Science & Technology

The Army Science and Technology (S&T) strategy (Figure 1) supports the Army's goals to restore balance between current and future demands by providing new technologies to enhance and modernize systems in the Current Force and to enable new capabilities in the Future Force. This strategy is enabled through a portfolio with three types of investments, each providing different results in distinct timeframes.

Figure 1: Strategy—Develop and mature technology to enable the Future Force while seeking to enhance the Current Force.

The three types of S&T investment are: far-term, funding basic research for discovery and understanding of phenomena; mid-term, funding applied research laboratory concept demonstrations; and near-term, funding advanced technology development demonstrations in relevant environments outside the laboratory (Figure 2). The technology demonstrations prove technology concepts and their military utility to inform the combat developments process and provide the acquisition community with evidence of technologies' readiness to satisfy system requirements. This portfolio supports the overseas contingency operations in three ways: 1) Soldiers benefit today from technologies that emerged from our past investments; 2) we exploit transition opportunities by accelerating mature technologies derived from ongoing S&T efforts; and 3) we leverage the expertise of our scientists and engineers to develop solutions to unforeseen problems encountered during current operations such as the armor applied to Mine-Resistant Ambush Protected (MRAP) combat vehicles for enhanced protection from rocket propelled grenades (RPGs). The entire S&T program is adaptable and responsive as evidenced in its support of the Army Modernization Strategy.

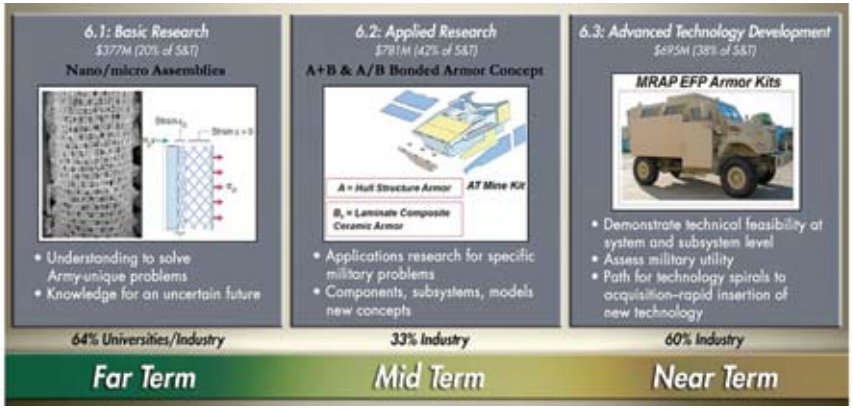

Figure 2: The S&T portfolio consists of three types of investments.

S&T INVESTMENT—FUTURE FORCE TECHNOLOGY AREAS

The diverse S&T portfolio is characterized in terms of Future Force Technology Areas. The investments in these areas are shown on the next page in a color depiction (Figure 3) that approximates their proportionate dollar value in FY2010 by Technology Area. Training and Doctrine Command/Army Capabilities Integration Center (TRADOC/ARCIC) represents the warfighter in the S&T process, and articulates the warfighter's needs to the S&T community through the development, staffing, and coordination of the TRADOC "Warfighter Outcomes" to guide the S&T investment. The Deputy Assistant Secretary of the Army for Research and Technology consolidated the 37 Tier 1 TRADOC "Warfighter Outcomes" into 10 Comprehensive Warfighter Outcomes.

Within these Technology Areas, the highest priority efforts are designated by Headquarters Department of the Army (HQDA) as Army Technology Objectives (ATOs). We do not designate ATOs within the basic research area since these investments fund sciences (discovery and understanding) not technology. The ATOs are co-sponsored 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 and, subsequently, to acquisition.

This S&T section of the *U.S. Army Weapon Systems 2010* handbook is organized by Future Force Technology Area. Selected ATOs are described within most of the Technology Areas. The complete portfolio of 97 ATOs is described in the 2009 Army Science and Technology Master Plan (distribution limited to government and current government contractors).

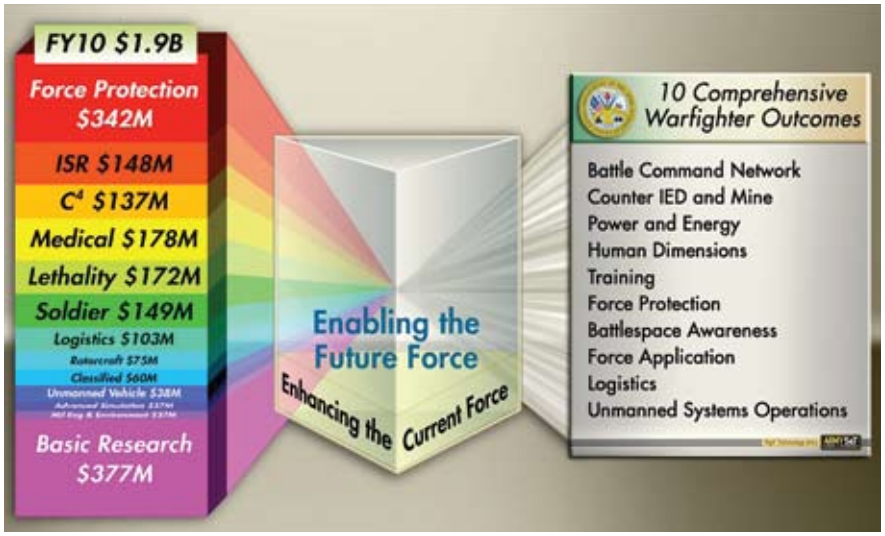

Figure 3: The Future Force technology area color bands shown on the left are approximately proportional to the financial investment within the Army's requested FY10 S&T budget. The specific technologies funded in these investment areas are aligned to the 10 Comprehensive Warfighter Outcomes. The 10 CWOs are the consolidation of TRADOC's Tier I Warfighter Outcomes, which include their "Big 5" Integrated Warfighter Outcomes. The Warfighter Outcomes articulate the warfighter capability needs.

Short descriptions of Future Force Technology Areas:

- **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, and counter rocket, artillery, and mortars (CRAM) 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 (C4)** technologies provide capabilities for superior decision making, 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, prevent or treat infectious diseases, reduce casualties, improve clinical care and rehabilitative medicine, 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.

FORCE PROTECTION

Kinetic Energy Active Protection System

The Kinetic Energy Active Protection System ATO provides the additional capability to defeat tank-fired kinetic energy rounds to the chemical energy system that currently defines the Brigade Combat Team (BCT) Modernization Point-of-Departure Active Protection System. This program develops warhead and interceptor chassis designs and conducts robust component testing. These components support the hit-avoidance suite designed to enhance the protection of BCT against tank-fired threats.

