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This Defense Research and Engineering (R&E) Strategic Plan provides members of the Department of Defense R&E team a reference point as we collectively develop the strategic and operational capabilities necessary to support the men and women who put on the cloth of the Nation. It provides a framework that gives all members involved in the Department's R&E program a shared purpose and shared goal. This Strategic Plan also provides an understanding of our priorities to our customers and partners, who include the President, the Combatant Commanders, the Acquisition and Sustainment Community, industry, academia, and our allies.

John J. Young Jr.

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Purpose & Executive Summary

Purpose: This strategic plan guides investment and management priorities for the collective Department of Defense (DoD) Research and Engineering (R&E) program[1]. While each Service and Agency with an R&E program has specific responsibilities to plan, program, and execute programs to meet their specific Component's needs, this strategy develops a broader context that fosters coordination of Service and Agency efforts to provide complete and integrated DoD capabilities. Each of the Services' and Agencies' R&E programs should leverage and complement each others' efforts in an integrated program and framework. Indeed, the objective for all efforts within the R&E program should be to meet the larger Defense Department enterprise's needs efficiently and effectively, achieving the greatest degree of collaboration and coordination possible.

There is no single priority, principle, capability, or technology that constitutes a successful DoD R&E program; but rather a number of priorities and a portfolio of technologies that support the National Security Strategy and the Quadrennial Defense Review (QDR). This R&E strategic plan identifies these higher-valued principles, capabilities, and technologies that are used to guide the investment and management of the DoD R&E program. The result is a proactive R&E program that:

- Generates new scientists and engineers for the national security program
- Develops new and enhanced operational capability options for our warfighters and strategic decision makers
- Transitions technologies to acquisition programs and the warfighters
- Reduces risk for acquisition programs
- Enhances the affordability of DoD systems and capabilities
- Enhances sustainment and upgrade of existing weapon systems
- Forges partnerships with other government agencies, industry, academia, and international allies
- Shares information across multiple Components through proactive collaboration
- Minimizes the probability of technology surprise against U.S. capability advantage
- Values technical competency and integrity
- Provides maximum value for the taxpayer.

Develop and deliver technology to provide unmatched capability, against any adversary, for the men and women who protect America.

[1] The R&E program is the combination of Science and Technology (Budget Activities 1, 2, and 3 of Program 6) with Advanced Component Development and Prototypes (Budget Activity 4). In this context the word "collective" means the total program of the Department of Defense, which encompasses all Services, Agencies, and other DoD Components.

Executive Summary: Superior technology has been, and continues to be, a cornerstone of the U.S. military's strategic posture. This was true during the Cold War, when technology provided superior conventional weapons for U.S. and allied forces. The same is true in today's Information Age which involves significant activity in the cyber domain, and by non-state actors[2]. The DoD R&E program needs to create, demonstrate, apply, and partner in the transition to operational use of technologies to enable affordable and decisive military superiority to defeat any adversary on any battlefield. Just as the past superior technologies have enabled an operational advantage for U.S. forces, continued technology development should enable future military superiority. The operational capability advantage enabled by technology used in previous conflicts did not occur instantaneously, but was the result of long-term, sustained, and balanced DoD research and engineering. Today, the wide availability of technology and the agility of our adversaries demand that the DoD R&E program be executed with urgency, agility, and creativity.

This strategy uses higher-level guidance to establish a framework for R&E investment and policy priorities. The QDR describes strategic challenges and strategic outcomes. Strategic challenges describe broad portfolio areas that could threaten our national security. These challenge areas are traditional, irregular, catastrophic, and disruptive. The belief is that the current U.S. capabilities in traditional systems are sufficiently superior, and that presently there are no nations able to effectively challenge the U.S. The other three challenges are areas that could possibly threaten U.S. superiority in the future. Taken as a whole, the strategic challenges set a backdrop for where the DoD is to increase investment and place emphasis on irregular (e.g., urban operations, war on terrorism, etc.), catastrophic (e.g., defense against weapons of mass destruction (WMD)), and disruptive technologies (i.e., those that could render our most significant weapons systems less effective) challenges.

[2] As defined in the Quadrennial Defense Review

Following the strategic challenges are the strategic outcomes. Outcomes are those events the U.S. seeks to make happen. These outcomes are to:

Defeat terrorist networks;

Defend the homeland in-depth;

Shape the choices of countries at strategic crossroads; and

Prevent the use of WMD.

The net impact results in an R&E program that is increasing investment in "non-kinetic" capabilities compared to the traditional "kinetic" capabilities of weapons platforms and munitions. Described another way—the DoD and the supporting R&E program is increasing emphasis on activities like persistent surveillance; locating, tagging and tracking personnel and materiel; cultural and language awareness; tailored lethality; and information technologies. The DoD is shifting the R&E program to provide much greater capabilities to sense and understand all objects in the battlespace, to understand how other cultural groups react to various events, to develop enhanced interoperable joint command and control and information management, to protect U.S. forces and the homeland against evolving threats, and to develop tailored force application with less emphasis on "kinetic" capabilities. These capabilities supported by focused logistics are core competencies for any military operation.

As the U.S. military continues its 21st Century transformation, it is important to acknowledge the role of technology in previous transformations. While transformation can occur from changes in doctrine and force employment concepts, technology has been, and remains, a key driver to capabilities-based transformation. This strategic plan lays out the principal elements of a DoD R&E program that enable achieving the goals and objectives of the Department and the accelerated fielding of joint warfighting capabilities through development and delivery of technology.

Defense Research & Engineering Vision and Mission

Current and future members of our military rely on our Nation's and Department's Science and Technology (S&T) investment to provide superior systems with the capabilities to defeat any adversary on any battlefield. Achieving this vision requires an inspired, high performing enterprise, where each person makes a difference, and all elements of the DoD R&E program work together effectively across organizational boundaries. Achieving this vision will also require the DoD to collaborate effectively, as part of a community, with interagency, international, and industrial partners.

Continuing to reorient the DoD's capabilities and forces to address a wider range of asymmetric challenges and to hedge against future uncertainty will require the strong support of the DoD R&E program, in partnership with the operational forces, acquisition community, industry, and academia. Superior technology translates to superior military capability. The ability to focus the R&E program on providing the warfighter with capability options is essential. Future capabilities depend on today's R&E investment. Consequently, the mission of the DoD R&E program is to create, demonstrate, prototype, and apply S&T that enables affordable and decisive military superiority to defeat any adversary on any battlefield. Pursuing the R&E mission requires attention to identification and development of new technological opportunities, insertion of new technologies into warfighting systems and operations, and management and evaluation of the effectiveness of technology programs. Pursuing the R&E mission also entails nourishing the science and engineering workforce and physical infrastructure, as well as establishing partnerships with industry, universities, international allies, and other agencies. This strategic plan articulates priority desired operational capabilities and enabling technology needed to pursue and advance the R&E mission.

Service and Agency Visions and Core Missions

The Department's S&T Components each play an important role in the Defense R&E Program. The Services provide the stable long-term part of the program, focused on their Services' responsibilities. The Service S&T communities are also constantly looking for opportunities to achieve revolutionary breakthroughs; however, they must also maintain a range of core competencies while also supporting the acquisition and logistics systems that produce and maintain military equipment. Each Service has a vision of future capabilities required to support the core competencies they are uniquely responsible for maintaining. Likewise, the Defense Agencies play key roles in rounding out the Department's S&T program. The Defense Advanced Research Projects Agency (DARPA) focuses its S&T program on high-risk, high-payoff technology development efforts. The Defense Threat Reduction Agency (DTRA) focuses its R&E investment on protecting the Nation and our armed forces from present and future WMDs, while the Missile Defense Agency (MDA) develops technology to protect the Nation and our armed forces from present and future missile threats.

