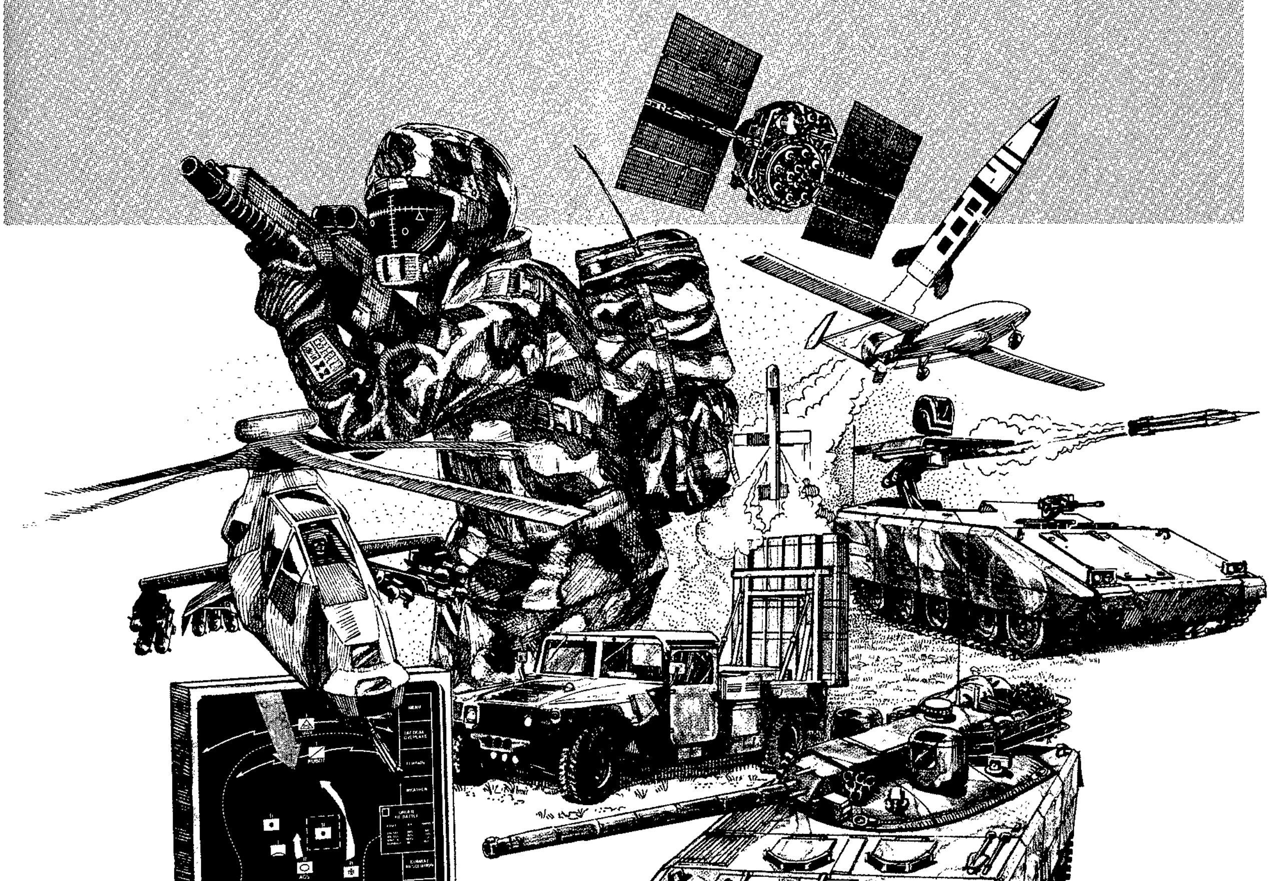
FISCAL YEAR 1997

ARMY SCIENCE AND TECHNOLOGY MASTER PLAN

VOLUME II



UNCLASSIFIED

AD NUMBER

B226514

NEW LIMITATION CHANGE

TO

Approved for Public Release; Distribution Unlimited.