Figure 4: Kinetic Energy Active Protection System.

Tactical Wheeled Vehicle Survivability

Tactical Wheeled Vehicle Survivability ATO identifies, analyzes, develops, demonstrates, and transitions an integrated suite of advanced survivability technologies for the protection of crew and passengers in current and future tactical wheeled vehicle (TWV) fleets. For TWV platforms, both traditional and nontraditional armor approaches do not independently defeat objective threats within the system's weight, power, and cost constraints. Integrated survivability technology suites will be determined through trade-off analyses to balance payload, performance, and protection at a reasonable cost. Technologies included are high-performance, lighter weight ballistic materials; active protection systems; electronic warfare; and signature management for both Army and

Marine Corps TWVs. The armor technologies developed in this program are designed as a B-kit solution and follow the interface requirements of the current Long-Term Armor Strategy (LTAS) A–B kit configuration. Similarly, the non-armor survivability technologies are designed to easily interface with the LTAS A-kit configuration in terms of size, weight, power, and cooling considerations. When integrated, these technologies (both armor and non-armor) offer an upgradable, modular approach to protection, thus supporting the warfighter's need for mission-adaptable survivability concepts for TWVs.

Threat and Minefield Detection Payload for Shadow Tactical Unmanned Aerial Vehicle

This ATO matures and demonstrates a tactical unmanned aerial vehicle (TUAV) payload incorporating multi/hyper-spectral imaging sensors, adaptive spectral detection, and change detection algorithms. The TUAV payload will demonstrate real-time detection of roadside threats, threat deployment activity, and minefields at realistic mission altitudes. It also provides an advanced reconnaissance, surveillance, and target acquisition capability for detection of difficult targets, including home-made explosives.

Detection for In-Road Threats

This ATO matures and demonstrates an advanced mine and threat detection capability to address a broader spectrum of in-road threats—including those deeply buried—at higher rates of advance for modular engineer platforms and the Early Infantry Brigade Combat Team (E-IBCT). In order to meet current and Future Force needs, this effort matures and then integrates ground penetrating radar and metal detection technologies onto vehicles to detect the evolving underbelly threat on primary and secondary roads. The technologies demonstrated include an optimized metal detector, signal processing, a downward-looking ground penetrating radar, and algorithms optimized for both shallow and deep targets.

Extended Area Protection & Survivability (EAPS) Integrated Demo

Enhanced Area Air Defense System (EAADS) is the Army's objective maneuver Air and Missile Defense system. EAADS will be a deployable maneuver capability that leverages the best combination of directed energy and/or kinetic energy technology against the aerial threat. The most technologically challenging element of the EAADS mission is the protection against rocket, artillery, and mortar (RAM) attack. The Counter RAM (C-RAM) multi-pillar system of systems is a successful, quickly fielded, initial capability against the near- and medium-term RAM threat. The C-RAM intercept pillar does not, however, meet objective EAADS criteria, including effectiveness at required range, multiple simultaneous engagements, 360-degree coverage, and ability to control collateral damage. This ATO further matures missile and bullet technologies, and integrates these technologies for hardware demonstrations to bridge the gap between the initial C-RAM capability and the objective EAADS.

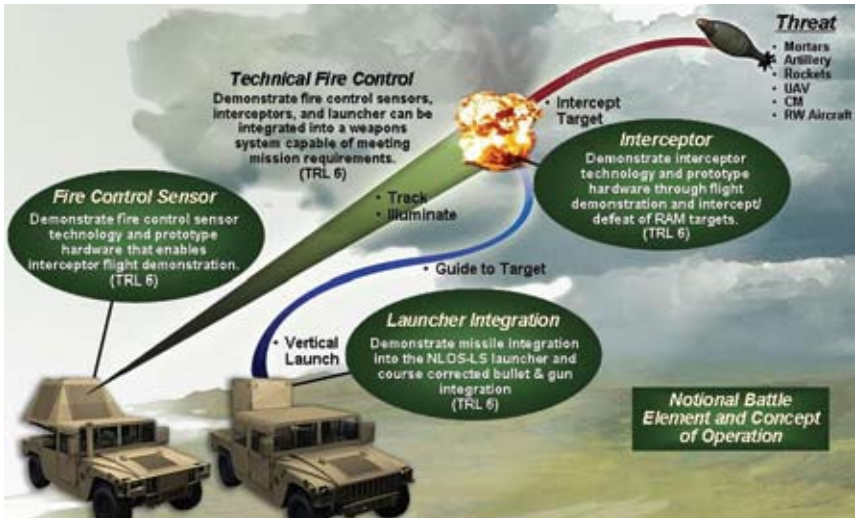

Figure 5: Extended Area Protection & Survivability (EAPS) Integrated Demo

INTELLIGENCE, SURVEILLANCE, RECONNAISSANCE

All-Terrain Radar for Tactical Exploitation of Moving Target Indicator and Imaging Surveillance (ARTEMIS)

This ATO matures and demonstrates an airborne, all-weather, all-terrain ground moving target indication (GMTI), tracking, and cueing system for a Class IV unmanned aerial system (UAS). Unlike most tactical radars, this system will be able to track both mounted and dismounted threats moving in open terrain or using cover for concealment. Additionally, ARTEMIS incorporates synthetic aperture radar (SAR) capability that is able to image vehicle-sized threats in foliated and open terrains, as well as smaller threats that are shallowly buried or in the open. The effort builds a smaller multifunction foliage penetration radar system that satisfies Class IV UAS requirements. The efforts under demonstration are: persistent SAR and GMTI surveillance against mounted and dismounted threats; reduced susceptibility to camouflage concealment and deception measures; and detection of surface/sub-surface roadside threats.

Figure 6: All-Terrain Radar for Tactical Exploitation of Moving Target Indicator and Imaging Surveillance

Battlespace Terrain Reasoning Awareness—Battle Command

This ATO provides integrated battle command capabilities to create and utilize actionable information from terrain, atmospheric, and weather effects on systems, platforms, and Soldiers. This will enable agile, integrated ground and air operations in all operational environments. In FY10, an initial spiral of urban-based technologies from the Network-Enabled Command and Control ATO program will be incorporated. The resulting capability will provide net-centric, n-tier, terrain reasoning services and embedded battle command applications.