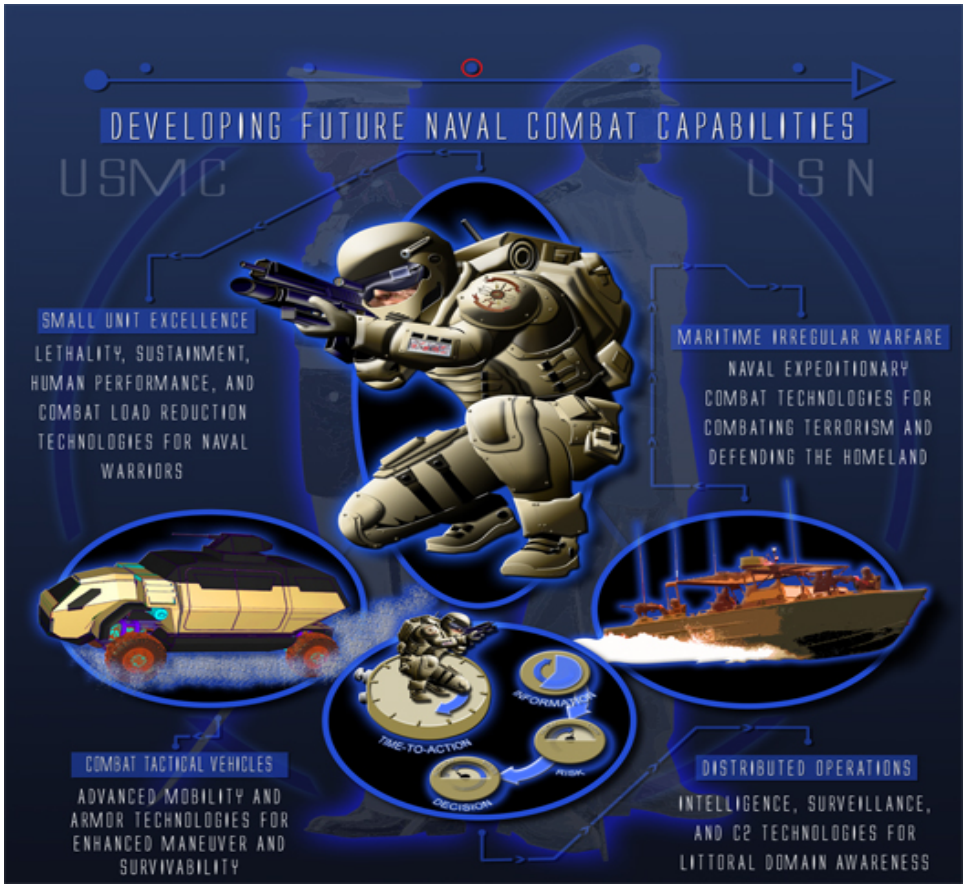
Defense Research and Engineering Vision:
Develop Technology to Defeat Any Adversary on Any Battlefield

Army

The Army's S&T program must be as adaptable and responsive as our Soldiers in the field. Our S&T strategy is to pursue technologies that will enable the future force, while simultaneously seizing opportunities to enhance the current force. This strategy is shown pictorially below. To achieve this strategy, we are developing technology through investments in the three components of S&T: (1) for the near term, demonstrating mature technology in relevant operational environments and facilitating transition of technology to acquisition; (2) in the mid term, translating research into militarily useful technology applications; and (3) in the far term, research to create new understanding for technologies that offer paradigm-shifting capabilities. Our technology demonstrations prove the concept, define the combat developments process, and provide the acquisition community with evidence of a technology's readiness to satisfy system requirements. The Army's largest S&T investment area focuses on force protection technologies for detection and neutralization of improvised explosive devices, mines, rockets, artillery and mortars; vehicle protection for protection against a full range of threats; and pulse power for directed energy. The Army's other top investment areas are command, control, communication, computer, information, surveillance and reconnaissance (C4ISR), lethality, Soldier systems, unmanned systems, logistics, and advanced simulation. In basic research, key investments include nanomaterials research for ballistic protection, biotechnology research for improved materials and network sensors, and Holodeck-like immersive simulation capabilities.

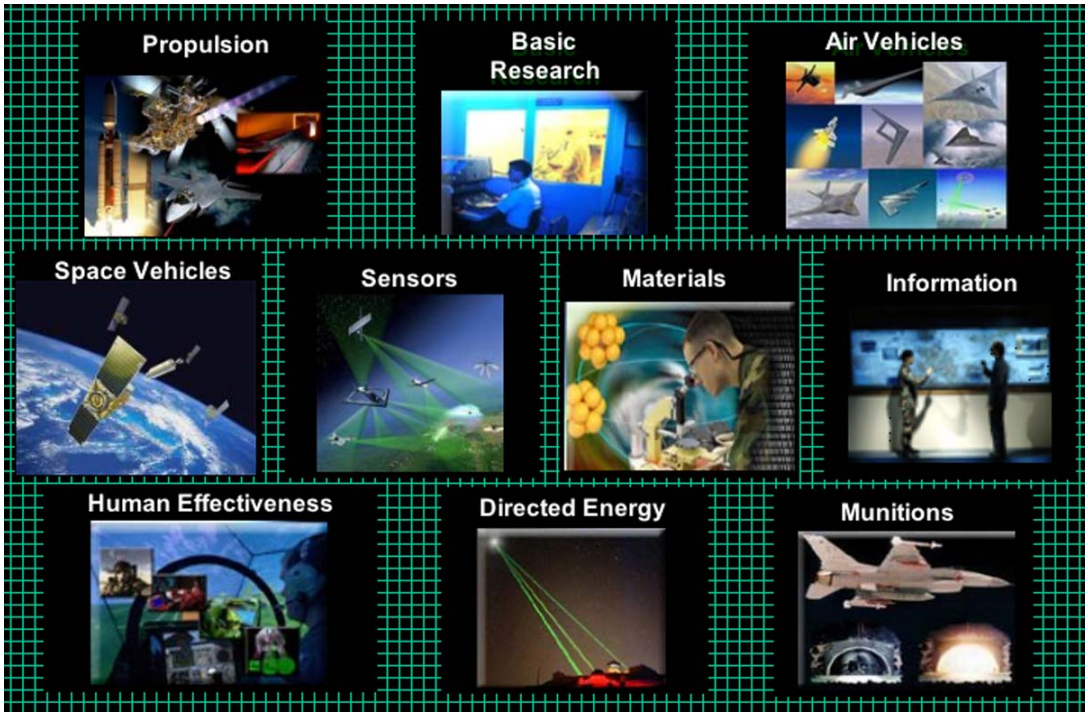
Navy

The Department of the Navy (DoN) vision for its S&T program is to inspire and guide innovation that will provide technology-based options for future Navy and Marine Corps capabilities. The Office of Naval Research and the DoN S&T Enterprise have developed an S&T portfolio that addresses the short-, mid-, and long-term capability needs. The "Quick Reaction" portfolio sector addresses immediate and very short-term capability needs as identified by the Fleet and Operating Forces. The "Acquisition Enablers" program centers primarily on the Future Naval Capabilities (FNCs), which work to mature technology into requirements-driven, transition-oriented products in the late stages of Applied Research and Advanced Technology Development. These mid-term programs provide Enabling Capabilities to fill identified gaps in the naval transformational strategy and Naval Power 21. The "Leap Ahead Innovations" portfolio sector is based on a set of Innovative Naval Prototypes that explore potentially disruptive technologies that can change the way naval forces conduct warfare. Finally, the "Discovery and Invention" (D&I) Program is the mid- to long-term broad-based Basic Research and early Applied Research investment to fulfill the needs of the Fleet/Force after next. Individual D&I investments are selected through their fundamental Navy and Marine Corps relevancy and will provide the foundation for solving the long-term Fleet/Force capability needs.



