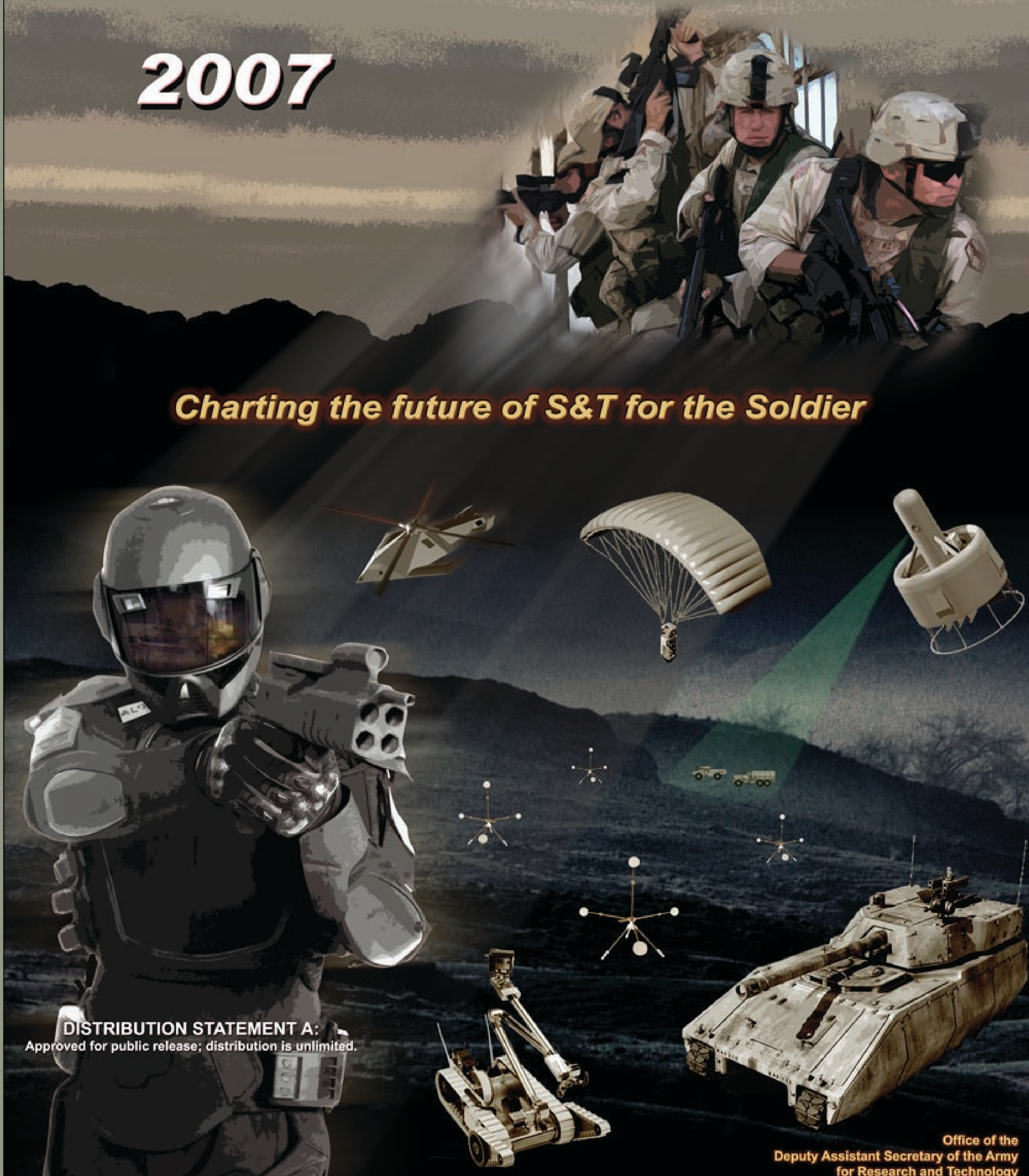
Army Strong . . . Technology Strong

Army Science & Technology Master Plan - Executive Summary

2007



Charting the future of S&T for the Soldier

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DEPARTMENT OF THE ARMY
WASHINGTON DC 20310

FEB 27 2007

Our U.S. Army continues to fight a war against an adaptive and resourceful enemy unlike any we have faced before. Success in the Global War on Terrorism demands that we remain steadfast and unrelenting in our quest to equip our Current Force with the best warfighting technologies available, while simultaneously nurturing the transformational scientific and technological potential to ensure success for the Future Force in tomorrow's wars.

Soldiers are the centerpiece and focus of all our efforts. The Future Combat Systems (FCS) embody the core attributes of the U.S. Army's Future Force. U.S. Army Science and Technology (S&T) continues to mature technologies for FCS and, where feasible, to accelerate selected technologies directly into the Current Force. Our S&T efforts have already demonstrated contributions to current operations such as improved ballistic protection, networking, and unmanned systems. We have seen evidence of the payoffs in our technology investments such as the Interceptor Body Armor with Small Arms Protective Insert plates saving Soldiers' lives in Iraq and Afghanistan. We have also increased force protection by developing and fielding counter-Improvised Explosive Device systems.

This U.S. Army S&T Master Plan describes the major technology programs and fundamental research that seek to satisfy the capability gaps in the Current Force and the Future Force. In responding to the capability gaps identified by the U.S. Army Training and Doctrine Command, combat and materiel developers have collaborated with the warfighter throughout the development and approval process. The U.S. Army S&T investments are synchronized with the Defense-wide programs through coordination and collaboration process overseen by the Director, Defense Research and Engineering.

U.S. Army Scientists and Engineers are expanding the limits of our understanding to provide our Soldiers, as well as our Joint and coalition partners, with technologies that enable transformational capabilities in the ongoing war on terrorism to ensure that the U.S. Army remains a victorious, relevant, and ready land component of the Joint Force.

Peter J. Schoomaker
General, United States Army
Chief of Staff

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Secretary of the Army

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The U.S. Army Science and Technology (S&T) program is the "engine of change" that seeks to accelerate the U.S. Army's Transformation into a more agile force that is dominant over the traditional, and emerging irregular, catastrophic, and disruptive challenges our Forces must encounter. The S&T community has demonstrated its Soldier focus by responding to demands of current operations in Afghanistan and Iraq by providing selected technologies for immediate limited fielding such as those to counter Improvised Explosive Devices (IEDs).

This Army S&T Master Plan is the capstone planning document that describes the major U.S. Army funded S&T efforts to enable Future Force and enhance Current Force capabilities defined by our warfighters. The major technology efforts are described as Army Technology Objectives. Equally important, the basic research program pursues new understandings in science that can provide potentially revolutionary, paradigm-shifting technologies for our Soldiers to decisively defeat our adversaries.

The U.S. Army's largest S&T investments are in force protection technologies to detect and neutralize IEDs, mines, rockets, artillery and mortars, to protect vehicles, and to provide area/facilities protection. Other important technology investments include command, control, communication, computer, information, surveillance and reconnaissance, lethality, Soldier System, unmanned systems, logistics, and advanced simulation.

The U.S. Army's Scientists and Engineers are innovation change "agents" committed to developing the technologies that will provide America's Soldiers with capabilities superior to any adversary and to achieve decisive results and return home safely.