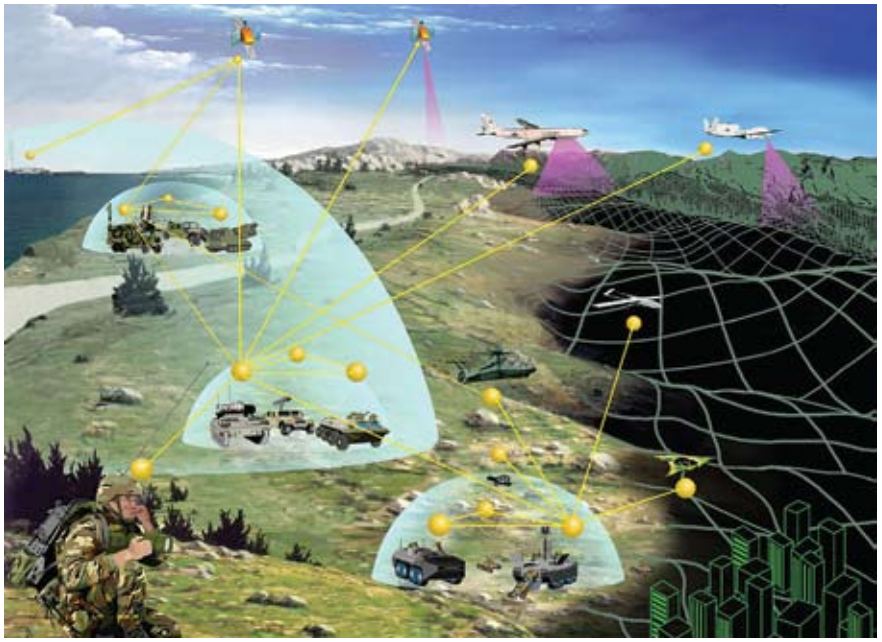

Figure 7: Battlespace Terrain Reasoning Awareness—Battle Command

This effort is working with key transformational battle command programs and TRADOC schools to (1) conduct controlled demonstrations to gain insight into effectively integrating actionable terrain, atmospheric, and weather information into battle command system-of-systems (SoS), staffs, processes, and functions; (2) improve, extend, and mature terrain- and weather-based information products and embedded applications within battle command SoS; (3) transition capabilities to the Distributed Common Ground System–Army (DCGS–A), BCT, and

commercial joint mapping toolkit; and (4) support the development of a geo-battle management language that extends the current model to include representation of actionable terrain, weather, and atmospheric information.

Target Location Designation System

This ATO demonstrates an improved, man-portable, target acquisition and laser designation system with reduced size, weight, and power. The effort enables real-time target identification and acquisition, laser designation, and precision target location of distant targets in a very lightweight, low-power, cost-effective, and high-performance package. This effort will produce: (1) an improved mid-wave infrared focal plane array; (2) a common designator module using end-pumped, mono-block laser technology; and (3) precision target location with improved global positioning, gyroscope, and magnetometer. The results of this effort will demonstrate to the warfighter improvements in target acquisition, precision target location, and laser designation capabilities to thus increase combat effectiveness and lethality. The increased target acquisition range will provide a greater standoff range and increase Soldier survivability; the reduced weight will achieve greater Soldier mobility.

Flexible Display Technology for Soldiers and Vehicles

This ATO will develop flexible display technologies for affordable, lightweight, rugged, low-power, and reduced-volume displays in conjunction with the development of human factors parameters for systems utilizing flexible displays. Flexible displays have reduced weight and are inherently rugged with ultra-low power electro-optic technologies as compared to traditional liquid-crystal, glass-based displays. The development of displays on flexible substrates will enable novel applications that cannot be achieved by glass-based technologies (e.g., wearable and conformal for Soldier applications, conformal for vehicle and cockpit applications, and compact display that can be rolled out for multiuser applications). This ATO program is coordinated with human factors studies to optimize design trade-offs, and will produce flexible, 4-inch diagonal displays (greater than 320 x 240 resolution), as well as technology for color emissive and reflective displays. Benefits to the warfighter include a 60 percent weight reduction of display components compared to glass displays, and a 30 to 90 percent power reduction compared to liquid crystal displays.

Figure 8: Flexible Display Technology for Soldiers and Vehicles

Multi-Spectral Threat Warning

Ultra-violet (UV) sensors utilized in aircraft threat warning systems are limited in their ability to accurately distinguish Man-Portable Air Defense System threats from false alarm sources. This ATO investigates and quantifiably measures the benefits to aircraft protection of integrating currently fielded, UV-based Missile Warning System with infrared (IR) and acoustic sensors. Specifically, Multi-Spectral Threat Warning seeks to enhance the current system's probability of detection and reduce its false alarm rate through correlating IR signature data with the UV data. Additionally, providing acoustic spectra to the current UV-based system's Hostile Fire Indication algorithms increases the probability of detection for non-tracer rounds.

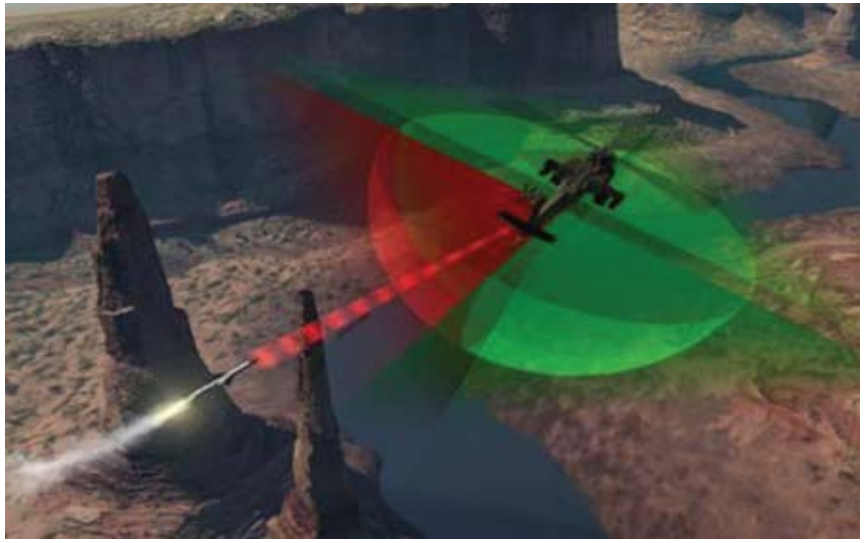

Figure 9: Multi-Spectral Threat Warning

COMMAND, CONTROL, COMMUNICATIONS, AND COMPUTERS (C4)

Network-Enabled Command and Control

The Network-Enabled Command and Control (NEC2) ATO develops, integrates, and transitions technologies, products, and software services that provide network-centric command and control capabilities to the current and Future Force. Transition of these products and services are focused on current, transitional, and future battle command systems throughout all environments and phases of operations. NEC2 will develop advanced software and algorithms that tailor and manage the flow of battle command information and command and control services across current and Future Force systems. This will enable the commander and his staff to effectively use vast amounts of information horizontally and vertically throughout the theater of operations for decision and information superiority. Technology efforts under NEC2 focus on applications in complex and urban terrain; battle command planning, execution, and replanning products for unmanned systems and sensors; and decision making tools that account for political, religious, and cultural factors, and expand the commander's reach to other government and nongovernment experts. An Unmanned Systems Capstone Experiment will: (1) evaluate unmanned software services for air and ground systems performance across tactical application scenarios; and (2) collect and process communications characterization data and deliver refined unmanned software services to the BCT modernization program.