** St'mt: A

** Code: 1

FROM

N/A

AUTHORITY

Dir'te for FOIA & Scty Review, (OASD-PA)

THIS PAGE IS UNCLASSIFIED

Fiscal Year 1997

ARMY SCIENCE AND TECHNOLOGY MASTER PLAN

VOLUME II

DECEMBER 1996

ANNEXES

Annex A

SCIENCE AND TECHNOLOGY OBJECTIVES

CONTENTS

CHAPTER III: TECHNOLOGY TRANSITION

CHAPTER IV: TECHNOLOGY DEVELOPMENT

CHAPTER VI: INFRASTRUCTURE

SCIENCE AND TECHNOLOGY OBJECTIVES (STOs) FOR CHAPTER III: TECHNOLOGY TRANSITION

D. AVIATION

III.D.01. Rotorcraft Pilot's Associate ATD. By FY99, develop and demonstrate through simulation and flight test a cooperative man/machine system that synergistically integrates revolutionary mission equipment package (MEP) technologies, high speed data fusion processing, cognitive decision aiding knowledge-based systems, and an advanced pilotage sensor and display to achieve maximum mission effectiveness and survivability of our combat helicopter forces. The product will contribute greatly to the pilot's ability to "see and comprehend the battlefield" in all conditions; rapidly collect, synthesize, and disseminate battlefield information; and take immediate and effective actions. Measures of Performance (MOP) beyond a "Comanche-like" baseline during day/night, clear, and adverse weather battlefield conditions include: reduction in mission losses by 30 to 60 percent; increased targets destroyed by 50 to 150 percent; and a reduction in mission timelines by 20 to 30 percent. Milestones include System Preliminary Design 3Q95, Software Build #1 4Q95, Simulation Evaluation 2Q97, Flight Test 3Q98.

Supports: RAH-66 Comanche, AH-64 Enhanced Apache, and system upgrades, Quiet Night, EELS, D&SA, MBS, DBS, BC, and CSS Battle Lab. Dual use potential for general/commercial aviation, law enforcement, mass transit, etc.

STO Manager:	**TSO:**	**TRADOC POC:**
LTC George Demitrov	Drew Orlino	Ted Hundley
ATCOM/AATD	SARD-TT	U.S. Army Aviation Center and School
804-878-2770	703-697-8434	334-255-2571

III.D.03. Advanced Rotorcraft Transmission - II (ART-II). Demonstrate a "quantum leap" in transmission system technology through the integration of emerging technologies in materials, structures, mechanical components, dynamics, acoustics, lubrication, and manufacturing processes. ART Phase II will utilize advanced component technologies such as split torque transmission design, improved gear tooth geometry, low volume lube systems, and corrosion resistant housing materials, which have been developed under ART Phase I, industry IR&D, or RDT&E 6.2 programs, and integrate them into a full-scale demonstration of critical transmission subsystems. Candidate subsystems include: lube system/accessory drives, input module, tail rotor drive system, or main gear box. Technologies will be demonstrated through detail design (by FY98), fabrication (by FY99), and subsystem performance/endurance/noise testing (by FY00). The specific technology objectives to be demonstrated under ART Phase II by FY00 will be: 25 percent weight reduction, 10 dB noise reduction, increase in MTBR to 12,000 hours, and improved producibility. In terms of warfighting capabilities/payoffs, ART Phase II technology will provide: 15 percent increase in range or 25 percent increase in payload from an AH-64 baseline, significantly improved readiness, and improvements in maneuverability/agility and O&S cost reduction.

Supports: Joint Transport Rotorcraft (JTR), AH-64 Enhanced Apache, RAH-66 Comanche, system upgrades, Naval aircraft (Common Light Vertical System Replacement), EELS, D&SA, MBS and CSS Battle Labs, and Dual-Use Potential for both general/commercial aviation.