Air Force

As the nation adapts to a new security environment filled with unconventional and non-traditional threats, so the Air Force adapts to fight the global war on terror and proliferation of WMD. Created in response to the QDR, the Air Force technical vision, Anticipate, Find, Fix, Track, Target, Engage, Assess – Anything, Anywhere, Anytime, guides investment in traditional, irregular, catastrophic, and disruptive technologies. Born from the Air Force kill chain to find, fix, track, target, engage, and assess the enemy in a traditional theater, the Air Force added "anticipate" to the front of its kill chain to capture the need to develop new technologies that predict our enemy's intentions before they act, and "anything, anywhere, anytime" to the end of the kill chain to focus more research in "24x7" tagging, tracking, and locating of terrorists and WMD in what is now a global theater of war. Game-changing initiatives are pursued in cyber, directed energy, and energy and power technologies. To enable a tighter link to capabilities-based planning, the Air Force has baselined a new planning framework called Focused Long-Term Challenges. This framework allows the Air Force to focus S&T investments on demonstrating and delivering technologies that meet stated warfighter capability objectives. The Air Force is aggressively pursuing high-payoff technologies focused on countering the new threats of today, while modernizing systems for tomorrow. The Air Force S&T Program provides a wide range of technology options to integrate the Air, Space, and Cyber Force, enabling rapid and decisive global engagement anywhere, anytime. The program is executed by the Air Force Research Laboratory, which includes the Office of Scientific Research and nine technology directorates: Air Vehicles, Directed Energy, Human Effectiveness, Information, Materials and Manufacturing, Munitions, Propulsion, Sensors, and Space Vehicles.



Defense Advanced Research Projects Agency (DARPA)

DARPA's mission is to prevent technological surprise against the U.S. as well as creating technological surprise for the Nation's potential adversaries. DARPA accomplishes its mission by sponsoring revolutionary, high-payoff research that bridges the gap between fundamental discoveries and their military use. DARPA is DoD's only research agency not tied to a specific operational mission and is focused on developing advanced transformational capabilities based on revolutionary technological options for all DoD mission areas. DARPA collaborates with the Combatant Commands, Services, and other DoD agencies and organizations to transition advanced warfighting capabilities.

Defense Threat Reduction Agency (DTRA)

DTRA is charged with the mission to safeguard the U.S. and its allies from Weapons of Mass Destruction (WMDs) (chemical, biological, radiological, nuclear, and high yield explosives) by providing capabilities to reduce, eliminate, and counter the threat and mitigate its effects. Thus, DTRA's technology investment strategy is focused on developing enabling technologies for capabilities to address the WMD threat. DTRA also leverages other Federal and industry research and development investments where appropriate, and integrates and demonstrates emerging technologies for near-term technology insertions in current acquisition programs or to provide an advanced capability to address evolving WMD threats. DTRA is the intellectual, technical, and operational focal point for DoD's and USSTRATCOM's strategy to combat WMD, and serves as the principal integrator and synchronizer, by supplying tools, services, and capabilities needed for each of the three pillars of that strategy: nonproliferation, counter proliferation, and consequence management. DTRA's science and technology (S&T) program identifies, conducts, and delivers innovative S&T through systematic, risk-balanced processes that enable the U.S. to combat WMD.

Missile Defense Agency

The Missile Defense Agency's (MDA) Science and Technology vision is, "We build tomorrow's technologies to outpace the ballistic missile threat, bringing certainty to an uncertain future." This vision is achieved through a coordinated analysis of current and projected threats, which guides development and testing of alternative solutions. A major focus is for outside-the-box ideas that provide significant innovation in approaches to achieve the mission of the MDA, which is "to develop and field an integrated, layered, ballistic missile defense system to defend the United States, its deployed forces, allies, and friends against all ranges of enemy ballistic missiles in all phases of flight." While significant effort is devoted to preventing technological surprise, there is also a strong objective of developing missile defense solutions that address and eliminate asymmetric threats. The range of defense solutions covers all phases of missile flight from boost to terminal and includes hardware for threat detection, acquisition, tracking, discrimination, and intercept. Individually and collectively, these systems are designed to provide robust solutions to missile defense problems.

Strategic Context for the Research & Engineering Program

The DoD R&E program is shaped by strategic guidance, warfighter needs, and technology opportunities. Strategic guidance is found in the National Defense Strategy (NDS) and National Military Strategy (NMS), the QDR, and Strategic Planning Guidance (SPG). These documents should be viewed in the broader context of strategic interests, strategic awareness, and strategic resilience—all three of which are significant to the DoD R&E program.

Strategic Interests: Today, our strategic interests are global—with new competitors on the horizon. Our nation's human capital must be creatively engaged in devising and delivering innovative technology and responsive solutions for a rapidly changing global environment and evolving threat.

Strategic Awareness: The nation with global strategic interests will have to correspondingly develop and maintain the ability to generate global strategic awareness. Using a wide range of sensors, information tools, and training, the dedicated civilian and military members of the nation's defense enterprise must be able to detect the subtle and overt danger signals in environments ranging from isolated neighborhoods, to foreign military facilities, to cyber space.

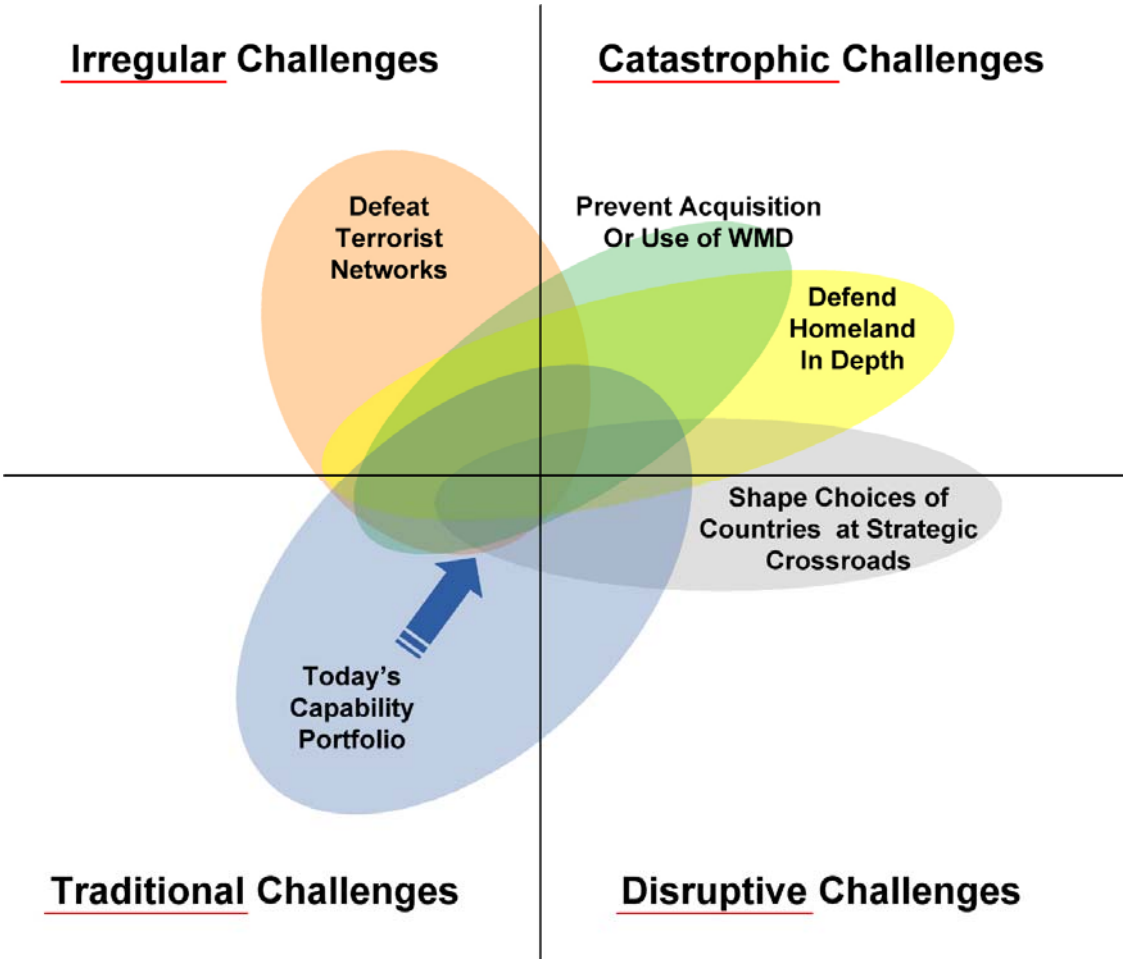
Strategic Resilience: Strategic resilience comes from having a complete toolbox of capabilities that our forces can use today, with enough depth that tomorrow's forces can use those same tools in new ways or with new tactics. Resilience also means having foresight about who the enemy is or might become, and creating new and better tools for tomorrow, ensuring we spend taxpayer dollars on the right things.