Tactical Mobile Networks

This ATO develops, matures, and demonstrates communications and networking technologies that optimize throughput, bandwidth usage, size, energy, and network prediction of tactical voice and data networks. Tactical Mobile Networks address emerging Future Force requirements through (1) proactive diverse link selection (PAD–LS) algorithms to optimize use of available communications links within multilink nodes (vehicles, TOCs, etc.); (2) multiband, multimode tactical voice and data network communications services for dismounted Soldiers and manned and unmanned systems (sensors, munitions, etc.) through the development of a Joint Tactical Radio System (JTRS) Software Communications

Architecture (SCA) v2.2 Soldier Radio Waveform (SRW); and (3) software tools to dynamically predict and visualize on-the-move communications network performance.

The Tactical Mobile Networks ATO conducts modeling and simulation to verify the functional and performance characteristics of PAD–LS algorithms during development and develops implementations, and conducts demonstrations of the link selection algorithms under controlled environment. The effort matures the network management tools, incorporating increasing number of networking waveforms, entities, processing speeds, network topologies, and network visualization (network statistics and user priorities).

Collaborative Battlespace Reasoning and Awareness

The Collaborative Battlespace Reasoning and Awareness (COBRA) ATO develops and demonstrates multiplatform, cross community applications and software services that support the integration and synchronization of intelligence and operations functions through the design, development and implementation of information interoperability, and through collaborative management and decision support technologies. This ATO also develops and demonstrates systems that will improve mission execution success by providing software to more tightly couple operations and intelligence and to better facilitate collaboration. Research and development will be focused on mapping intelligence and geospatial information requirements to military tasks. This effort will make possible faster and higher quality decision cycles and increased battle command unification through collaboration and real-time sharing, exploitation, and analysis to support the operational mission, tasks, and desired effects.

RF Adaptive Technologies Integrated with Communications and Location (RADICAL)

This ATO develops and demonstrates Radio Frequency (RF) dynamic spectrum technologies for tactical communications and improved position determination in Global Positioning System (GPS)-degraded environments (Figure 10). ATO efforts include a software module that enables spectrum policy management for dynamic spectrum access-enabled radios, architecture development to integrate and enhance disruption tolerant networking (DTN) in the tactical environment, and a software module that improves position determination based on net-assisted GPS and RF ranging technologies. RADICAL will leverage the Defense Advanced Research Projects Agency (DARPA) Wireless Network After Next (WNAN) program to provide consistent dynamic spectrum policy management using software implementation, ensure reliable message delivery in a disruptive communications environment by enhancing and extending the DTN technology into tactical networks, mitigate multipath through RF ranging, and improve GPS performance through net-assisted GPS technologies.

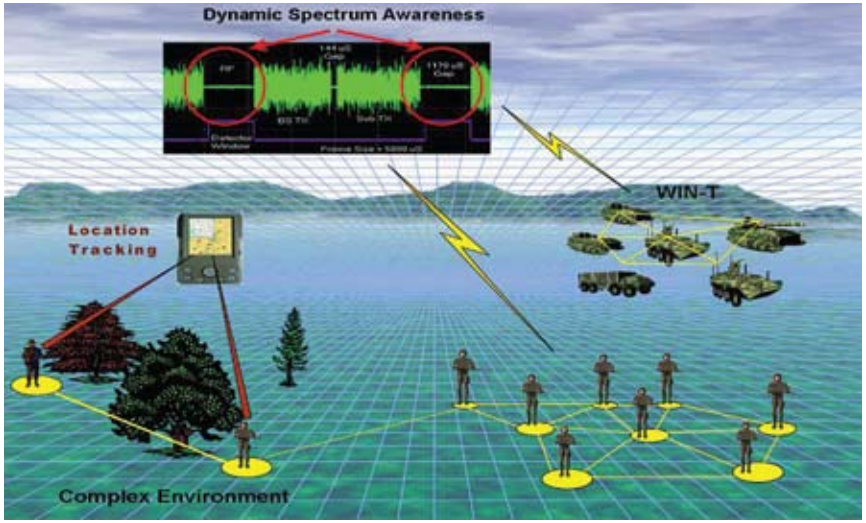

Figure 10: RF Adaptive Technologies Integrated with Communications and Location (RADICAL)

LETHALITY

Non Line of Sight–Launch System Technology

The Non Line of Sight–Launch System (NLOS–LS) Technology ATO is developing and maturing improved components and subsystem technologies for the NLOS–LS missile system, a core program of the BCT modernization effort.

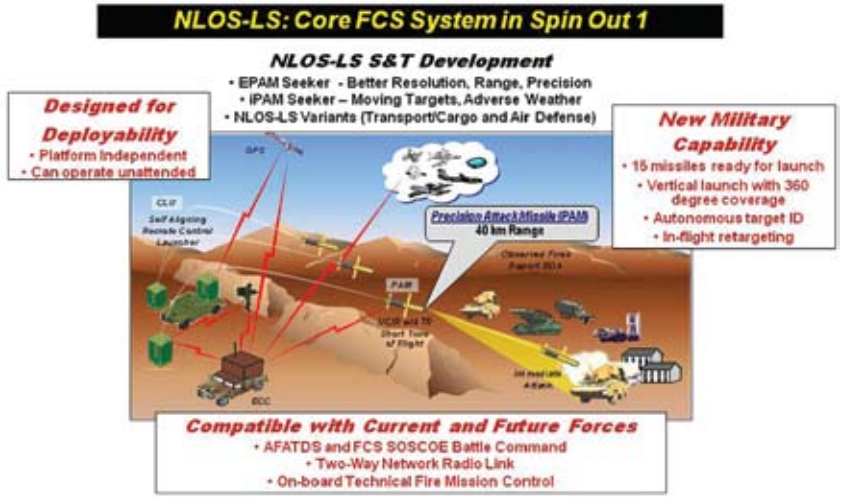

Figure 11: Non Line of Sight–Launch System Technology

The ATO supports the NLOS–LS development by transitioning affordable, mature components that enhance the threshold performance through a subsystem maturation effort; continuing critical component development efforts for future performance enhancements and integrated missile variants providing mission flexibility launched from the NLOS–LS. This effort has developed and successfully transitioned enhanced seeker technology for the Precision Attack Missile (PAM) baseline seeker that provides better resolution and acquisition range at a reduced average unit production cost to the NLOS–LS program manager and prime contractor. Other technology development efforts have been focused on maturation through the development, fabrication, and testing of critical subsystems including semi-active laser (SAL)/laser radar (LADAR) seeker; controllable rocket motor propulsion; high efficiency turbine engine technology; multi-purpose warhead technologies; an improved multi-mode seeker (iPAM); and miniature electronics. Modeling and simulation efforts have included the linkage of physics-based engineering models, hardware and software-in-the-loop (HWIL/SWIL) designs, constructive analysis, and virtual prototype development and exercise.