STO Manager:	**TSO:**	**TRADOC POC:**
Hank Morrow	Drew Orlino	Ted Hundley
ATCOM/AATD	SARD-TT	U.S. Army Aviation Center and School
804-878-4130	703-697-8434	334-255-2571

III.D.04. Helicopter Active Control Technology (HACT). Demonstrate Helicopter Active Control Technology (HACT), i.e., second generation digital fly-by-light control systems, integrated fire/fuel/flight control, multi-mode Stability Control Augmentation System (SCAS) for carefree maneuvering, and define Handling Qualities (HQ) Criteria for National Transport Rotorcraft (NTR). Current vertical lift aircraft pilot and flight management workload inhibits pilot situational awareness and response and directly impacts night, adverse weather, and low altitude operations. Lack of complete control integration (fire/flight/fuel) prevents exploitation of full air vehicle capabilities; restricts maneuverability/agility, impacts safety and survivability. By FY99, develop concepts and demonstrate via simulation; by FY00, complete hardware design, fabrication, and component test; by FY01, demonstrate via hardware-in-the-loop simulation simplified redundancy management schemes and improved V&V techniques; by FY02, demonstrate via flight test the integration of active control technology through application of systematic, robust control law design methods and fault tolerant architectures to improve cargo and utility class rotorcraft slung load handling qualities to a Cooper-Harper rating of 4; increase bandwidth 70 percent for gust rejection capability; improve weapon platform pointing accuracy 60 percent; reduce envelope maneuvering margins 66 percent.

Supports: JTR, system upgrades and Dual-Use; RAH-Comanche, AH-64 Enhanced Apache, EELS, D&SA, MBS Battle Labs.

STO Manager:	**TSO:**	**TRADOC POC:**
Wayne Mantay	Drew Orlino	Ted Hundley
ATCOM/AFDD	SARD-TT	U.S. Army Aviation Center and School
804-864-3953	703-697-8434	334-255-2571

III.D.09. Future Missile Technology Integration (FMTI). By FY98, demonstrate lightweight, fire-and-forget, air-to-air, multirole missile technology in support of GTG missions. Missile system must include the integration of common guidance and control, propulsion, airframe and warhead technologies capable of performing in high clutter/obscurants, day/night adverse weather environments, and under countermeasure conditions. Missile system performance (i.e., range, speed, lethality) must exceed current baseline systems.

Supports: TOW follow-on, Bradley, HWMMV, RAH-66 Comanche, AH-64 Enhanced Apache.

STO Manager:	**TSO:**	**TRADOC POC:**
James Bradas	Mike Rithmire	Ted Hundley
MICOM	SARD-TT	U.S. Army Aviation Center and School
205-876-5935	703-697-8434	334-255-2571

III.D.12. Advanced Helicopter Pilotage Phase I/II. Develop and demonstrate advanced night vision pilotage technology and revolutionary helmet-mounted display (HMDS) technology for night/adverse weather helicopter pilotage. By FY95, develop Image Intensified (I^2) sensor and fast (60 Hz) focal plane array for wide FOV FLIR. By FY96, conduct flight demonstration and evaluation of sensor technology for wide field of view FLIR and Image Intensifier (I^2). By FY98, demonstrate ultra-wide FOV (40° x 80°) night pilotage system—HMDS and dual spectrum (IR and I^2) sensors in a single turret—to provide a significant reduction in pilot cognitive and physical work load.

Supports: Mounted Battlespace, Depth and Simultaneous Attack, Battle Command, Early Entry Lethality and Survivability, RAH-66 Comanche, Enhanced Apache, Special Operations Aircraft, RPA ATD, SARD-B.

STO Manager:	**TSO:**	**TRADOC POC:**
Phil Perconti	Carolyn Nash	Ted Hundley
CERDEC/NVESD	SARD-TT	U.S. Army Aviation Center and School
703-704-1369	697-8432	334-255-2571

III.D.13. Multispectral CM ATD. This project will demonstrate advances in laser technology, energy transmission, and jamming techniques for an all laser solution (eliminate non-coherent sources) to IRCM and as a P3I to the Advanced Threat Infrared Countermeasure System (ATIRCM)/Common Missile Warning System (CMWS). These improvements will provide the capability to counter both present and future multi-color imaging focal plane array and non-imaging missile seekers. A tunable multiline laser with a fiber optic transmission line and advanced jamming algorithms will be live fire tested using the Advanced Threat Infrared Countermeasures (ATIRCM) testbed. The goal is a 20X reduction in laser jam head volume, 35 lbs in weight reduction, a 2X reduction in ATIRCM/CMWS power consumption, and a 6X improvement in jam-to-signal ratio. By FY97, complete module testing and evaluation of competitive solid state mid IR laser technologies, initiate jamming algorithm enhancements, and fiber optic coupling design. By FY98, integrate laser, fiber optic coupler, and advanced/jammer algorithms. By FY99, conduct live fire cable car test to demonstrate situational awareness and countermeasure capability against advanced imaging IR missiles and other secondary threats to rotary-wing aircraft.

