significant to the Department as we move into the 21st Century. Our research programs include activities that will lead to revolutionary advances in ubiquitous and pervasive computing systems, information assurance, and embedded software for high-performance and autonomous systems. Other significant activities are focused on advanced human-computer interactions including intelligent retrieval of intelligence information, translingual information detection and summarization. It also includes performance computing systems including hardware that is reconfigured by software, as well as power- and energy- aware computing devices. New activities in information technology will

include the exploration of quantum and biological computing devices for new paradigms of secure, fault-tolerant and adaptive computation and communication. Many of these activities would benefit from the funding increases proposed in the Administration's Information Technology R&D Program, one of the components of the National Science and Technology Council Initiatives which includes DoD, specifically DARPA, as a major participant. Each of these areas, while having strong DoD applications will also have broad commercial impact. For example, DARPA's work in Human-Computer Interaction, specifically in Multilingual Information Management, will help lead to a computer that can operate in any language, and "self-translate." DARPA activities in new techniques for writing verified embedded software will result in greater competitiveness in vehicle electronics (vetronics) and avionics. The DARPA activity in ubiquitous computing is likely to revolutionize the way we deal with computers pervasively distributed in the environment around us. Much like the work at DARPA that lead to the Internet, the DARPA effort in scalable networks should led to a wireless network interface that operates faster than the wired Internet of today.

Smart Sensor Web

Smart SensorWeb (SSW) is a recent focus inspired by extraordinary technological advances in sensors and microelectronics and by the emergence of the Internet as a real-time communication tool. The near future will see a proliferation of sensors and associated processors available for battlefield use. Commercial and military space technology and systems will provide major leaps in coverage, timeliness, and resolution. Many efforts in

these areas are ongoing in the Services and Agencies, and together could provide a tremendous new warfighting capability. The overall vision for *SSW* is an intelligent, secure, web-centric distribution and fusion of sensor information that provides greatly enhanced situational awareness, on demand, to Warfighters at lower echelons.

Cognitive Readiness

To achieve the capabilities outlined in Joint Vision 2010, our Armed Forces will rely on superior learning technologies that must be available on demand, anytime, anywhere. It is known that the complexity, tempo, and dispersion of current military operations stresses traditional training and education systems based in the classroom (synchronous learning). In addition, time spent in on-site education and training impacts operational readiness. The pace of technological change in weapons systems and complex cognitive demands of the variety of missions, including missions-other-than-war, further complicate this concern. Development of new learning technologies to address these concerns and provide cost-effective systems will provide high quality "learner-centric" systems for military training and education under the Department's overall Advanced Distributed Learning program.

Learner-centric systems require technologies for both synchronous and asynchronous learning, and require that we undertake technology development through focused research investments in human factors, cognitive task assessment, learning object modules, adaptive learning, intelligent tutors, information network design, knowledge agent development, advanced distributed learning standards, embedded training, and modeling and simulation based collaborative tools.

In addition to the three focus areas (Information Technology, Smart Sensor Web, Cognitive Readiness), the Department's science and technology program is actively involved in several high-priority interagency efforts. First, in response to Presidential Decision Directive-62, Protection Against Unconventional Threats to the Homeland and Americans Overseas, an assessment of the Department's science and technology contribution to this area has been completed. The interagency effort in this area is active with many cooperative exchanges of information and technology discovery whenever defense efforts can be applied to use in homeland defense. A related program responds to PDD-63, Critical Infrastructure Protection. In this area, we are identifying technologies that will address activities related to cyber terrorism, and better protect critical information systems within the Department, and throughout the nation. Finally, we have initiated a specific executive-level science and technology working group to coordinate ongoing efforts in detecting, characterizing, and neutralizing hard and deeply buried targets, in response to the emerging threat from other nations due to underground facilities.

In addition to these technical challenges, we also are examining ways to revitalize the Department of Defense laboratory and test center infrastructure. Specifically, we have initiated an experimental pilot program that allows a Defense laboratory and Test and Evaluation Center from each Service to relax some constraints pertaining to Federal workforce, infrastructure, and program execution; and to provide the laboratories a mechanism to cooperate more effectively with industry. Additionally, most laboratories

are included in existing personnel demonstrations, which provide flexibility in the pay and progression of DoD scientists and engineers.