Advanced Lasers and Unmanned Aerial System Payloads

This ATO develops, integrates, and demonstrates a 7-pound advanced sensor payload with laser rangefinding and laser designating capabilities to address the reconnaissance, surveillance, and target acquisition mission requirements for the BCT Class I unmanned aerial system (UAS). New multifunction lightweight lasers, optical receiver components, and electronics will be developed suitable for UAS and other Soldier applications. The new laser components will be integrated with a compact, small-pixel, uncooled infrared imaging sensor into a two-axis pointing platform (gimbal) to enable an airborne organic laser designation capability for the lower echelon warfighter. The advanced lasers and UAS sensor payload will enable Soldiers to quickly see and characterize potential targets as well as nontarget objects that are in the open or in complex and urban terrain, and support beyond-line-of-sight situational awareness, targeting, and engagement with precision weapons. A parallel ManTech effort seeks to develop an optimized manufacturing process for a universal, monoblock laser designator module component that can be integrated into a wide variety of laser applications.

Applied Smaller, Lighter, Cheaper Munitions Components

Affordably reducing space, weight, and power at the component level remains essential to increasing precision munition lethality for full spectrum operations, particularly military operations on urban terrain (MOUT) (Figure 12). This ATO focuses on developing increasingly smaller, lighter, cheaper components and subsystems that will enhance current system capabilities against asymmetric threats and mature technologies for next-generation small precision munitions. Primary investment areas include: nano/advanced composite structures and new fabrication techniques to save weight while maintaining or enhancing structural and thermal properties; miniaturized electronics to reduce size and weight, and support increased processing demands for capability enhancements like image stabilization; sensor/image processing for MOUT environments, including people tracking; and warhead safe and arm integration for precision lethality against expanded target sets in urban terrain. Major warfighter payoffs will be enhanced precision lethality and cost savings through common components.

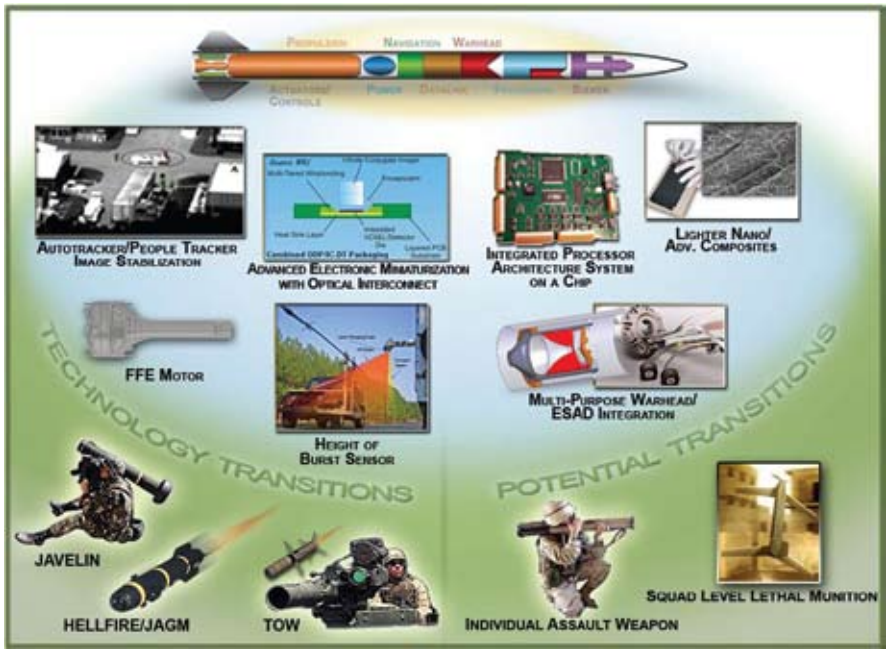

Figure 12: Applied Smaller, Lighter, Cheaper Munitions Components

Scalable Technology for Adaptive Response

The Scalable Technology for Adaptive Response (STAR) ATO is maturing and demonstrating new energetic materials, fuzes, and warhead technologies that can provide selectable and scalable effects against platforms and personnel. The STAR ATO will demonstrate technologies for selectable lethal effects in large-, medium-, and small-diameter munitions and missiles; and development of controlled lethal effects, multipurpose energetics and formulations, reactive materials, and advanced fuzing and power technologies. The STAR ATO will demonstrate 250mm (Guided Multiple Launch Rocket System), 155mm (Excalibur), and 30mm (M789/Mk238); enable improved weapon effectiveness and lethality; and reduce collateral damage and logistics.

MEDICAL

Psychological Resetting after Combat Deployment: Advanced Battlemind

This ATO develops and validates an advanced unit-training program to reduce combat-related psychological problems, including symptoms related to mild traumatic brain injury (mTBI) and post-traumatic stress disorder (PTSD) during the post-deployment resetting phase. The goal is to facilitate recovery from psychological injuries related to combat, build individual and unit resilience in preparation for subsequent deployments, reduce the incidence of debilitating symptomatic problems, and reduce risk-taking behaviors that have the greatest impact on a Soldier's mental health, well-being, relationships, and job performance. An in-depth six session Battlemind Training Package will be developed that integrates state-of-the-art cognitive-behavioral approaches to traumatic stress, while maintaining the focus on Soldier strengths, unit cohesion, leadership skills, and individual cognitive skill building. The package will also incorporate cognitive education strategies shown to be effective in reducing symptoms from mTBI, which often overlaps with PTSD.