Thomas H. Killion

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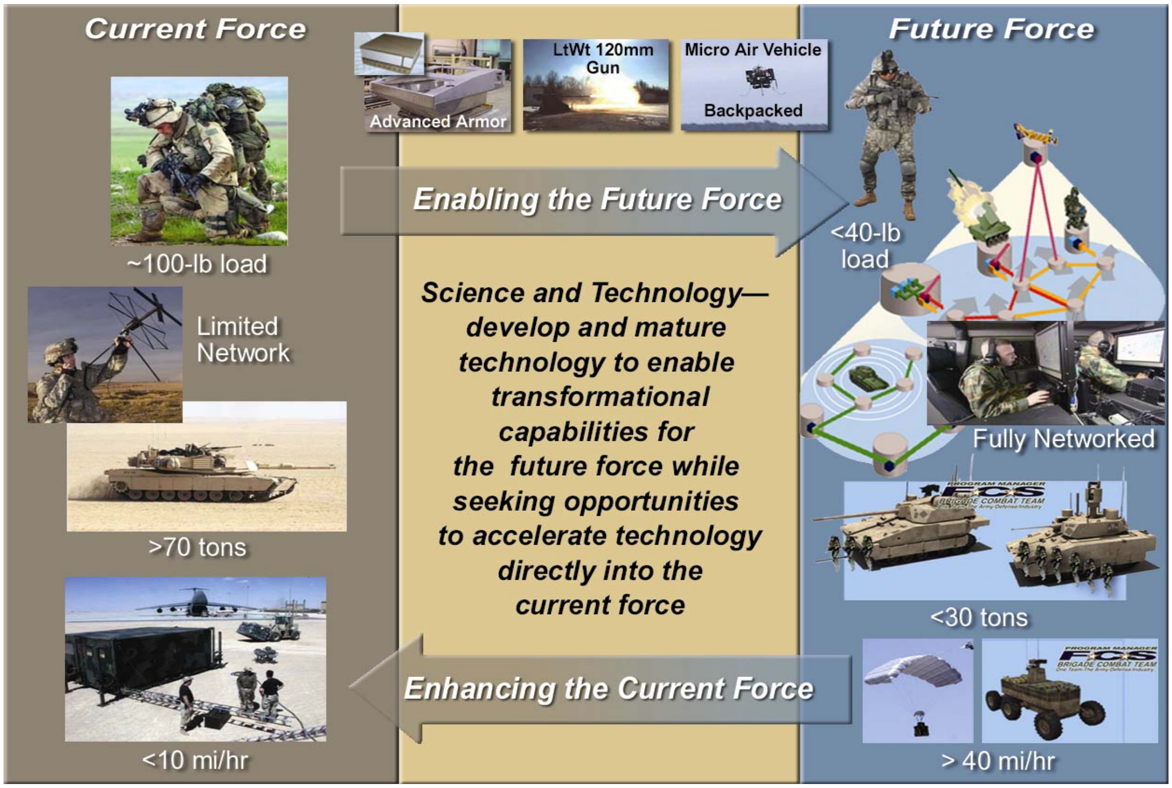
EXECUTIVE SUMMARY

This document is an executive summary of the *2007 Army Science and Technology Master Plan* (ASTMP), developed under the direction of the Deputy Assistant Secretary for Research and Technology (DAS(R&T)). The ASTMP, with its associated Web sites, is the single source document describing the Army S&T program strategy, major technology objectives, research goals, as well as roles and relationships between S&T and strategic partners. To the S&T community, it fosters collaboration to the warfighting community, provides an understanding of technology opportunities for enabling advanced warfighting concepts, and provides insights on the ability of the S&T program to shape strategic outcomes. The ASTMP provides our industry partners with a compendium of the major technical efforts pursued by the Army S&T program to assist in developing related programs. The ASTMP also provides Congress with a description of the relevance and responsiveness of the Army's S&T investments. The ASTMP is published biennially in odd-numbered years to align with the convening of the first session of each new Congress. The next publication will be 2009.

The ASTMP presents the Army's S&T strategy (Chapter I–Army Science and Technology Strategy); the planned Army S&T program (Chapter II–Developing Technology for Decisive Capabilities and Chapter III–Discovery and Understanding: Enabling Future Generations); and the Army S&T enterprise (Chapter IV–Army Laboratories and Partnerships: Engines of Change) including our partnerships with industry and academia. Annex A describes the Training and Doctrine Command's role in S&T. Annex B provides a broad view of international S&T cooperation.

ARMY SCIENCE AND TECHNOLOGY STRATEGY

The Army is at war. The science and technology (S&T) program has to be as adaptable and responsive as our Soldiers in the field. The S&T strategy is to pursue technologies that will enable the future force while simultaneously seizing opportunities to enhance the current force (Figure 1). 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 technology's readiness to satisfy system requirements.



The Army S&T strategy is to pursue technologies that will enable the future force while simultaneously seeking opportunities to enhance the current force. These forces require technology solutions for networked capabilities and increased responsiveness through speed and precision lethality.

Figure 1. Enhance the Current Force/Enable the Future Force

The diverse S&T investment portfolio exploits the dynamic nature of opportunities presented through scientific discovery and the "game-changing" potential of innovative technology applications. Likewise, these investments are responsive to specific needs identified by combat developers. Both of these approaches work in synergy to provide overmatching capabilities against threats that are constantly adapting and changing.

STRATEGY FRAMEWORK

Quadrennial Defense Review and Army Modernization Plan

The 2006 *Quadrennial Defense Review* (QDR) provides "a roadmap for change, leading to victory." The 2006 *Army Modernization Plan* (AMP) describes the Army program decisions to support transformation by improving current capabilities and developing new ones using a comprehensive and balanced approach. The *Army S&T Master Plan* characterizes the strategy and summarizes the major efforts funded in the Army's S&T enterprise that will provide technology options to enable warfighting system capabilities stated in the AMP.

The QDR defined two fundamental imperatives for the Department of Defense: (1) continuing to reorient DoD's capabilities and forces to be more agile in this time of war, to prepare for wider asymmetric challenges, and to hedge against uncertainty over the next 20 years; and (2) implementing enterprise-wide changes to ensure that organizational structures, processes, and procedures effectively support its strategic direction. The Army's S&T program is the "engine" of change for developing new and transformational capabilities envisioned in the QDR.

The Quadrennial Defense Review *and the* Army Modernization Plan *are used to shape the Army's S&T program that is reflected in the* 2007 Army S&T Master Plan.

The Joint Operations Concepts (JOpsC) are the foundation from which this change will build. The JOpsC describe how the joint force will operate across the entire range of military operations within the next 15 to 20 years. The JOpsC are the basis for the development and acquisition of new capabilities through changes in doctrine, organization, training, leadership, education, personnel, facilities, and materiel that are enabled by technology. Achieving the full-spectrum dominance described in the JOpsC depends, in part, on developing the capabilities identified in the eight Joint Functional Concepts identified by the Joint Chiefs of Staff: Battlespace Awareness, Joint Command and Control, Force Application, Protection, Focused Logistics, Net-Centric Environment, Joint Training, and Force Management.

The AMP modernization strategy has two components that define a clearer focus for science research and technology developments. The first component is to maintain and enhance capabilities of the current force to meet all strategic and operational requirements. This includes restoring and improving the readiness of units returning from or preparing for operations; implementing current major initiatives to restructure units into more responsive and capable modular formations; the continued fielding of immediate operational capabilities by organizing and equipping seven brigade-sized units outfitted with a family of internetted Stryker combat vehicles and other state-of-the-art, off-the-shelf technologies; and the accelerated effort to insert into existing systems and units, where feasible, newly developed capabilities derived from matured technologies.