Our nation's leaders and military commanders must have the tools to allow agility in planning and executing policy and military operations. America's military forces are uniquely capable of providing global access to, and protection for, the nation's interests. Men and women in uniform and civilian positions need to be prepared and equipped for the new spectrum of missions ranging from combat operations, to disaster response, to diplomacy. The DoD R&E team must prepare the current and future force to succeed in all missions that emerge from the convergence of America's global strategic interests, need for strategic awareness, and requirement for strategic resilience. The DoD R&E team needs to embrace the challenge and opportunity of continuously reinventing the warfighter's toolbox and filling it with flexible, resilient systems for the future, doing so with constant willingness to look at new ideas and question current technologies and methods.

Within this context, the DoD's R&E program is focused to pursue S&T options that offer high payoff military capabilities. While technology developed by the DoD should support a broad strategy, there should be a balance between near-term efforts and the long-term future (between capability pull and technology push). The DoD R&E program will strive to satisfy both.

The NDS and the 2006 QDR define the strategic framework that is used to prioritize the R&E investment profile. These documents identify strategic challenges, strategic outcomes, and desired capabilities. The strategic challenges are traditional, irregular, catastrophic, and disruptive. Traditional challenges are those capabilities and forces used to fight a conventional force-on-force maneuver war.

Irregular challenges include activity like urban and guerilla warfare, and arise from adversaries employing "unconventional" methods to counter the conventional capability overmatch of the U.S. Catastrophic challenges involve preventing the acquisition, possession, and use of WMDs or WMD-like effects. Disruptive challenges are those that can change the capability balance between forces, such that they drive changes in doctrine of force employment. Disruptive challenges may come from adversaries who develop and use breakthrough technologies to negate current U.S. advantages or existing technology used in a novel way. The QDR establishes a strategy whereby the Department is prepared to accept some risk in countering traditional challenges, while enhancing capabilities to combat irregular, catastrophic, and disruptive threats. The diagram below is taken directly from the 2006 QDR, and depicts the programmatic context for developing the R&E program. Since the R&E program develops technologies for new capabilities, it is logical that the R&E program must similarly shift emphasis to the three non-traditional quadrants shown in the following graphic below.



In the course of addressing these strategic challenges, certain strategic outcomes are envisioned. These strategic outcomes are identified in the 2006 QDR as:

- Defeat terrorist networks
- Defend the homeland in-depth
- Shape the choices of countries at strategic crossroads
- Prevent the use of WMD

To complement the strategic framework defined in the NDS and 2006 QDR, the DDR&E, as the Department's Chief Technology Officer, has defined an overarching goal of delivering focused technology to meet warfighter needs within the Under Secretary of Defense for Acquisition, Technology, and Logistics (USD(AT&L)) Strategic Goals Implementation Plan. Under this goal, the following objectives will define success:

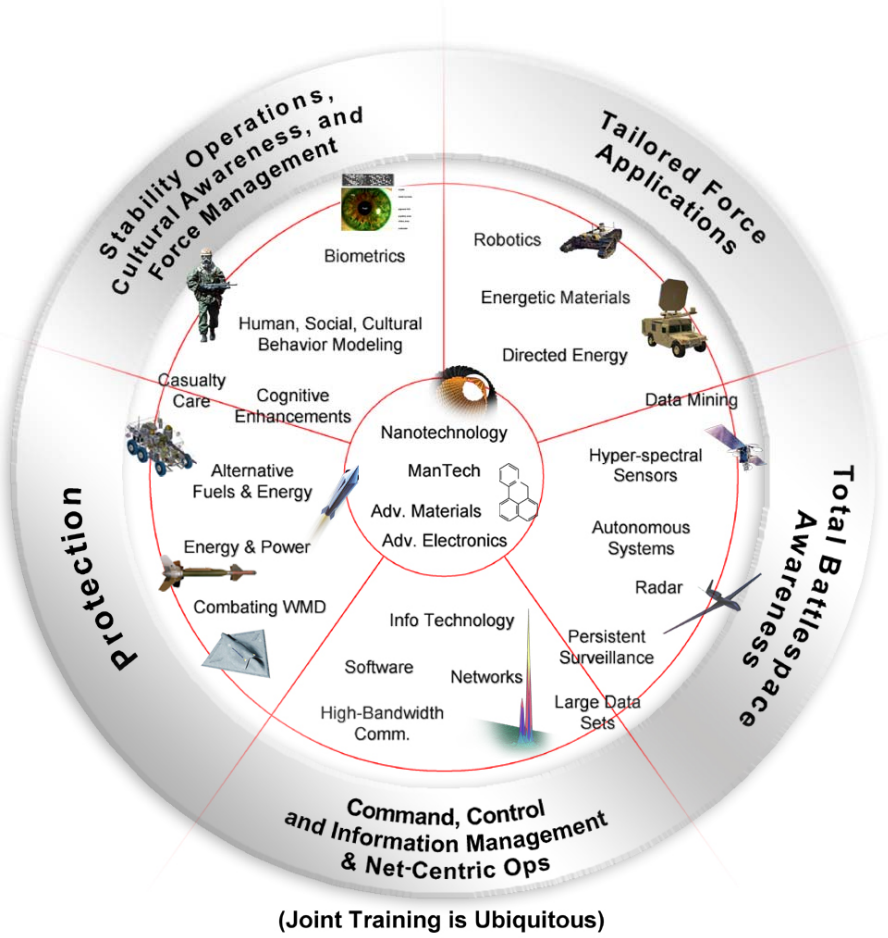
- Investments deliver innovative, product-ready technology
- Joint and interoperable is the way of doing business
- Vibrant S&T program which delivers results and attracts highly capable people
- S&T processes deliver maximum value for the tax dollar

Strategic Science and Technology Priorities

DoD's R&E program should focus on delivering the capabilities outlined in the QDR and other high-level guidance to the warfighters. Each of these capability sets are supported by a large number of enabling technologies that provide S&T focus areas. Taken as a whole these capabilities and enabling technologies drive the S&T priorities needed to achieve the desired strategic outcomes. S&T priorities represent the most important S&T investment areas, and are organized into three broad categories depending upon technology maturity:

- Desired Capabilities to Support Strategic Outcomes
- Enabling Technologies
- Basic Research

Desired Capabilities S&T Investment Areas: These investment areas focus on developing and delivering capabilities (demonstrations and prototypes) that support achievement of the desired strategic outcomes. Examination of these areas present two key observations: 1) The number of non-kinetic capabilities outweigh the number of kinetic capabilities, and 2) The capabilities can be aggregated into a few high-level mission areas. These high-level mission areas include: *Total Battlespace Awareness; Stability Operations, Cultural Awareness, and Force Management; Command, Control and Information Management & Net-Centric Operations; Protection; Joint Training;* and *Tailored Force Application.* These high-level mission areas and associated enabling technologies are depicted below.