Technology Enablers

"Technology Enablers" are vital to the success of the Department's RDT&E programs. While they do not fit neatly into any particular technology compartmentalization scheme, they are nevertheless critical to the success of individual and collective S&T programs. Examples of such enablers would certainly have to include the Department's High Performance Computing Modernization Program and our Modeling and Simulation program. The Department recognizes the tremendous impact of these technologies in the development, maturation and evaluation of our existing and future warfighting technologies. In particular, over the last several years, the Department has developed a world-class computational and modeling infrastructure supporting over 5000 scientists and engineers working on some of our most challenging technical and developmental problems such as the Airborne Laser, the design of the Navy's DD-21, global ocean modeling, THAAD and other ballistic missile defense issues and Automated Target Recognition to name just a few. The progress we have made in these areas and a great host of others would simply not be affordable, or even achievable, without these technology enablers and we encourage your continued support in the FY 2001 budget for our efforts.

CIVIL AND MILITARY TECHNOLOGIES MERGING

As is apparent, warfighter systems and defense doctrines are constantly evolving to new dimensions. Many of the DoD science and technology achievements, designed to maintain a technologically superior military force, have progressed to the civilian economy and formed the basis of technological advancement in industry. Today, there is much movement of technology in the other direction, from the commercial world to defense. Historically, there had been a distinct difference between the technologies of warfare (gunpowder, cannons, bombs) and those of the normal day-to-day commercial economy. As defense has moved increasingly toward information-based warfare, however, and as the information age has moved the civilian economy into the high-tech environment, there has been a growing merger of the technologies of the two arenas.

Common technologies, however, are not enough to yield dual-use operations; there are other areas of concern. The commercial sector frequently offers lower-cost, higher quality, faster new product realization times and state-of-the-art performance and equipment that meets environmental requirements that are at least as rigid as those of the military. The Department has three programs in particular, the Domestic Technology Transfer program, the Commercial Operations and Support Savings Initiative (COSSI), and the Dual Use Science and Technology program, which foster this innovative environment.

Domestic Technology Transfer Program

The DoD Domestic Technology Transfer Program encompasses a wide range of activities involving spin-on, spin-off, and dual use. One technology transfer instrument especially important is the Cooperative Research and Development Agreement (CRADA). While this instrument was designed to transfer federally developed technology to enhance the economic competitiveness of private industry, we have found CRADAs to be a viable method for the DoD laboratories to jointly develop technology with industry, universities, and state and local governments. Both DoD and the non-Federal partners may contribute personnel, services, and property in support of CRADAs, but all direct funding is provided by the non-Federal entices. The flexibility of this instrument is unparalleled -- we have 1751 active CRADAs - up from 1364 a year ago. We are doing research in a wide range of technology areas, including vaccine technology, hazardous materials management systems, software development, acoustics and signal processing, imaging technology, and laser development. One project completed this year via CRADA is a forced air de-icing system. It uses a patented nozzle that shoots a 700-mile per hour air stream injected with de-icing fluid to remove ice and snow from aircraft surfaces. This system uses 30-50 percent less fluid than current de-icing systems and can de-ice a plane in a fraction of the time it takes with fluid alone. Both American Airlines and the Air Force have ordered this forced air de-icing system. Both the commercial and military sectors will save resources by reducing flight delays and costs associated with the de-icing process.

Commercial Operations and Support Savings Initiative

Many DoD systems are being retained far beyond what was initially anticipated and, as equipment ages, operations and support (O&S) costs increase. The Commercial Operations and Support Savings Initiative (COSSI) addresses increasing O&S costs by adapting available commercial technologies for use in military equipment. These technology insertions reduce O&S costs by replacing high maintenance components with ones that are more reliable, less expensive to buy, and able to be upgraded more easily. For example, one project selected in FY 2000 will provide an electronic propeller control system for P-3 aircraft that will reduce propeller maintenance costs from $26 per flight hour to less than $4 per flight hour. COSSI currently supports 57 projects. The President's Budget requests $51.9 million for COSSI projects in FY 2001. This investment is essential if we are going to get O&S costs under control and keep our legacy systems operating at peak performance.