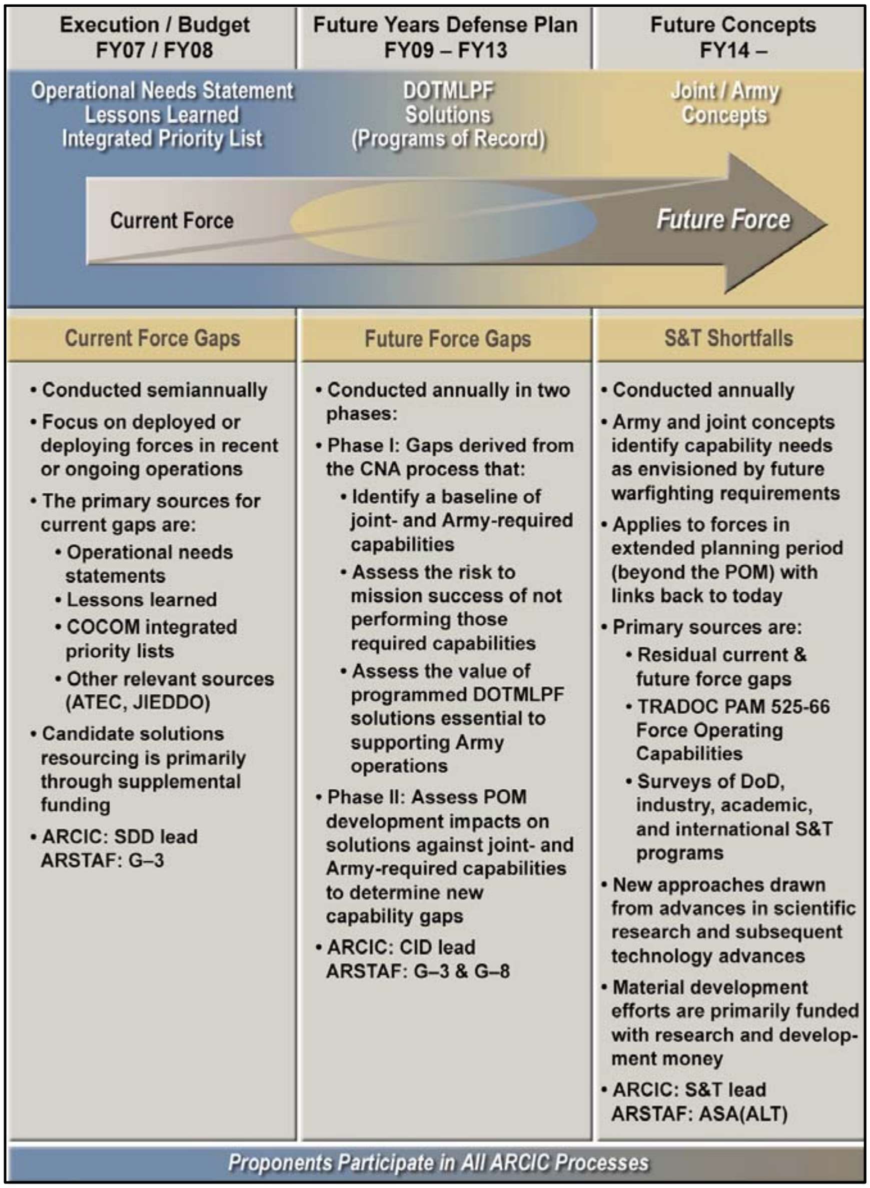
The second component of the AMP strategy demands that S&T investments develop technologies to enable entirely new, or significantly improved, materiel capabilities for the future force. Central characteristics of this future force are significantly increased agility, tailored precision lethality, and reduced logistics demand. The foundational system for achieving these transformational capabilities is the Future Combat Systems (FCS).

Warfighter Needs

This graphic depicts the cover of the Army Weapons Systems "handbook." This handbook illustrates that we develop technology to enable the weapon systems that are provided to our Soldiers to accomplish their mission.

Combat developers from the Training and Doctrine Command (TRADOC) inform the S&T community of warfighter needs in capability gaps and technology shortfalls identified through three Army Capabilities Integration Center (ARCIC) processes: current gap analysis, capability needs assessments (CNAs), and technology shortfall analysis. TRADOC refines these analyses and identifies force operating capabilities to enable joint and Army concepts. At TRADOC, the ARCIC defines and describes capability gaps for the current and future forces and identifies technology shortfalls based on analyses of current investment plans and Army Technology Objectives (ATOs). The fiscal year timeframes for three sets of capability gap information—current force capability gap analysis (CGA), future force gaps–CNAs, and S&T shortfalls—are described in Figure 2. These three sets of gap information are derived by ARCIC in conjunction with TRADOC centers, schools, and battle laboratories and the Army Medical Department and School.

The outputs from these processes are used to define Force Operating Capabilities (FOCs). Metrics have been established to evaluate fulfillment of gaps and related FOCs based on ATO "products." Technology shortfalls are provided to material developers along with the descriptions of FOCs listed in TRADOC Pamphlet (TP) 525–66. The current version of TP 525–66 is available on the TRADOC Web site at http://www.tradoc.army.mil/tpubs/pams/p525-66.htm. The TRADOC/ARCIC role in the S&T program planning process is further explained in Annex A of the ASTMP.



This figure displays the three components of ARCIC's gap analyses process, the frequency, and proponent staffs. The components are current force gaps (CGA), future force gaps (CNA), and S&T shortfalls.

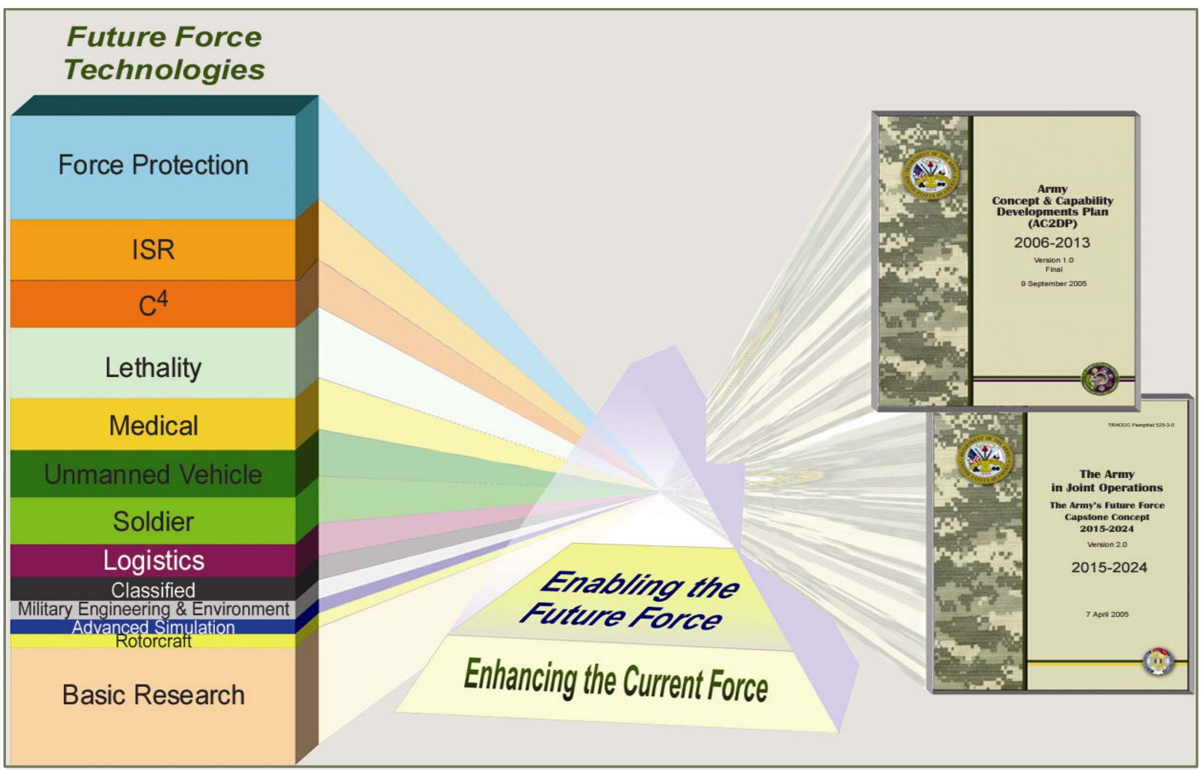
Figure 2. Force Capability Gaps Over Time

S&T Investment—Future Force Technology Areas

The S&T investments described in the ASTMP are responsive to the goals and objectives stated in the QDR, reflected in the AMP, and expressed as technology shortfalls through the TRADOC/ARCIC process. These investments are also synchronized with the

DoD-wide S&T program through Director, Defense Research and Engineering (DDR&E) S&T Strategic Overview briefings.