- ***Capabilities to defeat terrorist networks***
  - **Total Battlespace Awareness**
    - Persistent surveillance (penetrate and loiter)
    - Locate, tag, and track terrorists and WMD in denied areas
    - Human intelligence (HUMINT)
    - Predict, detect, neutralize, and mitigate Improvised Explosive Devices (IEDs)
    - Foliage/structure/surface penetrating sensors
    - ISR through walls and underground
    - Counter-sniper, motor, and rocket
  - **Stability Operations and Cultural Awareness**
    - Improved language and cultural awareness
    - Post combat operations (Security, stability, transition, and reconstruction (SSTR))
    - Human, social, cultural and behavior modeling
    - Strategic communications
  - **Command, Control, and Information Management**
    - Joint Command and Control and Networked-Enabled Operations
    - Robust, Secure Self-Forming Networks
  - **Tailored Force Application**
    - Pre-combat operations (real time mission rehearsal course of action development and analysis)
    - Tailored lethality with non-lethal options
    - Urban warfare capabilities (C3I and ISR)
    - Prompt global strike
    - Small Unit & riverine warfare capabilities
- ***Capabilities to defend the homeland in depth***
  - **Total Battlespace Awareness**
    - Enhanced air and maritime awareness
    - Low-cost reliable access to space
  - **Protection**
    - Broad spectrum medical countermeasures
    - Air and missile defense
  - **Command, Control, and Information Management**
    - Joint Command and Control and Networked-Enabled Operations
    - Consequence management
    - Infrastructure protection
  - **Tailored Force Application**
    - Large vessel stopping or maritime interdiction operations
    - Tailored deterrence, including prompt global strike
- ***Capabilities to shape the choices of countries at strategic crossroads***
  - **Total Battlespace Awareness**
  - Wide area persistent surveillance (penetrate & loiter)
    - Confident automated ID, tagging & tracking
  - **Stability Operations and Cultural Awareness**
    - Improved language and cultural awareness
    - Automated language translation (speech and text)
    - Human, social, cultural and behavior modeling to predict individual and group behavior and support effects-based planning
  - **Command, Control, and Information Management**
    - Secure broadband communications
    - Cyberspace shaping / defense
    - Survivable joint command and control
  - **Protection**
    - Integrated defense against all missiles
  - **Tailored Force Application**
    - Sensor and weapon pairing
    - Air dominance
    - Undersea warfare
    - Rapid deployment
  - **Space as a Force-Multiplier**
    - Access and infrastructure
    - Situational awareness
    - Space mission protection and denial
    - Space based support to the Warfighter
- ***Capabilities to prevent the use of weapons of mass destruction***
  - **Total Battlespace Awareness**
    - Stand-off detection of fissile material
    - Stand-off detection of chemical, biological, radiological, nuclear, and enhanced high explosive (CBRNE) materials
    - Locate, tag, track, and characterize WMD
    - Wide area persistent surveillance
  - **Protection**
    - Capabilities to “render safe” WMD
    - Shield critical, vulnerable systems from EMP
    - Countermeasures against advanced bio-technology threats
  - **Tailored Force Application**
    - Tailored lethality with non-lethal options
    - Detection, characterization, assessment, and defeat of hard and deeply buried targets
    - Directed energy weapons
  - **Command, Control, and Information Management**
    - Fusion of HUMINT, ISR, and open source information
  - **Stability Operations and Cultural Awareness**
    - Improved language and cultural awareness

The investment in desired capabilities is typically focused on the more mature technologies and engineering systems.

Enabling Technology Investment Areas: These investments focus on developing and maturing broad technology areas, leading to mature technologies that are ready to be integrated into demonstrations. Enabling technologies support multiple types of systems and platforms, all capable of providing the above listed desired capabilities. Technology enablers also capture the S&T response to non-traditional and disruptive technology threats and serve to preclude technology surprise. Table 1 provides a mapping of the enabling technologies (across the top) that support the desired capabilities S&T investment areas (column on the left).

It is this list of enabling technologies that should receive the highest level of corporate attention and coordination. The specific enabling technologies are:

- **Biometrics & Bio-inspired Technologies**
- **Nanotechnology**
- **Information Technologies**
- **Persistent Surveillance Technologies**
- **Networks & Communications**
- **Software Research**
- **Organization, Fusion, & Mining Data**
- **Human, Social, Cultural, & Behavioral Modeling**
- **Cognitive Enhancements**
- **Casualty Care & Human Performance Optimization**
- **Advanced Materials**
- **Advanced Electronics**
- **Energy & Power Technologies**
- **Alternative Fuels & Energy Sources**
- **Energetic Materials, Rocket Propellants , & Explosives**
- **Directed Energy Technologies**
- **Hyperspectral Sensors**
- **Radar**
- **Autonomous Systems Technologies**
- **Robotics**
- **Manufacturing Technologies**
  - Affordability & Producibility
  - Agile Fabrication
- **Combating Weapons of Mass Destruction Technologies**
- **Large Data Set Analysis Tools**

Enabling Technologies and Desired Capabilities

Capabilities \ Technologies	Biometrics	Nanotechnology	Info Technology	Surveillance Technologies	Networks & Communications	Software Research	Organization, Fusion, & Mining Data	Human, Social Cult. & Behavioral Modeling	Cognitive Enhancement	Casualty Care & Human Performance Ops.	Advanced Materials	Advanced Electronics	Energy & Power Technologies	Alternate Fuels & Energy Sources	Energetic Materials Rocket Propsn. & Exp.	Directed Energy Technology	Hyperspectral Sensors	Radar	Autonomous Systems	Robotics	Manufacturing Technology	Combating WMD	Data Set Analysis
Persistent Surveillance*	●	●	●	●							●	●	●				●	●	●	●	●	●	●
Locate, Tag, & Track Terrorists & WMD*	●	●	●	●			●	●	●			●	●				●	●	●	●	●	●	●
Fuse Intelligence Information*			●		●	●	●	●	●													●	●
Improved Language & Cultural Awareness*			●				●	●	●													●	●
Human Intelligence (HUMINT)*		●	●		●		●	●	●	●												●	●
Tailored Lethality with Non-Lethal Options*				●							●		●		●	●				●	●		
Urban Warfare*	●	●	●	●	●			●	●		●	●	●				●	●	●	●	●	●	●
Prompt Global Strike*		●	●	●	●						●	●	●	●	●	●	●	●		●	●	●	
Small Unit & Riverine Warfare*		●	●	●	●			●	●				●	●	●		●	●		●	●		
Protect Against IEDs	●		●	●				●	●	●	●	●	●			●	●	●	●	●	●		
Interoperable, Joint Command & Control*		●	●		●	●			●			●	●								●	●	
Enhanced Air & Maritime Awareness		●	●	●	●		●	●	●			●	●	●			●	●	●	●	●	●	●
Consequence Management	●		●		●			●	●	●			●	●					●			●	●
Broad Spectrum Medical Countermeasures		●	●																		●	●	
Air & Missile Defense*		●	●	●	●							●	●	●	●			●	●	●	●	●	
Large Vessel Stop/Maritime Interdict Ops*			●	●	●		●		●				●		●	●		●		●	●	●	
Secure Broadband Communications*		●	●		●	●	●					●	●								●		
Air Dominance*		●	●	●	●				●		●	●	●	●	●	●		●		●	●		
Undersea Warfare*		●	●	●	●						●	●	●	●	●					●	●		
Cyberspace Shaping/Defense*		●	●			●	●	●				●	●								●		
Rapid Deployment*			●		●		●	●	●	●	●		●	●	●	●	●	●		●			●
Survivable Joint Command & Control*		●	●		●	●						●	●							●	●	●	
Stand-off Detection of Fissile Materials*	●	●	●	●			●				●								●	●	●	●	
Stand-off Detection of Chem & Bio Agents*	●	●	●	●			●				●								●	●	●	●	
Nuclear & Enhanced High Explosive Mats.		●													●						●		
Capabilities to "Render Safe" WMD*	●		●				●		●				●		●	●				●	●	●	
EMP Shielding of Critical & Vulnerable Sys*		●									●	●									●		
Responsive, Affordable Space Access		●									●	●	●	●	●						●		

*Indicates QDR Designated Capability

Basic Research (Science) Investment Areas

"We need to make sure … our country is more competitive by strengthening math and science skills."

President George W. Bush
State of the Union Address, February 2006

New military capabilities emerge from numerous sources. Historically, the Department's investment in basic research has produced scientific and engineering breakthroughs that laid the foundation for new operational concepts and undreamed of military capabilities. In the past 20–30 years, basic research has spawned such tools and concepts as the Global Positioning System, stealth, and night vision devices. Since there is never a requirement for something that is unknown, the planners of basic research programs are rarely able to predict the operational capabilities resulting from their discoveries. The Department should continue to sustain its investment in basic research because of the proven and significant long-term benefits to the military. DoD requires a basic research program that invests broadly in many scientific fields to assure that it has early cognizance of new scientific knowledge. Areas of research that have produced significant improvement in military capabilities include: electronics, materials science, physics, chemistry, mathematics, computer science, mechanics, biological and life sciences, atmospheric and space sciences, cognitive and neural sciences, terrestrial sciences, and ocean sciences.