Damage Control Resuscitation

This ATO pursues the best combination and optimal use of alternatives to whole blood (plasma, red blood cells, blood clotting agents, etc.) to prevent bleeding and maintain oxygen delivery and nutrients to tissue (Figure 13). These products will likely enhance survival of casualties after severe blood loss, which is the leading cause of death to injured warfighters. Recent data from the battlefield suggests that blood clotting disorders and immune system activation, which damages normal cellular metabolic processes, commonly occur in severely injured patients. Therefore, a priority is to maintain blood clotting capability and oxygen and nutrient delivery to tissues by using the best resuscitation products that can be administered at far forward locations.

Figure 13: Damage Control Resuscitation

Drug for the Treatment of Traumatic Brain Injury (TBI)

This ATO is testing a candidate drug to treat TBI to determine its safety and effectiveness in 200 human subjects that have suffered TBI. It is estimated that 15 to 25 percent of all injuries in recent conflicts are to the head. TBI survivors often have physical and cognitive impairment, memory loss, and mood and personality disorders. There are currently no drugs to treat or reduce brain related injuries.

Prophylactic Drugs to Prevent Drug Resistant Malaria

This ATO develops candidate antimalarial prophylactic drugs and test these candidates in animals Successful completion of this ATO will allow clinical testing of candidates and potentially may lead to a safe and efficacious replacement antimalarial prophylactic drug. The goals in developing these candidate prophylactic drugs are to replace current drugs that are becoming less effective due to the development of drug resistance in the malaria parasite, to reduce or eliminate unwanted side effects that impact Soldier's use of the drugs, and to allow for a less critical and more convenient dosing schedule for deployed Soldiers. This drug would also increase operational readiness by maintaining a healthy force, as well as reduce the logistical and combat health support burden associated with treatment in theatre or after evacuation.

UNMANNED SYSTEMS

Robotic Vehicle Technologies Control Architecture for BCT Modernization

The Robotic Vehicle Technologies Control Architecture (RVCA) for BCT modernization develops an unmanned ground vehicle (UGV) end-to-end control architecture to reduce future integration risk and demonstrate the viability of autonomous UGV operations in a relevant environment using representative system-of-systems hardware and software components. This program will enhance UGV program viability and reduce program risks through the maturation, integration, and test representative hardware and software onto a surrogate UGV platform. The Crusher vehicle developed by DARPA under its UGCV PerceptOR Integration program will serve as the initial integration platform and be used for test and experimentation. Phase I of the effort integrates the autonomous navigation system onto the Crusher platform to provide autonomous maneuver capabilities, and will also mature and integrate the mission execution, computer operating environment, and vehicle management system hardware and software necessary for unmanned vehicle control. A series of engineering evaluations and a Soldier operational exercise to measure system performance and effectiveness from both the technical and operational contexts will be conducted. Phase II of the effort will see the migration/integration of hardware and software from the Crusher vehicle to a new test platform developed under the Tank-Automotive Research, Development and Engineering Center (TARDEC) Autonomous Platform Demonstrator program, and the task will finalize hardware and software implementations. It will conduct another series of engineering evaluations and conduct a final Soldier operational exercise in military significant environment.

Safe Operations of Unmanned Systems for Reconnaissance in Complex Environments

Safe Operations of Unmanned systems for Reconnaissance in Complex Environments (SOURCE) ATO develops, integrates, and demonstrates robust robotic technologies required for Future Modular Force unmanned systems (figure 14). The ATO will advance the state of the art in perception and control technologies to permit unmanned systems (UMS) to autonomously conduct missions in populated, dynamic urban environments while adapting to changing conditions; develop initial tactical/mission behavior technologies to enable a group of heterogeneous UMS to maneuver in collaboration with mounted and dismounted forces; optimize soldier operation of UMS; and provide improved situational awareness for enhanced survivability. Modeling and simulation will be used to develop, test, and evaluate the unmanned systems technologies (e.g. tactical behaviors and perception algorithms). Test bed platforms will be integrated with the software and associated hardware developed under this program, as well as appropriate mission modules, to support warfighter experiments in a militarily significant environment in conjunction with TRADOC.

Figure 14: Safe Operation of Unmanned Systems for Reconnaissance in Complex Environments

SOLDIER SYSTEMS

Soldier Planning Interfaces & Networked Electronics

This ATO develops a government-owned, Soldier-borne electronic equipment architecture that incorporates a National Security Agency-approved wireless personal area network subsystem (Figure 15). Soldier Planning Interfaces & Networked Electronics (SPINE) will reduce the soldier-borne footprint and system weight by 30 percent through the loss of wires and connectors. The wireless network will be powered by a conformal battery currently under development which will increase power by 50percent for 24 hour period. Additionally, it will utilize emerging software services to enable Soldier connectivity and data exchange to current and future tactical radio networks and battle command systems. Throughout this effort, capability demonstrations will be conducted at the C4ISR On The Move (OTM) test bed at Ft. Dix, NJ.

Figure 15: Soldier Planning Interfaces & Networked Electronics

Soldier Blast and Ballistic Protective System Assessment and Analysis Tools

This ATO provides analysis tools and test protocols to aid development and assessment of ballistic and blast protective systems. It will provide a benchmark of current capability, and develop system and component test protocols and devices with an initial focus on primary blast lung and facial/ocular injury. Models such as the Integrated Casualty Estimation Methodology (ICEM) model will be enhanced and exploited to begin characterizing blast effects to mounted and dismounted Soldiers for an improved Soldier armor design prototype. The payoff will be technology for improved Soldier armor and blast protection systems.

Enhanced Performance Personnel Armor Technology

Existing personnel armor systems cover less than 50 percent of the Soldier's body. This ATO will consider materials technology and tools to provide armor protection to the head, face, and extremities and will consider the penalties associated with that protection. ATO products will include new materials concepts for expanded Soldier body armor protection against blast and ballistic threats; improved materials models for predicting blast and ballistic performance; and full scale, high-fidelity modeling and diagnostic tools to guide technology development. The technologies and tools will transition to advanced technology development efforts in FY10 or earlier as options mature to TRL 5.

High-Definition Cognition (HD-COG) In Operational Environments

This ATO researches real-time understanding of brain function in operational environments to allow matching of Soldier capabilities and advanced technologies. For example, vehicle crewstations could cue Soldiers based on how their brains process what they see, hear, and feel. Such neuro-ergonomic designs can exploit how the brain functions, providing tremendous Soldier performance improvements. This program will develop technologies to assess Soldier neuro-cognitive processes in operational environments, as well as techniques to use them for neuro-ergonomic design. Technology development will focus on solutions to cognition, visual scanning, and platform control for mounted and dismounted operations. Approximately three experiments will be performed each year to look at ATO-developed technologies in a motion-based simulation environment.