The Army's S&T investment strategy pursues technologies to achieve the QDR goal to field forces that are "lighter, yet more lethal, more sustainable and more agile" while achieving entirely new capabilities such as the ability to "locate, tag and track terrorists." The Army S&T program continues to pursue technologies that will enable a fully capable FCS Brigade Combat Team (BCT) within the joint land force and to spin out technologies as they are available for the current force. In the near term, the Army's single largest S&T investment focuses on maturing technologies to enable fielding of the initial FCS BCT and follow-on technology spinouts. These technologies include advanced lightweight armors, active protection for kinetic energy threats, the 120mm line-of-sight/beyond-line-of-sight (LOS/BLOS) ammunition suite, and the next generation of technologies for the non-line-of-sight launch system (NLOS–LS) precision attack missile (PAM) and the organic air vehicle within the unmanned systems technologies. Although FCS technology developments are the highest priority focus in the S&T portfolio, the majority of the investment is allocated across 13 future force technology areas (including the classified program) (Figure 3).



The future force technology area color bands shown on the left are approximately proportional to the financial investment within the Army's requested FY07 S&T budget and Future Years Defense Plan. The specific technologies funded in these investment areas are aligned to achieve the FOCs defined by TRADOC. The documents depicted on the right describe the FOCs and joint operations concepts.

Figure 3. Proportion of Financial Investment Devoted to Future Force Technology Areas

To better understand the diversity of the S&T investment enterprise, the future force technology areas are described below and graphically depicted in Figure 3 in proportion to funding within the total investment of $1.7 billion requested in the President's budget for FY2007:

- *Force Protection* technologies enable Soldiers and platforms to avoid detection, acquisition, hit, penetration, and kill. These technologies include advanced armor, countermine and counter improvised explosive devices (IEDs) detection and neutralization, aircraft survivability, and active protection systems.
- *Intelligence, Surveillance, and Reconnaissance (ISR)* technologies enable persistent and integrated situational awareness and understanding to provide actionable intelligence that is specific to the needs of the Soldier across the range of military operations.
- *Command, Control, Communications, and Computers (C^4)* technologies provide capabilities for superior decisionmaking, including intelligent network decision agents and antennas to link Soldiers and leaders into a seamless battlefield network.
- *Lethality* technologies enhance the ability of Soldiers and platforms to provide overmatch against threat capabilities and include nonlethal technologies enabling tailorable lethality options.
- *Medical* technologies protect and treat Soldiers to sustain combat strength, reduce casualties, and save lives. It includes technologies to enhance Soldier performance in extremely demanding environments imposed by battlefield physical and psychological demands as well as extremes in topography and climate.
- *Unmanned Systems* technologies enhance the effectiveness of unmanned air and ground systems through improved perception, cooperative behaviors, and increased autonomy.
- *Soldier Systems* technologies provide materiel solutions that protect, network, sustain, and equip Soldiers and non-materiel solutions that enhance human performance. Together these solutions enable Soldiers to adapt and dominate against any threat.
- *Logistics* technologies enhance strategic response and reduce logistics demand. Focus is on technologies that increase efficiency of systems or subsystems or sustainment processes that enable production of consumables closer to the point of use, that conserve or reduce demand for consumables (such as fuel and water), and that enhance the nation's assurance of sufficient energy for Army missions.
- *Military Engineering and Environment* technologies enhance deployability and sustainability. These technologies also enable sustainment of training and testing range activities.

- *Advanced Simulation* technologies provide increasingly realistic training and mission rehearsal environments to support battlefield operations, system acquisition, and requirements development.
- *Rotorcraft* technologies enhance the performance and effectiveness of current and future rotorcraft while seeking to reduce operational and sustainment costs.
- *Basic Research* investments seek to develop new understanding to enable revolutionary advances or paradigm shifts in future operational capabilities.

Within the future force technology areas, the highest priority S&T efforts are designated by Headquarters Department of the Army (HQDA) as Army Technology Objectives. We do not designate ATOs within the Basic Research area since these investments fund sciences (discovery and understanding), not technology. The ATOs are cosponsored by the S&T developer and the warfighter's representative, TRADOC. The ATOs are focused efforts that develop specific S&T products within the cost, schedule, and performance metrics assigned when they are approved. The goal is to mature technology within ATOs to transition to program managers for system development and demonstration (SDD) and subsequently to acquisition.

The key applied research, advanced technology development, and manufacturing technology initiatives, managed as ATOs, are presented in Chapter II of the ASTMP. The basic research program is described in Chapter III of the ASTMP.

ENABLING WARFIGHTING CAPABILITIES—TECHNOLOGY TRANSITION

Maintaining the Army's Technology Edge

The U.S. Army is the most technologically advanced and capable Army in the world. The S&T community is responsible for pursuing technologies that maintain and enhance that superiority. Technologies must be demonstrated as having achieved sufficient maturity for transition and integration into acquisition programs within their schedules. Technology maturity is described in terms of technology readiness levels (TRLs), which are defined in Table 1. The general goal of the technology developer is to mature a technology for transition from S&T to an acquisition program at TRL 6. More than 60 percent of the advanced technology development funding is contracted to industry partners by the S&T community. This approach enhances the opportunity to transition technology to the acquisition community faster. Acquisition program managers, in coordination with warfighting customers, determine which technologies are integrated and fielded into new or existing systems, and when they are provided to our Soldiers.

Table 1. Technology Readiness Levels

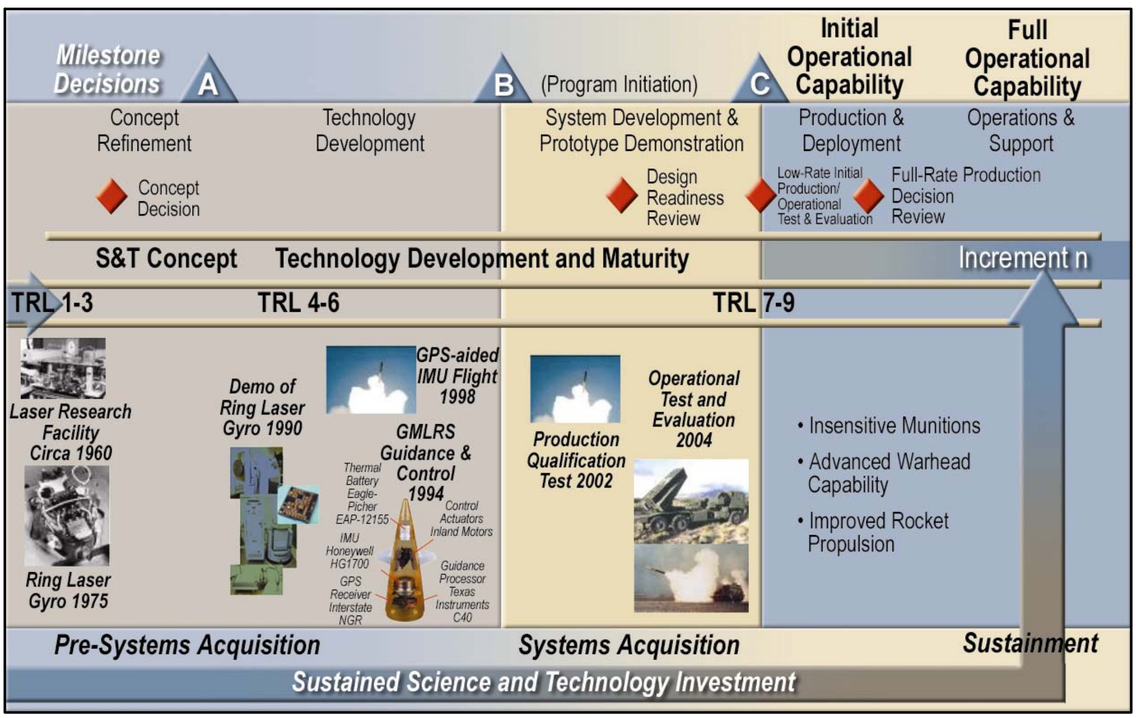
Technology readiness levels are used to assess the maturity of technology solutions and their readiness for transition to acquisition programs of record.