Management Principles

In conjunction with the specific desired capabilities and enabling technologies of high priority to the Department, the R&E program should have a consistent set of management principles that provide guidance on how to develop and field technology. The following management principles serve as guidelines for the development and fielding of technology:

Generate New Scientists and Engineers for the National Security Program

> "To keep America competitive, one commitment is necessary above all: We must lead the world in human talent and creativity. Our greatest advantage has always been our educated, hardworking, ambitious people."
>
> President George W. Bush
> *State of the Union Address, February 2006*

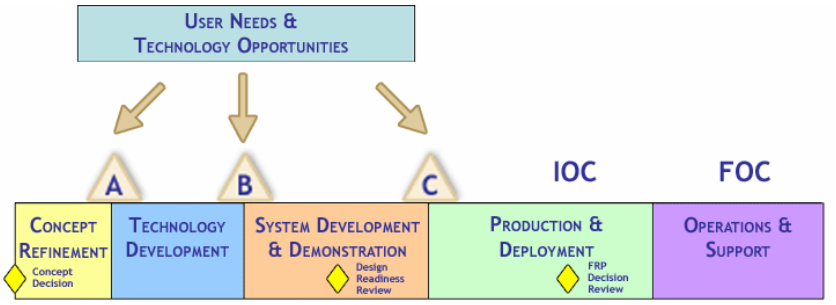
The DoD R&E program should support a sustained supply of scientists and engineers working on national security problems. This is becoming an increasingly critical element of the DoD R&E strategy as there are metrics suggesting that the American advantage in intellectual capital is eroding. Many countries of the world are producing scientists and engineers at a faster rate than the U.S. and the production gap is growing. Although the primary output of the DoD basic research program is new scientific knowledge, the secondary output is scientists and engineers who make up the national security workforce. The bulk of federal funding for scholarships and internships to support research in such areas as electrical and aeronautical engineering at universities comes from DoD investment. The DoD should continue to maintain a strong investment in basic and applied research to sustain the supply of scientists and engineers for the national security program.

Develop New and Enhanced Capability Options

The DoD R&E program should continually develop new capability options for operational commanders and strategic policy makers. In practice, this means that some portion of the DoD R&E investment should be working on new technologies and applications to refresh the U.S. military capability advantage. Programmatically, new capability options would include items such as scramjets to augment conventional propulsion, hyperspectral sensors to enhance sensing, active armor to augment conventional armor, directed energy to augment conventional weapons, improved individual air and ground systems to augment battlespace awareness, and survivability systems.

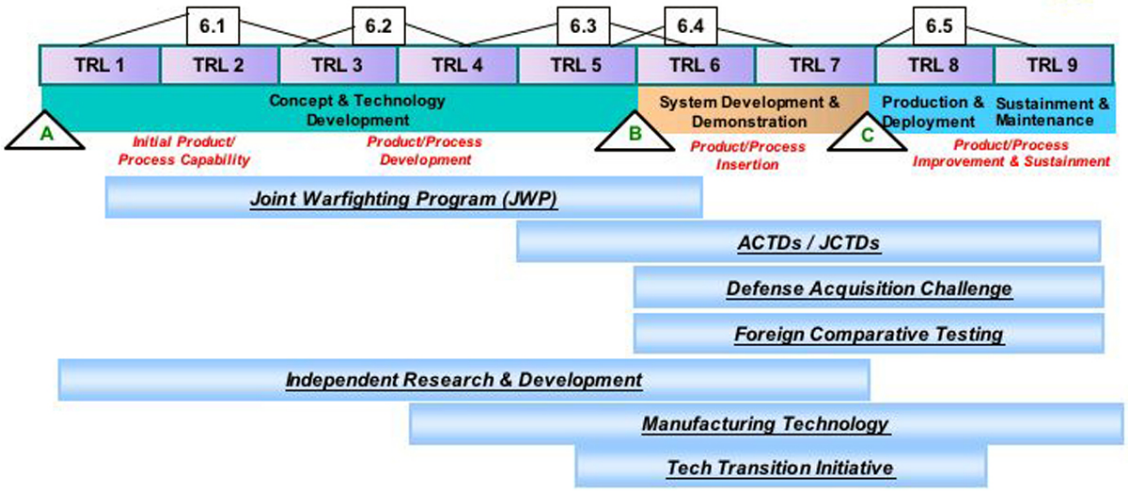
Transition Technologies to Acquisition Programs and the Warfighters

Accelerating the flow of technology to the warfighter is a top priority for the Department. Increasingly, advanced technology is becoming readily available while proliferating in international markets, requiring DoD to accelerate the development, test and evaluation, and transition of technology to maintain the technological superiority of military systems. The DoD has taken steps to reduce the time and provide the flexibility for fielding new technology. The new acquisition process is described in recent revisions of acquisition regulations and is built around technology insertion and spiral acquisition. Often referred to as an evolutionary acquisition strategy, the new process provides capabilities to the warfighters in increments. Military capability is improved over time as the technology matures and warfighters gain experience with the new systems. To be fully effective, there should be continual interaction between technologist, acquisition executive, and operational requirements specialist.



Reduce Technology Risk in Acquisition Programs

Recent studies and reports on the acquisition process have stated that ensuring sufficient technology maturity levels, supported by adequate test and evaluation and manufacturing assessments, is an excellent way to avoid cost overruns in acquisition programs. In conjunction with DDR&E representatives, Component S&T Executives are responsible for conducting Technology Readiness Assessments (TRAs) and Manufacturing Readiness Assessments (MRAs) and assigning Technology Readiness Levels (TRLs) and Manufacturing Readiness Levels. The DDR&E is responsible for both oversight and evaluation of TRAs and MRAs. TRAs are conducted for all major acquisition programs and their role shall continue to grow in importance. The Defense R&E community, working with all representatives of the Defense enterprise, must ensure that necessary S&T investments are made to deliver appropriate TRLs at each development phase, allowing successful progression through milestones. One of the primary tools available for reducing risk in acquisition programs is the effective use of prototyping, and the DoD enterprise should significantly expand the use of prototypes. Enhanced prototyping also benefits the Defense Department by serving as a tool to recruit capable scientists and engineers, to develop system engineering and program management skills, to successfully transition technology, and to advance the development of concepts of operation.



Enhance the Affordability of DoD Systems and Capabilities

Reducing acquisition and life cycle costs through the balanced development or insertion of advanced technology is a goal of the R&E program. These technology programs should continue to deliver new systems with increased lethality and survivability, a decreased logistics burden, and greatly improved situational awareness. Platforms should be lighter with more efficient propulsion systems and engines. Less fuel will be consumed by air, land, and sea vehicles and more efficient propulsion systems could reduce the costs for access to space. Munitions with improved accuracy, increased explosive density, rapid target acquisition, and reduced delivery time to target could reduce the number of weapons required for combat operations. The net result will be a reduction in expendables and the number of systems that need to be purchased to support military operations. MRAs are being inserted into our system to ensure manufacturing issues are addressed early in the process to reduce costs, increase affordability, and ensure production capability for our systems. Transformational capabilities, enabled by advanced technology, should produce a versatile full spectrum force that costs less to procure, maintain, and operate, thereby driving down acquisition and life cycle costs.

Enhance Sustainment and Upgrade for Existing Weapon Systems

Technology is a major force multiplier that can be used to significantly increase the efficiency of DoD systems and weapon platforms. Therefore, one of the overriding goals of the R&E program is to develop technology that will reduce the costs for both new and legacy systems. This goal may not be achieved by lowering the unit cost of a ground combat vehicle, ship, or airplane; in fact, due to complexity, the unit costs for these systems are likely to continue to increase compared to their predecessors. However, the capability and reliability of these systems can be dramatically improved. Driving down the life cycle costs for planned and operational systems should be a priority.