Supports: Mounted Battlespace, Depth and Simultaneous Attack, Battle Command, Early Entry Lethality and Survivability, Tri-Service ATIRCM/Common Missile Warning System Upgrades, Hit Avoidance ATD, FSV, ATGM Defense ACT II Project.

STO Manager:	**TSO:**	**TRADOC POC:**
Bud Carbonaro	Carolyn Nash	Ted Hundley
CERDEC/NVESD	SARD-TT	U.S. Army Aviation Center and School
908-427-2676	697-8432	334-255-2571

III.D.14. Air/Land Enhanced Reconnaissance and Targeting ATD. The ALERT ATD will demonstrate on-the-move, automatic aided target acquisition and enhanced identification via the use of a second generation FLIR/Multifunction laser sensor suite for application to future aviation assets which do not have radar. ALERT will leverage ongoing Air Force and ARPA developments for search on-the-move ATR including the use of temporal FLIR processing for MTI. This approach will also enable application of the ATR capability to all weapons systems with integrated FLIR/Laser sensors. The demonstration will be a real-time, fully operational flying testbed emulation of all modes of the basic RAH-66 target acquisition system. By FY98, demonstrate baseline on-the-move performance using second generation FLIR and standard rangefinding mode. By FY99, integrate laser range mapping capability to demonstrate on-the-move aided target acquisition with acceptable false alarms as a lower cost alternative to FLIR/Radar fusion. By FY00, integrate laser profiling capability to demonstrate automatic acquisition and identification.

Supports: Mounted Battlespace, Depth and Simultaneous Attack, Battle Command, Early Entry Lethality and Survivability, RAH-66 Comanche, AH-64C/D Apache.

STO Manager:	**TSO:**	**TRADOC POC:**
Don Reago	Carolyn Nash	Ted Hundley
CERDEC/NVESD	SARD-TT	U.S. Army Aviation Center and School
703-704-1301	697-8432	334-255-2571

III.D.15. Low Cost Precision Kill (LCPK) 2.75-Inch Guided Rocket. By the end of FY98, develop and demonstrate through HWIL simulation and captive field test using best available seeker/sensors, inertial instrumentation, controller characterizations, and launch platform integration technologies; a low cost, accurate (1-m CEP) guidance; and control package concept for the 2.75-inch rocket that provides a standoff range, surgical strike capability against specified non-tank point targets. This capability will provide for a high single shot probability of hit against long range targets, exceeding the current unguided 2.75-inch rocket baseline by 1 or 2 orders of magnitude, thereby reducing the cost/kill, minimizing collateral damage, and greatly increasing the number of stowed kills. Fratricide will be reduced to a minimum by use of guidance techniques allowing post-launch adjustment of the rocket's point of impact. Low cost will be achieved by the combination of proven techniques with innovative sensor/control mechanizations and manufacturing processes to support a two-thirds reduction in manufacturing costs compared to current guided missiles.

Supports: EELS, D&SA, and CSS Battle Labs, Hydra-70 Improvement, Apache, Kiowa warrior, Avenger, Bradley, SOF, and RFPI.