TECHNOLOGY READINESS LEVELS	DESCRIPTION
TRL 1—Basic principles observed and reported.	Lowest level of technology readiness. Scientific research begins to be translated into applied research and development. Examples might include paper studies of a technology's basic properties.
TRL 2—Technology concept or application formulated.	Invention begins. Once basic principles are observed, practical applications can be invented. The application is speculative and there is no proof or detailed analysis to support the assumption. Examples are limited to analytical studies.
TRL 3—Analytical and experimental critical functions or characteristic proof of concept.	Active research and development are initiated. This includes analytical and laboratory studies to physically validate analytical predictions of separate elements of the technology. Examples include components that are not yet integrated or representative.
TRL 4—Component or breadboard validation in laboratory environment.	Basic technology components are integrated to establish that they will work together. This is relatively "low fidelity" compared to the eventual system. Examples include integration of ad hoc hardware in the laboratory.
TRL 5—Component or breadboard validation in relevant environment.	Fidelity of breadboard technology increases significantly. The basic technology components are integrated with reasonably realistic supporting elements so that they can be tested in a simulated environment. Examples include high-fidelity integration of components in a laboratory.
TRL 6—System/subsystem model or prototype demonstration in a relevant environment.	Representative model or prototype system, which is well beyond that of TRL 5, is tested in a relevant environment. Represents a major step up in the technology's demonstrated readiness. Examples include testing a prototype in a high-fidelity laboratory environment or in a simulated operational environment.
TRL 7—System prototype demonstration in an operational environment.	Prototype is near, or at, planned operational system. Represents a major step up from TRL 6, requiring demonstration of an actual system prototype in an operational environment, such as an aircraft, vehicle or space. Examples include testing the prototype in a test bed aircraft.
TRL 8—Actual system completed and "flight qualified" through test and demonstration.	Technology has been proven to work in its final form and under expected conditions. In almost all cases, this TRL is the end of true system development. Examples include developmental test and evaluation of the system in its intended weapon system to determine if it meets design specifications.
TRL 9—Actual system "flight proven" through successful mission operations.	Actual application of the technology in its final form and under mission conditions, such as those encountered in operational test and evaluation. In almost all cases, this is the end of the last "bug fixing" aspects of true system development. Examples include using the system under operational mission conditions.

Particularly important during the global war on terrorism (GWOT) is the S&T community's ability to rapidly provide limited or interim capabilities to warfighters responding to highly adaptive threats. In these instances, maturing technology is rapidly exploited to modify currently fielded systems. Deployed forces communicate urgent needs through formal and informal processes. Assessing potential solutions to these urgent needs requires close coordination between technology developers, the acquisition community, and forces in the field to ensure understanding of capabilities and operational impacts from accelerated fielding of technology. In most cases, these accelerations of technology do not include full life-cycle support. Therefore, end users must weigh the advantages and disadvantages of accepting new technology through accelerated fielding.

From Ideas to Weapon Systems

Providing new capabilities begins with ideas that generate technology concepts in basic research that are matured, demonstrated, acquired by program managers (PMs) and program executive offices (PEOs), produced by industry, and ultimately fielded by the Army as systems for Soldiers. An example of successfully implementing this process is the Guided Multiple-Launch Rocket System (GMLRS) (Figure 4). Laser research begun in the early 1960s evolved into a demonstration of a research model of a ring laser gyro about 1975. Ring laser gyros were demonstrated at component levels by about 1990. In 1994, the GMLRS Advanced Technology Demonstration (ATD) was started to provide precision guidance



This graphic depicts the relationship between S&T and acquisition to improve systems capabilities. The upper part of the graphic shows the acquisition cycle from operational concept to the left of the milestone A decision (begins technology development phase), through milestone B (program initiation), to milestone C (production decision). The lower part uses the Guided Multiple Launch Rocket System development as a case study to depict the increasing TRLs' increasing maturity, from research at TRL 1 (basic principles observed and reported) through demonstrations of technology at TRLs 4–6 to systems demonstration at TRLs 7–9. After milestone B the acquisition program manager works with the S&T community to assess the readiness of technology to be inserted into the systems throughout its life cycle to satisfy baseline and follow-on system requirements.

Figure 4. Basic Research Ideas May Lead to Field Deployment: GMLRS Exemplar

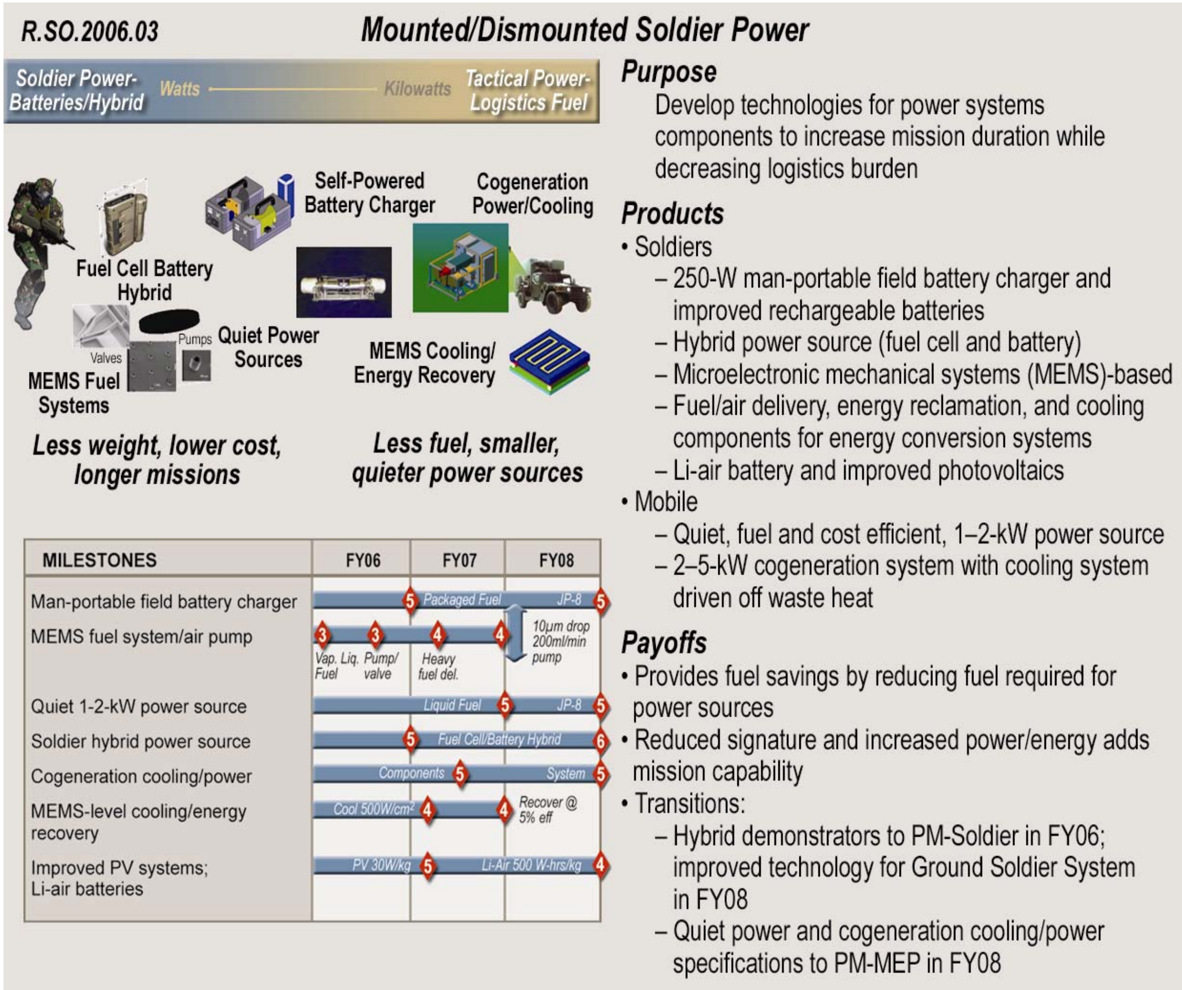
technology for the M26 MLRS rocket. The M30 GLMRS (standard) rocket uses a guidance system with an inertial measurement unit (IMU), a Global Positioning System (GPS) receiver, and four small additional control fins to improve accuracy out to the missile range of more than 60 km (37 miles). The first fully guided missile test of an XM30 was conducted in May 1998. The GMLRS ATD was completed in 1999 after successfully demonstrating accuracy to within 1 meter of the intended target at full range of the missile. In late 1998, the GMLRS program entered a 4-year SDD phase, and the final production qualification tests were successfully completed in December 2002. In March 2003, the M30 GMLRS rocket was approved for low-rate initial production, and operational testing was completed in December 2004. Approval to enter full-rate production was granted in June 2005. A variant of the M30 with a 90-kg (200-lb) unitary high-explosive warhead is currently (2006) in the SDD phase. The Army fielded 486 GMLRS unitary warhead rockets in Iraq between June and December 2005.