Forge Partnerships

Partnerships are critical to a healthy S&T program. Increasingly, defense needs can be met by leveraging the global technology explosion and commercial products such as computers, software, electronics, and communications. In today's world, DoD technology is provided from various sectors, typically DoD laboratories and agencies, industry, and academia. The DoD also enters into collaborative technology development agreements with our close allies. The Department should use the best technology available worldwide to provide the best capability to the warfighter, and an awareness of international S&T and cooperation with our allies are vital parts of providing that capability. Universities provide a source of new ideas and fundamental knowledge. Industry plays a critical role in conducting technology demonstrations that are funded by Budget Activity 3, building innovative prototypes that are funded by Budget Activities 3 and 4, and completing the transition of technology to military systems. Finally, a critical component to the overall DoD R&E strategic plan is collaborative technology development programs with other U.S. Government agencies, such as the Department of Energy, the National Aeronautics and Space Administration, and the Department of Homeland Security. These collaborative efforts expand the defense technology base and permit technology leveraging. All players are important to the partnership and each provides unique solutions to national security problems.

Share Information Across Multiple Components Through Information Reuse

The collection, sharing, and dissemination of DoD scientific and technical information (STINFO) are vital to the DoD R&E community and are required by DoD instruction. Reuse of technical information prevents unintended duplicative efforts, promotes collaboration between researchers, and allows the results of previous work to be leveraged by the entire community. Consolidation of the DoD's comprehensive STINFO allows researchers to easily access information and promotes a robust and open interchange of information between the Services and Defense Agencies. In a rapidly changing Defense environment, keeping pace with the latest R&E developments is an ongoing challenge to DoD researchers and acquisition professionals. In order to provide these customers with the most up-to-date information, the Office of the Director, Defense Research & Engineering and the Defense Technical Information Center developed, launched, and are maintaining the R&E Portal, a one-stop, single sign-on information gateway for the R&E community. It provides users a single source for all current and historical R&E information including technical data resources, S&T planning documents, financial databases, and numerous other resources. Also available through this portal is information on global technology development consisting of qualitative assessments of foreign S&T centers and individual assessments of a country's technical capabilities.

Minimize the Probability of Technology Surprise

Disruptive military capabilities and challenges may come from adversaries who develop and use break-through technologies to negate current U.S. advantages in key operational areas. A revolutionary technology and the associated military innovation can fundamentally alter long-standing concepts of warfare. Some potential adversaries are seeking disruptive capabilities to exploit U.S. vulnerabilities and offset our current advantages. The DoD R&E program will work to hedge against the uncertainty brought about by disruptive technologies and partner with the intelligence community in an attempt to identify them early. Not only must we be aware of technology breakthroughs of a potential adversary, but also the intended or unintended application of that technology. Connecting to the intelligence community allows the S&T community to better assess a potential adversary's emergent technologies and resultant capabilities, and allows the Department to minimize the potential of technology surprise.

Value Technical Competence and Integrity

The Department will maintain a relevant and robust R&E program that attracts the best and brightest scientists and engineers. The Department will continue to pursue initiatives to recruit and retain top scientists and engineers and to maintain and operate modern facilities. We will ensure the work environment allows all to participate productively, free from harassment, discrimination, and unethical behavior.

Provide Value for the Taxpayer

Those who execute the DoD R&E program will invest each tax dollar as if it were their own. We must all be good stewards, responsible to our primary shareholder…the American taxpayer. To deliver value for the taxpayer, our efforts should be guided by a number of principles. Truly open and fair competition should be used to select projects whenever possible. The enterprise should proactively encourage academic institutions and industry to propose their ideas and technologies to solve mission needs. The enterprise must always be open to new ideas, including those ideas which call into question current programs or avenues of research. We will leverage other government, industry, and allied

technology investments. Every member of the DoD R&E enterprise must strive to deliver results and value and must pursue their work in a manner that inspires the confidence of taxpayers, the warfighter, the Congress, industry, and the academic community.

Summary

This strategic plan is intended to guide the collective R&E program of the DoD and provide the broad context that will integrate Service and Agency programs to provide joint DoD capabilities. The Department's R&E program has an outstanding record of delivering the technological superiority that continues to be a cornerstone of our national military strategy. The operational advantage our armed forces enjoy today is the legacy of decades of investment in S&T. It is a legacy delivered by past members of the Defense R&E enterprise team who pursued their work with urgency, creativity, and objectivity. Likewise, our future military capabilities will be substantially determined by today's investment in S&T. Today's dedicated team of Defense R&E professionals in Government, industry, and academia will define the future capability of our military and ensure the nation's security for future generations.

Appendix

Enabling Technology Descriptions

Advanced Electronics: Investments should focus on electronic and photonic technologies that enable asymmetric defense capabilities for the warfighter. Focused advanced electronics technology development to enhance the performance, affordability, and sustainment of sensors, signal processing, and communications for military systems. Emphasis is on innovations and development of electronic and photonic materials, processes, components, and integration technologies.

Advanced Materials: Advanced materials and processes technology spans the spectrum of structural, thermal protection, non-structural, and electronic materials. The scope of the program encompasses design and processing of advanced metal alloys, including aluminum, steels, titanium, magnesium, and intermetallic alloys; electronic and photonic materials, including semiconductors, superconductors, optical materials and magnetic materials; organic and inorganic polymers; materials property measurements, characterizations, and metrology; new and environmentally acceptable coatings; corrosion resistant materials and corrosion control materials and processes; nondestructive inspection/evaluation/characterization; fracture analysis/test; welding/joining; survivability, e.g., battle damage repair; erosion resistant, high-temperature antenna windows, radomes, and infrared transparent domes; and supportability materials and processes for Defense equipment.

Alternative Fuels & Energy Sources: R&E investments should focus on technologies that develop alternative energy sources such as the Hybrid Intelligent Power program and support the development of intelligent power management architectures that will fundamentally change power management, storage, and distribution on the battlefield. Technologies that support the development of new fuel sources using novel methods and sources, and technologies that increase the energy density of fuel cells while reducing the size and integrating multiple requirements into a single system, such as water and waste management should also be pursued. These technologies will enable DoD, and potentially the nation, to reduce its dependence on foreign fossil fuels.

Autonomous Systems Technologies: Autonomous systems technologies enable unmanned systems to sense, perceive, analyze, plan, decide, and act, in order to identify and achieve their goals. The systems include communication and interaction with humans and/or other unmanned systems. Unmanned systems in the air, on the ground, and at sea perform their functions with ever increasing capabilities and technological sophistication using autonomy/teaming, human system integration, power, communications, sensors, mobility, planning/C^2, processing, and diagnostics and prognostics. All of these technologies are critical to system level capabilities.

Biometrics & Bio-inspired Technologies: Technologies that enhance the development of individual biometrics and systems that collect, store, and match those biometrics to take away a potential adversary's anonymity, both in direct contact and remotely. Research conducted to discover biological structures and forms that can be adapted and applied to DoD capabilities and systems.

Casualty Care & Human Performance Optimization: Casualty care research seeks to develop methods and materiel for treating the major causes of morbidity and death among those injured in battle—for example, blood loss or penetrating head wounds. Preventative measures and technologies for treating non-life-threatening injuries result in positive outcomes and return to duty. Examples of

casualty care research products include new drugs, devices and techniques for hemorrhage control, casualty resuscitation, and casualty stabilization. Human performance optimization is the application of human knowledge and skills development and emerging technologies to sustain and improve human capability to complete essential tasks. Examples of R&E activities include selecting and retention of personnel, advanced distributed learning systems development for just-in-time training and mission rehearsal, extending physical endurance, enhancing psychological resilience, and reducing injury and illness through protective materiel, training, and nutrition.

Cognitive Enhancements: Cognitive Enhancements seeks to develop the knowledge and supporting technologies to enhance our warfighting capabilities by optimizing the human–machine systems. Our knowledge of human cognitive capabilities and limitations drive military systems design. These efforts push computer-aided performance to a new level. Cognitive Enhancements technologies will support the development of products that include advanced computer based decision aids for command and control systems, real-time embedded mission rehearsal technologies, and adaptive human-computer interfaces for a variety of systems (e.g., unmanned combat aerial vehicles).