LOGISTICS

Power for the Dismounted Soldier

This ATO matures and demonstrates technologies to provide small, lightweight, low-cost power sources. It demonstrates batteries what are half the size and twice the energy of C4ISR primary batteries (e.g., SINCGARS ASIP); conformal rechargeable Soldier system batteries; a soldier-mission-extending hybrid fuel cell; and a JP8-powered Soldier-portable power source for tactical battery recharging. Resulting efforts include: reduction in weight (~50 percent) for Soldier power; extended mission times in Soldier and sensor applications; reduction in resupply quantity, weight and costs; and increased Soldier mobility, sustainability, survivability and deployability by providing higher energy sources and recharging capability.

Wheeled Vehicle Power and Mobility

Wheeled Vehicle Power and Mobility ATO addresses the mobility and power requirements for the Army's current and future wheeled vehicles. With fleet modernization, wheeled vehicles require enhanced power and suspension capabilities to power more electronic components, transport payloads, support armor upgrades, and increase fuel efficiency. The ATO will demonstrate commercial engines adapted to military requirements that provide better fuel economy and lower heat rejection; compact, reliable, safe, and lightweight hybrid electric technology; incorporation of SiC power electronics; and a TRL 6 demonstration of an advanced magneto-rheological suspension system. The ATO provides wheeled vehicle platforms with power generation and control to include hybrid electric drive systems as well as an advanced suspension system for improved vehicle ride stability. The ATO provides the warfighter with enhanced vehicle mobility and safety to accomplish future missions.

High Performance Lightweight Track

This ATO will provide two high-performance lightweight track system options for 30–40 ton class vehicles: a Segmented Band Track and Lightweight Metallic Track for platform weights of 30–40 tons. Future combat vehicles need lightweight track with acceptable maintainability, durability, and survivability. The current lightweight track ATO developed a 16.5" wide segmented band track for a 25-ton vehicle. Requirements growth for BCT MGV has caused critical demand for a higher capacity, more survivable lightweight track. Lightweight track systems are challenged by increased vehicle weights and performance requirements and require innovative materials and design improvements to meet high strength, durability, and survivability targets. The program will improve/optimize lightweight segmented track technology through utilization of "Best in Class" high-performance elastomers and designs to enhance durability and survivability. This ATO seeks to develop and refine Lightweight Metallic Track through optimized and innovative designs and materials that deliver performance, maintainability, and survivability at 30–40 tons.

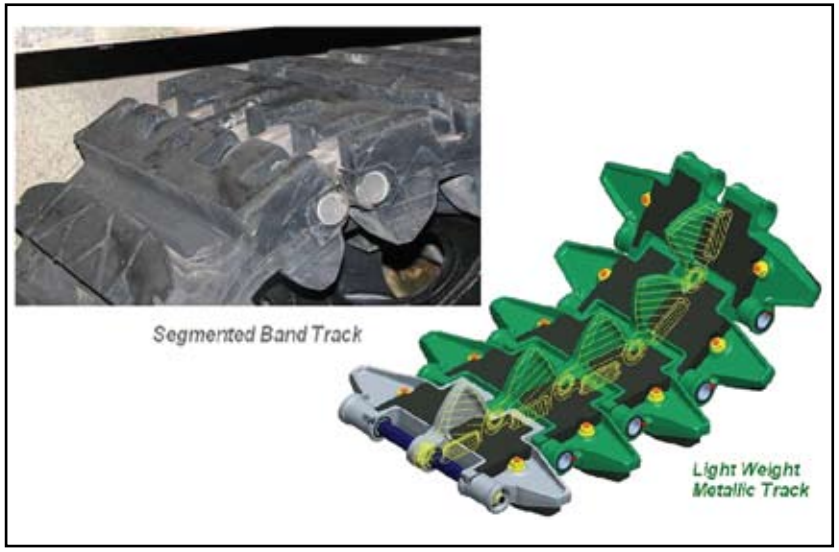

Figure 16: High-Performance, Light weight Track

Prognostics and Diagnostics for Operational Readiness and Condition-Based Maintenance

Near-term and future systems readiness and maintainability rely on the ability to detect health status and performance, and the environmental conditions that limit component lifetime. Improvements to current detection and prediction capabilities would reduce component losses and the logistics train, resulting in improved mission completion. This ATO develops prognostic software and application-specific sensors for remote health detection and prediction of vehicle

and weapons systems component performance. Part of this capability is comprised by diagnostic sensors that enable health assessment. Prediction of remaining lifetime also requires holistic interpretation of the data, and is a function of both the component and data quality. To achieve both, it is imperative that commanders and logisticians be able to access the data expeditiously with a minimum of effort. This effort will develop a core "tag" with embedded sensors and processing that can be wirelessly interrogated. The system component's sensor history data will be analyzed by both on-board and post-processed prognostics algorithms developed in this ATO, in order to assess immediate readiness and remaining time to maintenance or lifetime. Resultant data will yield actionable information for both commander and logistician leading to increased readiness, enhanced awareness of materiel condition, increased confidence of mission completion, and smaller logistics footprint through condition-based maintenance.

JP-8 Reformation for Alternate Power Sources

The JP-8 Reformer for Alternate Power Sources ATO provides the research and development required to convert JP-8 fuel into a hydrogen-rich alternate fuel for downstream power generation. This program will develop a JP-8 reformer brassboard capable of removing sulfur and other aromatic contaminants that are detrimental to fuel cell operation. Careful selection and design of desulphurization, reformer, thermal, water, and sensor technologies are paramount. The design, tests, and operation of the JP-8 reformer brassboard will be highly dependent on the fuel cell system design. The brassboard will be designed to provide from 12–120 liters/minute of a high-grade, low-sulfur (<1.0 parts per million) hydrogen-rich fuel for continuous operation. This reformed fuel will power a commercially available fuel cell platform. This critical front-end reforming step will be an integral technology development enabling 10 kilowatt of available power for silent watch and other power requirements in the theater. The success of this reformer program is designed to complement parallel developments in suitable fuel cell architectures under development within the Department of Defense, Department of Energy, and commercial fuel cell developers.

ADVANCED SIMULATION

Research for Scalable Embedded Training and Mission Rehearsal

Embedded training (ET), a key performance parameter for Future Force vehicles and Soldiers, is also required by Abrams, Bradley, and Stryker vehicles, but has been slow to evolve. The Scalable Embedded Training and Mission Rehearsal ATO will support a common implementation strategy and address known technology

Figure 17: Soldier Planning Interfaces & Networked Electronics

shortfalls in ET across current and Future Force systems. This ATO will accelerate ET and mission rehearsal implementation; develop tactical engagement simulation sensors for dismounted Soldier training, size, power, and accuracy requirements; and provide ET risk mitigation for GSS, Heavy Brigade Combat Team, and Stryker Brigade Combat Team. The ATO will be completed in FY09 with field demonstrations of mission rehearsal and live, virtual, and constructive ET using Current Force combat vehicles and dismounted Soldiers as the experimental force.