Army Technology Objectives—Technology for Soldiers

The Army Technology Objectives are the highest priority S&T efforts designated by HQDA funded within the future force technology area investments. ATOs are co-sponsored by the S&T developer and the warfighter's representative, TRADOC. Each ATO describes a significant Army S&T program. It has well-defined customer deliverables that represent significant technical advances; clear milestones, which include schedule and TRL; and quantitative metrics to measure progress. The goals of an ATO must be achievable within the funding available. Figures 5 depicts an example of an overview chart used in the ATO approval process.

There are three types of ATOs. The ATO–Demonstration (ATO–D) and ATO–Research (ATO–R) programs use S&T funding to mature technology for transition. The ATO–Manufacturing Technology (ATO–M) programs use non-S&T funding that is managed by the Deputy Assistant Secretary of the Army for Research and Technology (DAS(R&T)) specifically allocated to reduce the cost of new technology, improve probability of success in the manufacturing process, or reduce costs of existing manufacturing technology.

An ATO–D is intended to transition a "product" to the warfighter. These are major efforts of limited duration (2 to 4 years) that normally transition to an acquisition customer verified by a PEO/PM or that provide a major transformational capability endorsed by the Army command (ACOM) or equivalent organization's headquarters. An ATO–D program manager is required to have a signed technology transition agreement with a PEO/PM 1 year prior to completion specifying the technology products to be delivered, the schedule for delivery, the maturity of the technology at delivery, and the metrics that will be used to



Each ATO undergoes rigorous technical and management reviews before and during its execution. Overview charts spell out the ATO's purpose, products, payoffs, schedule, and metrics.

Figure 5. Example of ATO Overview Chart

demonstrate that maturity. Delivery of the technology demonstrated in an ATO–D should be synchronized with a program of record. ATO–Ds culminate with a TRL of 5 to 6.

An ATO–D encompasses about 80 percent of the 6.3 funding in a laboratory or research, development, and engineering center (RDEC). Remaining funds provide technical directors with needed flexibility to respond to emerging needs of warfighters engaged in the GWOT. This flexibility also enables the exploitation of technology concepts for new applications based on unforeseen technical achievement.

An ATO–R focuses on maturing technology and is funded primarily with 6.2 (applied research) dollars. An ATO–R sometimes transitions to an ATO–D effort. It contributes to satisfying a capability gap or has the potential to achieve a significant technology advance, normally resulting in a TRL 4 or 5 after a 3 to 5 years' duration. An ATO–R "product" may be a component such as a focal plane or improved armor capability; an improved tool to meet military needs, such as the capability for realistic embedded training; or applied research to select technology options to meet military needs, which can then be matured in a 6.3 program. In general, about half of an Army laboratory's or center's available applied research funding should be in ATO–Rs. The other half of the applied research budget is used to exploit applied research opportunities in higher risk, high-potential payoff technologies (e.g., ceramic laser materials for high-energy laser weapons).

Not every worthwhile funded technology program is designated as an ATO. Because ATOs are part of a rigorous process to "deliver" technology within a scheduled timeframe based on need, they are, by their nature, describing technology applications that are fairly well understood from a research perspective.

An ATO–M addresses the affordability and producibility of a technology solution by developing new or improved manufacturing technologies (ManTech). ATO–Ms are not funded with S&T dollars. An ATO–M has producibility milestones addressing a specified PEO/PM program and a duration of 3 to 5 years. There is close coordination among the ATO–M manager, the targeted PEO or PM, the user, and industry to promote successful implementation of a changed manufacturing approach.

BUILDING A PORTFOLIO—THE PROCESS

HQDA Guidance

Each year, HQDA provides guidance to the S&T materiel development and the TRADOC combat development communities on priorities and needs for annual adjustments to the ATO portfolio including new ATO proposals. This guidance is signed jointly by the DAS(R&T), the Assistant DCS G–3/5/7 and the DCS G–8, Director, Force Development, and reflects the most current Army strategic planning guidance as well as DoD transformation guidance. HQDA and the ATO-developing commands expand on this basic guidance, specifying how proposed ATOs will be presented for review and approval, and laying out a timetable of events for the process.

ATO Development, Review, and Approval Process

New ATO proposals and proposed revisions to existing ATOs are reviewed each year at HQDA level. Combat and materiel developers may request revisions to current ATOs, maintaining technological currency or making adjustments based on changes in warfighter needs.