Dual Use Science & Technology Program

The Department's Dual Use Science & Technology Program allows the DoD and contractors to form partnerships for the purpose of developing technologies that can benefit both parties. A primary Program objective is to help the Department meet future defense requirements by leveraging the technological advances taking place in the commercial marketplace. The Program is meeting that objective. Since the program began in 1997, the Department has initiated over 200 projects with industry. Over half of

the approximately $800 million being spent on these projects has come from industry. In addition, more and more non-traditional suppliers are starting to participate in the Dual Use S&T Program. However, the real measure of success for the Program is how well it is doing in making the development of dual use technology into a normal way of doing business in the Services. Once again, it is working. The Services are increasingly using cooperative development approaches outside the Program as well as inside. For example, the Army's Communications and Electronics Command are initiating six dual use projects this year. Three have received funding from the Dual Use S&T Program and three are being funded outside of the Program. The other Services and Commands are showing similar progress. The President's Budget for FY 2001 requests $30.4 million for the Dual Use S&T Program. This funding represents that which is required to maintain our momentum and reach our ultimate objective of making dual use technology development a normal way of doing business in the Services.

Manufacturing Technology/Industry

To implement the DoD's "Revolution in Business Affairs" we must take full advantage of the technologies and management lessons that have turned around American commerce and industry during the past decade. This means designing and building affordable systems and, simultaneously, cutting support and infrastructure costs. While continuing to explore long-term qualitative leaps forward in military technology, we must also lead the way in low cost, advanced technology. Affordability is just as great a technical challenge as performance.

The DoD can achieve lower costs, improved performance, and reduced cycle time. Our efforts are resulting in increased combat readiness, better equipment, faster deployment, and overall superiority for the United States military. For example the Manufacturing Technology, or "MAN-TECH" program, focuses on the needs of weapon system programs for affordable, low-risk development and production, providing the crucial link between technology invention, development, and industrial applications. ManTech is one of our keystone affordability programs, developing the process technology to make defense weapons and material better, faster, and cheaper. Our MAN-TECH request for FY 2001 is $149 million, up from the FY 2000 request of $133 million.

For example, the Army, Defense Logistics Agency, and American Metalcasting Consortium invented a metalcasting process that enables DoD agencies and suppliers to harness the benefits of metalcasting with streamlined weapon systems part design, use of blanket purchase agreements with pre-qualified foundries, and improved communications between suppliers and users. Over $4 million in annual life cycle savings is projected as a result of cycle time reductions and reduced parts count generated from redesign of various weapon systems components into casting assemblies, including the M1 tank, 120mm mortar, F-22 Raptor, lightweight howitzer, and other support equipment across the military services. We were honored to present this team the Hammer Award in 1999.

While ManTech is focused on developing improved technologies for Defense applications, transition to commercial products frequently occurs. The Navy's Advanced

Fiber Placement program, developed in the early to mid-1990's, is now receiving widespread industrial base application. This technology provides a state-of-the-art, automated machining process for composite material, replacing a more costly and less reliable touch labor process. Following initial implementation by Boeing and Northrop Grumman on F/A-18E/F stabilator, engine inlet ducts, and fuselage, technology application was expanded to include the V-22 Osprey fuselage skin, C-17 landing gear pod fairings, T-45 horizontal stabilator, and AH-1 helicopter main rotor spars and cuffs. Commercial applications include the Boeing helicopter 609, Boeing 777, and Raytheon Premier components. Over 14 fiber placement machines, valued at $37 million, have been sold to several prime aerospace contractors.

CONCLUSION

Mr. Chairman, we wish to thank the Committee for this opportunity to give you a broad overview of our defense research and development posture. The future of our modernization efforts will rely on the partnerships we form in the development and execution of our R&D programs, which in turn will enable tomorrow's warfighting superiority. The Congress and the Department have worked hard -- together -- to achieve our global dominance and to maintain our strength. We urge your continued support of our common, overriding interest in keeping our combat forces the best equipped, the best supplied, and the best sustained in the world.

Thank you very much.