Simulated Severe Trauma for Medical Simulation

The Severe Trauma Simulation ATO researches technologies that prepare Soldiers physically and psychologically for the severe injuries encountered on the battlefield. Many Soldiers are not prepared for the shock of treating severe trauma and are less effective in the use of their medical skills. Experience shows that training traditional techniques for treating injuries can be improved. Realistic simulated trauma will allow Soldiers to master their skills and equipment before entering the battlefield. This effort will investigate battlefield injuries and evaluate them against current training; research effects of severe trauma on patients and caregivers; and design a methodology to support combat medic training with realistic battlefield injuries, including compartmentalized trauma, physiology, transfer of care, and time milestones of care. The ATO will provide prototype simulations with advances in materials (realistic skin, flesh, blood, bone, fluids, and organs), sensor technologies, and simulated fluid loss. The prototypes will function as standalone training systems, as well as external accessories for patient simulators and actors. In FY09, the ATO will evaluate the developed components in the current program of instruction to assess training effectiveness at military training venues.

BASIC RESEARCH

Basic research investments are a critical hedge in acquiring new knowledge in areas that hold great promise in advancing new and technically challenging Army capabilities and concepts to enable revolutionary advances and paradigm-shifting future operational capabilities. Areas of emerging interest and focus in basic research are: Neuroscience, Autonomous Systems, Quantum Information Science, Immersive Technology, Biotechnology, Nanotechnology, and Network Science. Investment in basic research within the Army provides insurance against an uncertain future and guards against technological surprise. And if we are successful, these investments will make it possible to conduct ever more complex military operations, with greater speed and precision, to devastate any adversary on any battlefield. The following is a brief summary of the areas of investment, the synergy among them, and some of the capabilities they may provide.

1 **Neuroscience—Understanding how the human brain works**
Fundamental to the conduct of military operations is superior Soldier performance. Understanding how the human brain works, i.e. determining the brain's "software," is key to developing these capabilities. When embedded into a wide range of military platforms, this "software" will provide superior training methods and human system interfaces that will be tuned to an individual's characteristics, thereby resulting in superior Soldier performance. Research in this area will also dramatically advance our ability to prevent and treat those suffering from various types of battlefield brain injury.

2 **Autonomous Systems—Extending the operational effectiveness of Soldiers through robotic systems**
A major military objective is to totally frustrate and defeat our adversaries across a wide spectrum of conflicts while dramatically increasing the survivability of our Soldiers by keeping them out of harm's way. Autonomous systems of extraordinary capability can fulfill this objective; however, they must be completely safe and secure while operating in highly complex operational environments. Achieving such levels of capability will require significant investments in highly sophisticated sense, response and processing systems approaching that of biological systems; major advances in artificial intelligence; the development of intelligent agents approaching human- performance levels; and advances in machine learning, swarming, and actuation and control.

3 Quantum Information Science—Overcoming the limitations of Moore's Law
Increasing demands for information to support rapid and effective decision-making on the battlefield require advanced sensor systems to collect relevant data, as well as the means for processing it into actionable forms. Major advancements in processing power are required to cope with the demand to process ever larger amounts of data. Investments in this area will exploit the massive parallelism of the quantum world to create computers that will dwarf the capabilities of the most powerful computers today, making them look like pocket calculators. The development of such computational systems will enable the embedding of high-performance computing in all military platforms including the Soldier's uniform.

4 Immersive Technology—The path to virtual reality training
The evolving threat environment continues to put increasing demand on the diversity and effectiveness of Soldier skills. To meet this demand, superior training tools and methods are needed. Virtual worlds can provide this capability; however, we are currently at primitive stages in their realization. With advances in computational processing and steady progress in understanding the brain's "software" comes the possibility of creating highly realistic virtual training environments inhabited by humanlike avatars. Such environments will provide a paradigm shift in the way we provide training, while achieving low-cost, safe, low-environmental impact, highly variable simulation environments for the future training of our soldiers.

5 Biotechnology—Leveraging four billion years of evolution
The increasing importance and demands for wide-area persistent surveillance create significant challenges for sensor systems, real-time processing of vast amounts of data, the real-time interpretation of information for decision-making and challenging power and energy requirements to support such demanding systems. Through four billion years of evolution, biological systems have engineered solutions to some of these challenges. We seek to leverage research in these areas for improving the performance of our Soldiers. Major investments in this area through reverse engineering will lead to totally new sensing systems, new ways for the rapid processing of data into information, the development of novel sense and response systems, and biologically inspired power and energy solutions for our Soldiers.

6 Network Science—Managing complex military operations with greater speed and precision
Networks tie together the following: highly distributed sensor systems for reconnaissance and surveillance, information for decision-making, Soldiers, and the execution of fast distributed precision fires. Better functioning networks are essential to advancing our ability to conduct complex military operations with greater speed and precision. However, our state of knowledge of these networks is relatively primitive and, as such, significantly impairs our ability to fully realize the potential that networks can provide on current and future battlefields. A new multidisciplinary approach is being implemented that combines communications, information and the social/human component of networks, and that changes the way we address the challenges associated with optimizing the use of networks. This new research effort will allow us to predict and optimize network performance through the creation of totally new design tools before we build them.

S&T ROLE IN FORMAL ACQUISITION MILESTONES

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 Deputy Assistant Secretary of the Army (DASA) for Research and Technology (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 Office of the Secretary of Defense 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 Undersecretary of Defense USD Acquisition Technology & Logistics (AT&L).

SUMMARY

The technological sophistication required for 21st century operations constantly increases with the broadening nature of threats and the greater availability of technology to our adversaries. Much of the Army's ongoing research is characterized as high-risk, high-payoff—the type that the private sector is not likely to sustain over the long haul because there is no linkage to acquisition programs at the outset of research. This high-risk research is essential if we are to achieve the technological breakthroughs for dramatic performance improvements in the Army's systems. One such breakthrough in guidance and control technology led to the Excalibur precision artillery munition that has virtually eliminated collateral damage to noncombatants. Today's Current Force has significant technology-enabled advantages as a result of the Army's past investments in S&T, particularly in night vision, precision munitions, and individual Soldier protection. Scientists and engineers continue to expand the limits of our understanding to provide technology to our Soldiers in the systems they use to achieve transformational capabilities required for decisive victories.