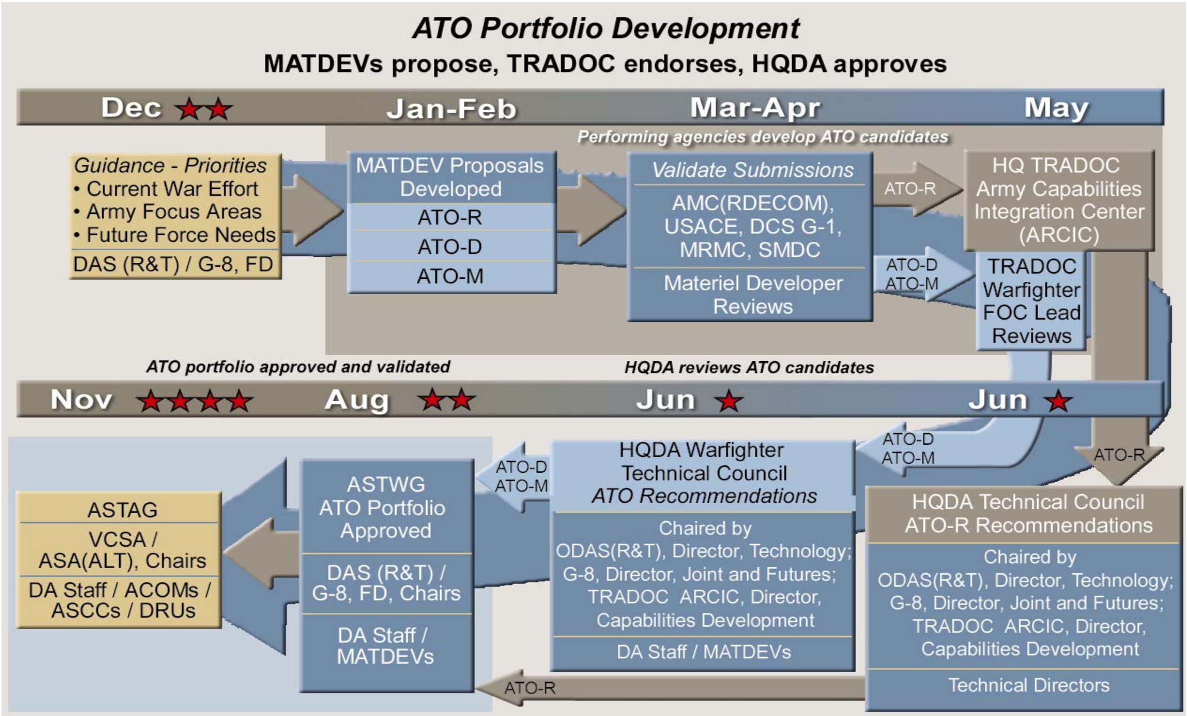
The ATO development, review, and approval process has five organizational levels. The first level begins with a review conducted by the ATO development laboratory or RDEC director. The next level is a review at the ACOM or equivalent level. This review seeks opportunities for synergy and efficiency across commands to speed technology development and avoid duplication. The last three review levels are directed by HQDA. Both ATO developing commands and the warfighting combat developer, TRADOC, review current and proposed ATOs on an annual basis to validate technical feasibility, warfighting relevance, and financial viability.

There is a fundamental difference between the maturity of the products from ATO–Rs and ATO–Ds, since the former provides a product to another technology developer and the latter provides a product for an acquisition program.

The ATO development and approval process has two paths, one for ATO–Rs and one for ATO–Ds and ATO–Ms. The difference in these two paths begins at the TRADOC reviews. The ATO–Rs are reviewed by the ARCIC Director for Capabilities Development with comments provided to the HQDA Technical Council (TC) review. The first level of HQDA review for new ATO–Rs is at the TC, a one-star level body consisting of the directors of the Army RDECs and laboratories, the RDECOM Deputy Commanding General for Systems-of-Systems Integration and co-chaired by the HQDA Director for Technology, the HQDA G–8 Director for Joint and Futures, and the TRADOC ARCIC, Director for Capabilities Development. The ATO–Ds and ATO–Ms are reviewed by the ARCIC Director for Capabilities Development and the FOC leads (battle laboratory directors and school combat developments directors).

The first level of HQDA review for ATO–Ds and ATO–Ms is the Warfighter Technical Council (WTC). The WTC is a one-star level body co-chaired by the HQDA Director for Technology, the HQDA G–8 Director for Joint and Futures, and the HQ TRADOC ARCIC Director for Capabilities Development, with SES-level members from Army laboratories, RDECs, and TRADOC FOC leads. Results of both TC and WTC reviews are provided to the Army S&T Working Group (ASTWG) for approval. Figure 6 illustrates the ATO portfolio development process.

After one-star level reviews, the next HQDA level of review and approval for all ATOs is the ASTWG, a two-star level body co-chaired by the DAS(R&T) and the DCS G–8, Force Development, with two-star members of the HQDA and ACOM, and equivalent command staffs who have S&T development or oversight responsibilities (Table 2). The RDEC and laboratory directors attend as the TC, and the PEOs attend as the Acquisition Council. Both advise the ASTWG during its review.



The HQDA guidance is provided to the ATO developing commands for shaping new and revised ATO proposals. Annually, ATOs are reviewed at ACOM and equivalent levels, then at TRADOC ARCIC, and then at HQDA.

Figure 6. ATO Development and Approval Process

Table 2. ASTWG and ASTAG Membership

ARMY SCIENCE AND TECHNOLOGY WORKING GROUP	ARMY SCIENCE AND TECHNOLOGY ADVISORY GROUP
Co-Chairs Deputy Assistant Secretary (Research and Technology) G–8, Director, Force Development	**Co-Chairs** Vice Chief of Staff, Army Assistant Secretary of the Army for Acquisition, Logistics, and Technology
Members Deputy Director, ARCIC, TRADOC Commanding General, RDECOM Commanding General, MRMC Chief Scientist, SMDC Director, Research and Development, USACE Deputy Assistant Secretary (Defense Export & Cooperation) Deputy, System Management G–1, Assistant Deputy Chief of Staff G–2, Technical Advisor G–3/5/7, Assistant Deputy Chief of Staff G–4, Director, Logistics Innovation Agency G–6, Deputy Chief Information Officer G–8, Deputy Director, Program Analysis and Evaluation Deputy Assistant Chief of Staff for Installation Management Commanding General, ATEC	**Members** Commanding General, TRADOC Commanding General, AMC Commanding General, FORSCOM Commanding General, MEDCOM/The Surgeon General Commanding General, USACE/Chief of Engineers Deputy Chief of Staff, G–1 Deputy Chief of Staff, G–2 Deputy Chief of Staff, G–3/5/7 Deputy Chief of Staff, G–4 Deputy Chief of Staff, G–6/Chief Information Officer Military Deputy, ASA(ALT) Director, ARCIC, TRADOC
Advisors Lab and RDEC directors as the Technical Council Program executive officers as the Acquisition Council	**Advisors** Deputy Assistant Secretary (Research and Technology) Director, Force Development, DCS G–8

Decisions of the ASTWG are validated annually by the four-star level Army S&T Advisory Group (ASTAG) that is co-chaired by the Assistant Secretary of the Army (Acquisition, Logistics, and Technology) (ASA(ALT)) and the Vice Chief of Staff of the Army (VCSA). Members include the ACOM and equivalent commanders and HQDA principal staff officers responsible for S&T oversight or execution. The results of the annual ATO process are published in the ASTMP biennially. This biennial process coincides with several other biennial functions, including the convening of a new Congress.

The Advanced Concept Technology Demonstrations/Joint Capability Technology Demonstrations

Advanced Concept Technology Demonstrations are intended to provide a mechanism for rapid insertion of very mature technology into the joint force. The ACTDs demonstrate mature technology in an operational environment and evaluate the technology's military utility. A limited number of demonstration "articles" may be provided as a low-cost, residual operational capability. ACTDs have combatant commander sponsors. ACTD proposals are validated by the Joint Requirements Oversight Council (JROC) and approved by the Under Secretary of Defense for Acquisition, Technology, and Logistics (USD(AT&L)). They are funded by the services and defense agencies. If an ACTD meets its objectives and the technology is militarily useful, the technology may be transitioned to a formal acquisition process at the appropriate milestone based on demonstrated military utility. In cases where only small quantities are needed and the hardware does not require modification (or requires only very minor modification), the technology may transition directly.

The Joint Capability Technology Demonstration (JCTD) program was initiated by OSD on 1 October 2006. The JCTD program will replace the ACTD program for new initiatives, although existing ACTDs will continue through completion. JCTDs are very similar to the predecessor program, but will be more closely aligned to emerging requirements of the Combatant Commands (COCOMs). The OSD ACTD/JCTD Web site http://www.acq.osd.mil/actd provides more information on the JCTD program.