Combating Weapons of Mass Destruction Technologies: Combating Weapons of Mass Destruction technologies enable an integrated and seamless response to nuclear, radiological, chemical, and biological threats. Technologies would be used to dissuade or impede access to, or distribution of, sensitive technologies, material, and expertise (nonproliferation). Technologies for defeat of WMD threats (counterproliferation) would include: timely target identification and characterization; prompt planning and execution of attacks; target defeat with minimal collateral hazards; and combat and collateral hazard assessment. Technologies to mitigate use of WMD (consequence management) would include those that strengthen the protection of the force, protect assets and equipment, advance early warning detection capabilities, and clean-up. Technology advances should be pursued in radiological, chemical, and biological standoff; early warning detection; miniaturization; interconnectivity; and enhancements in detection sensitivity, interference rejection, logistics supportability, and affordability. Medical Force protection technologies should develop vaccines and other pre-exposure prophylactic measures, post-exposure therapeutics, and diagnostic methods and devices.

Directed Energy Technologies: Directed Energy (DE) technologies, such as high-energy lasers and high-power microwaves, enable ultra-precision/low collateral damage, long range, and speed-of-light engagement capabilities. Demonstrations and transitioning DE technologies to systems require continued emphasis on: laser device power scaling; precision laser beam control; high-power microwave sources and antennas; lethality demonstrations/lethality modeling and simulation; efficient laser diodes; thermal management; pulse power/compact power supplies; adaptive optics; and system engineering for integration of directed energy weapon systems onto weight-constrained, mobile platforms.

Energetic Materials, Rocket Propellants & Explosives: Technology development efforts should support the fielding of new capabilities for managed lethality engagements, improved safety (via insensitivity), increased platform load-outs, improved logistics, and increased range/speed of offensive and defensive weapons. Novel energetic materials as well as management of energy release will produce warheads that can deliver tailored effects on their targets, and propellants that support the development of advanced propulsion systems.

Energy & Power Technologies: The demands for electric power and energy in modern weapon systems are increasing rapidly. Platforms demand more auxiliary as well as primary power for longer

endurance operations. In DoD's volume and/or weight limited systems, smaller packages, particularly sensor systems, have been the beneficiary of new power and energy technologies. Sensor system power requirements continue to increase because of the significant increase in capability that sensors bring to warfighting. Technologies that enhance power generation, energy storage, and power control and distribution, such as thermal management, are essential to achieving warfighting goals and should drive investments in this area.

Human, Social, Cultural, & Behavioral Modeling: Human, Social, Cultural, and Behavior (HSCB) Modeling is the application of knowledge, skills, and supporting technologies to give the DoD the ability to understand the complex human terrain and socio-cultural environments in which we operate. This work is a merging of the social sciences with the computational and computer sciences to deliver the methodologies and tools to support Phase 0 (planning/shaping) to Phase 4 (stabilization) military operations critical to success in military operations. HSCB technologies will support the development of products that include methodologies to collect socio-cultural data in denied areas, validated adversary and non-adversary models and synthetic entities to support training, simulation, and mission rehearsal, and validated socio-cultural models and tools to support operational planning and intelligence analysis.

Hyperspectral Sensors: Sensor and electronic technologies to enhance the performance and affordability of surveillance systems using electro-optical signals in multiple wavelengths for improved target detection and identification. The R&E investments include developing infrared and visible focal plane array technologies, high-speed processing of electro-optical signals, and high-speed simultaneous data fusion from multiple bands. Emphasis is on innovations in system design and spectral band phenomenology.

Information Technologies: Information technologies encompass a broad range of activities which include net-centric applications, information fusion and knowledge building, information management and distribution, wireless security, computer network operations, information assurance, high productivity computing systems, and modeling and simulation. DoD investment in these technologies will enable net-centric operations and warfare.

Large Data Set Analysis Tools: New generations of sensors and networks are rapidly increasing both the size and number of data sets available, both in real time and for later analysis. However, the full potential of such very large data sets is limited by the time and resources needed to extract operationally meaningful data from them. New analysis tools are needed to help convert very large data sets into useful information. Such tools should enable full and effective use of sensor and network data by allowing relevant items and objects within the data sets to be recognized, extracted, viewed, correlated, summarized, tagged, and directed intelligently to recipients who may vary widely in their ability to handle large data sets.

Manufacturing Technologies: Manufacturing technologies address production issues from systems development through transition to production and sustainment. Manufacturing technology is the application of advanced technologies to manufacturing processes, tools, or production equipment.

- **Affordability & Producibility:** Affordability technologies reduce manufacturing costs by enabling improved manufacturing processes. Producibility technologies support the development of reliable, repeatable processes in a timely manner.

- **Agile Fabrication:** Technologies to decrease production cycle time at the component, sub-component, or system level.

Nanotechnology: The nanotechnology area is based on recent experimental, analytical, and modeling tools that permit the deliberate control of material structure at critical dimensional scales less than 100 nanometers. At these scales, quantum mechanical effects and crystal-structure properties that are not determined at larger dimensions become significant. By controlling material structure at these dimensions new properties and even new forms of elemental structure, such as carbon nanotubes, become possible. The overall goals of the DoD nanotechnology efforts include the development of understanding and the control of matter in the nano-regime and exploitation of unique phenomena at these dimensions to enable novel applications enhancing warfighter and battle systems capabilities. The DoD program is aligned in its planning and overall thrusts with the National Nanotechnology Initiative with projects in each of the seven major initiative focus areas: (1) Fundamental Nanoscale Phenomena and Processes, (2) Nanomaterials, Nanoscale Devices and Systems, (3) Instrumentation Research, (4) Metrology and Standards for Nanotechnology, (5) Nanomanufacturing, (6) Major Research Facilities and Instrumentation Acquisition, and (7) Societal Dimensions, especially health and environmental impact understanding and control.

Networks & Communications: Networks and communications technologies provide the warfighter with effective access to and utilization of global, uninterrupted, seamless, communication services. Networks and communications technologies must provide robust, secure connectivity between globally dispersed sanctuary locations in theater down to the lowest echelon foot soldier or marine and to each ship and aircraft. Technologies should address surface-based, airborne, and space-based networks. Technology efforts within this area can be broadly categorized as antennas, wireless transport, networking, and network management.

Organization, Fusion, & Mining Data: Modern networks have multiplied the problem of how to merge and understand data from multiple sources, and the proliferation of sensor types has increased the types and ranges of data involved. Increases in levels of cyber warfare have at the same time increased the risk that such data may include intentional misinformation. Enabling technologies for organizing, fusing, and mining modern sensor data sets include the need for better ways to label, organize, and compare diverse types of data in real time, more dynamic and automated abilities to rank data streams based on factors such as timeliness and accuracy, and improvements in the ability to find important correlations and overlooked data items in large data sets, both in real time and in after-the-fact analysis.

Persistent Surveillance Technologies: Sensor, electronics, and communications technologies that enable improved battlespace awareness for the warfighter. The focus of R&E activities is on data fusion of multiple sensors with multiple phenomenologies, the quick and accurate processing of this data into timely and useful knowledge, and its dissemination to the warfighter. Emphasis is on developing affordable, reliable, maintainable, and effective architectures that provide improved situational awareness over large enough areas and for long enough duration to practically meet users' needs.

Radar: Technologies to enhance the performance and affordability of ground, sea, air and space radar systems for target identification and detection, discrimination, and tracking. The R&E investments include development of technologies that enable (a) fielding multifunctional RF systems that integrate

radar sensors with communications, (b) multi-mission capabilities for surveillance, tracking, discrimination, and targeting ID, and (c) sensing in frequency regimes beyond 100 GHz.

Robotics: Technologies that are key enablers for robots are similar to those for autonomous systems except robots employ electro-mechanical devices in addition to "autonomous software" to accomplish tasks.

Software Research: Software research investigates ways of determining whether software systems are fit for their intended use, i.e., whether they are sufficiently trustworthy, reliable, secure, robust, and adaptable to provide satisfactory performance. Software research should also produce programming and integration tools that enable rapid high-assurance and high-productivity software development and improved integration of complex embedded software systems.

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Strategic Plan