S&T ROLE IN ACQUISITION PROGRAMS

The Army S&T community role in acquisition involves not only technology development and transition, but also formal participation in milestone decisions for acquisition programs of record. As the component S&T executive, the DAS(R&T) is responsible for conducting a technology readiness assessment (TRA) at milestone B and C decision points for major defense acquisition programs (MDAPs). This assessment has become even more important with recent statutory requirements for the Milestone Decision Authority (MDA) to certify to Congress that the technologies of an MDAP have been demonstrated in a relevant environment prior to making a milestone B decision. The TRA serves as the gauge of this readiness for the MDA's certification at both Army and OSD levels. The TRA process is a collaborative effort carried out among the program office, the S&T community, and (for acquisition category (ACAT) 1D programs) the Office of the USD(AT&L).

TECHNOLOGY FOR THE CURRENT FORCE—SUPPORTING THE GLOBAL WAR ON TERROR

The Army S&T community provides support to the current force in the global war on terror. Army scientists and engineers provide technical advice and engineering support to program managers (PMs) fielding equipment to the current force, to the Rapid Fielding Initiative, and to the Joint Improvised Explosive Device (IED) Defeat Organization. To provide additional focus to maturing counterterrorism technology to meet warfighter needs, the Agile Integration, Demonstration, and Experimentation (AIDE) program was initiated in FY06. Its initiatives include accelerating the maturation of counter-IED, force protection, and Soldier capabilities for transition to an operational environment. In addition, the Army Field Assistance in Science and Technology program acts as a liaison between component commander staff to transmit their near-term requirements to Army laboratories and RDECs.

Army scientists and engineers have been instrumental in fielding capability for GWOT for IED detection and defeat, counter-mortar systems, individual Soldier and tactical vehicle protection, precision airdrop, robotic sensors, and improved surveillance. Several S&T successes are discussed below.

SUCCESS STORIES—ACCOMPLISHMENTS FOR SOLDIERS

The Army S&T program is focused on providing capability to the warfighter. This section gives examples of two technologies brought to production or transitioned into acquisition programs of record.

Joint Precision Airdrop System

The JPADS is a family of autonomous cargo parachute systems and an associated mission planning and weather system. JPADS decelerators have been matured through Army and Air Force S&T investments, and RDT&E funding, under the management of the Natick Soldier Center since the early 1990s in various weight classes (2,000-, 10,000-, and

30,000-pound). The weight classes are centered on current and planned Army intermodal distribution platforms, and all systems are based on a one- or two-actuator airborne guidance unit with GPS as the primary navigation sensor. Each weight class of the cargo system must be able to hit a preplanned GPS ground target within 50 meters (objective), be able to be deployed from altitudes as high as 24,500 feet mean sea level (threshold), and be able to be deployed from at least 8 kilometers horizontal offset from the ground target.

JPADS allows for aircraft and aircrew to fly above most threat areas (survivability), yet still accurately deliver cargo to preplanned ground impact points. Troops on the ground are now able to receive and retrieve supplies more accurately with less risk of threat action. With JPADS, aircraft can deliver supplies precisely to warfighters in very remote areas, including those not accessible by roads.

JPADS has been used in Afghanistan with great success (Figure 7). Natick supported USMC's and SOCOM's urgent requirements for rapid fielding of small quantities of JPADS 700- to 2,200-pound systems in FY04–05. Support and collaboration exists with many additional organizations and agencies to include U.S. Transportation Command and OSD Advanced Systems and Concepts. The success of these efforts led the CJTF–76 to submit an operational need statement in February 2006 for fifty 2,200-pound JPADSs. USAF Air Mobility Command provided additional and advanced funding to field twenty 2,000-pound systems to Afghanistan for operational use. With NSC's leadership, management, technical, and systems integration efforts and by direct training support in country, NSC met USAF goals of conducting the 1st Combat USAF/USA JPADS airdrop by the end of August 2006. Many more precision airdrops have been conducted, and NSC is executing an immediate warfighter need to provide an additional fifty 2,200-pound JPADSs in FY07. As of January 2007, over 120 combat airdrops (most of them ballistic drops with the JPADS–MP) and over 1 million pounds of critical supplies have been successfully airdropped to warfighters on the ground in numerous locations throughout Afghanistan.

JPADS Combat Airdrop Mission 2,000-lb Capacity Screamer is being used in Operation Enduring Freedom.

Figure 7. Transition of the Joint Precision Airdrop System

Small Arms Protective Inserts Plates

Ceramic-based Small Arms Protective Inserts (SAPI) plates are made from the latest composite materials and consist of a ballistic nylon spall cover, ceramic tiles (e.g., boron carbide), and Kevlar™, Spectra®, or other reinforced plastic backing material. On impact, the ceramic fractures the projectile core. A major portion of the kinetic energy is absorbed by the tiles or plate, with residual energy being absorbed by the backing. Selection of the backing material is determined by structural, ballistic, and weight requirements. Various compositions of Kevlar, fiberglass, Spectra, and aluminum are used. Army S&T defined the art-of-the-possible in terms of the lightest weight to defeat specific small arms threats, and demonstrated a technology system that would set a very stringent weight requirement. The system was based on:

- Army S&T conducted in the late 1980s and early 1990s that made the fiber technology for the SAPI reinforcing composite available for fielding. Composite technologies made from both Spectra/ultra high-molecular polyethlene, and Kevlar/Para-aramid, which were developed during this timeframe with support from Army S&T, have been employed in the SAPI technology.
- Army ManTech effort conducted in 1998–2000, which supported development of lower cost, high-performance ceramics for application to the SAPI.
- Army S&T development for "carbon crack arrestor" conducted in 1998 to improve the ability of plate technology to meet the multiple hit requirements and improve the durability of the SAPI.

SUMMARY

The Army S&T strategy seeks to enable capabilities described in the *Quadrennial Defense Review* and DDR&E strategy, as well as the needs established through the TRADOC capability gaps and technology shortfalls process. The S&T investments are characterized in future force technology areas. Within these, the highest priority investments are designated as ATOs. The ATOs are developed and approved for execution through a rigorous process that engages the S&T, acquisition, and combat development communities. Each ATO has defined products, milestones, designated resources, and projected warfighter payoffs. Acquisition program managers partner with the S&T developers to enhance opportunities for rapid transition of technology described in technology transition agreements. The ATOs are approved by the ASTWG and validated by the ASTAG, chaired by the Vice Chief of Staff, Army and the Assistant Secretary of the Army for Acquisition, Logistics, and Technology. The S&T community also plays a vital role in assessing technology maturity for acquisition programs. The DAS(R&T) performs technology readiness assessments at scheduled milestone decision points as prescribed in DoD 5000 (Defense Acquisition).

The warfighter representative, TRADOC, and HQDA are engaged in oversight and management of the Army's S&T program to ensure effective timing of technology development and relevance of proposed solutions to enhance Soldier capabilities in the current force and enable new capabilities in the future force.

The Army also has a robust basic research program to enable future battlefield concepts by pursuing innovative research as the foundation for entirely new capabilities. The basic research program is idea centric, not product oriented; therefore, it is inappropriate for management through the ATO program. Research oversight is provided through separate processes described in Chapter III.

Army laboratories maintain strong, enduring relationships with many partners. The Army S&T program is executed by over 10,000 scientists and engineers working at Army laboratories and research, engineering, and development centers. The research and technology development may be conducted within these organizations, through contracts to industry and grants to universities, or through cooperative agreements with other DoD organizations, national laboratories, industry, universities, and international partners. More information on Army laboratories and their partnerships can be found in Chapter IV of the ASTMP. To provide you a better understanding of information available in the complete ASTMP, the table of contents is duplicated as the Appendix for this Executive Summary. Although the Executive Summary of the ASTMP is available for public release as Distribution Statement A, the ASTMP itself is limited to "Distribution Statement C—Distribution Authorized to U.S. government agencies and their contractors only. Reason: administrative/operational use, March 2007. Other requests for this document shall be referred to the Director, Science & Technology Integration, Office of the Deputy Assistant Secretary of the Army for Research and Technology, 2511 Jefferson Davis Highway, Suite 9017, Arlington, VA 22202–3911."