STO Manager:	**TSO:**	**TRADOC POC:**
Charles L. Lewis	Mike Rithmire	(None)
MICOM	SARD-TT	
205-876-7663	697-8434	

III.D.16. Rotary-Wing Structures Technology (RWST). By FY01, fabricate and demonstrate advanced lightweight, tailorable structures and ballistically tolerant airframe configurations that incorporate state-of-the-art computer design/analysis techniques, improved test methods, and affordable fabrication processes. The technology objectives are to increase structural efficiency by 15 percent, improve structural loads prediction accuracy to 75 percent, and reduce costs by 25 percent without adversely impacting airframe signature. By 1998, develop and demonstrate manufacturing process feedback algorithms to actively control the cure state of composite resins to reduce problems with porosity, degree of cure, and fiber volume fraction. By 1999, demonstrate fully composite primary structural joints to reduce the manufacturing labor for large composite components and increase the structural efficiency. Also, by 1999, provide validated strength and fatigue life methodologies for rotorcraft composite structures. Demonstrate, by 2000, adaptive, out-of-autoclave tooling with preferential heating to optimize the cure cycle of co-cured composite elements of highly variable thickness. Exploit emerging technologies in nondestructive inspection, miniature sensors for manufacturing process control, and modeling/virtual prototyping for reducing development time and cost. Demonstrate by FY01 advanced airframe sections which are tailored for structural efficiency, affordable producibility, and field supportability. These goals support the systems payoffs of 55 percent increase in range or 36 percent increase in payload, 20 percent increase in reliability, 10 percent improvement in maintainability, 6 percent reduction in RDT&E costs, 15 percent reduction in procurement costs, and 5 percent reduction in O&S costs for utility type rotorcraft.

Supports: Primary emphasis provides technology options to the UH-60, AH-64, Improved Cargo Helicopter (ICH), RAH-66 and SOA upgrades, future air vehicles [Joint Transport Rotorcraft (JTR)], collaborative technology; and the Battle Lab OCRs (EEL, CSS, DSA, DBS and MTD). Contributes to RWV TDA objectives, goals, and payoffs.

STO Manager:	**TSO:**	**TRADOC POC:**
Graydon Ellicott	Drew Orlino	Glenn Harrison
ATCOM/AATD	SARD-TT	U.S. Army Aviation
(804) 878-5921	703-697-8434	334-255-2703

III.D.17. Advanced Rotorcraft Aeromechanics Technologies (ARCAT). By FY00, develop and demonstrate critical technologies in rotorcraft aeromechanics to contribute to enhanced warfighting needs for fielded and next generation systems. Conduct research and development to achieve technical objectives by increasing maximum blade loading 15 percent, increasing rotor aerodynamic efficiency 5 percent, reducing aerodynamic adverse forces by 10 percent, reducing aircraft loads and vibration loads by 33 percent, reducing acoustic radiation by 4db, increasing inherent rotor lag damping 50 percent, and increasing rotorcraft aeromechanics predictive effectiveness to 74 percent. By FY97, exploit concepts for smart materials active on-blade aerodynamic controls. By FY98, simulate high-lift, low-energy, periodic-blowing airfoil design; evaluate practical Navier-Stokes CFD solver for rotorcraft interaction aerodynamics; and demonstrate model-scale, on-blade active control rotor concepts for reduced vibration and noise. By FY99, demonstrate integrated CFD/finite-element structures rotorcraft modeling. By FY00, demonstrate concepts towards elimination of conventional rotor lag dampers through the application of smart structures. Achievement of aeromechanics technology objectives will contribute to rotorcraft system payoffs in range, payload, cruise speed, maneuverability/agility, reliability, maintainability, and reduced RDT&E, procurement, and O&S costs. Results will be achieved by addressing technical barriers of airfoil stall, high unsteady airloads, blade-vortex interaction, highly interacting aerodynamics phenomena, complex aeroelastic and structural dynamics characteristics, and limited analytical prediction methods and design tools. Concepts include application of on-blade active control to increase rotor performance and aerodynamic efficiency, reduce BVI noise, blade loads, and vehicle vibration at the source; optimizing the configuration geometry of the rotor blade and introducing advanced airfoil concepts to increase aerodynamic efficiency, and maximum blade loading; and vigorously integrating and validating advanced analytical tools such as CFD, finite element structural models, and advanced computational solution techniques to effectively advance rotorcraft aeromechanics technology.

Supports: RAH-66, AH-64, and Fielded System Upgrades, Next Generation Cargo Vehicles (Joint Transport Rotorcraft), collaborative technologies, and Battle Lab OCRs for EELS, CSS, D&SA, DBS, and MTD Battle Labs. Contributes to RWV TDA objective, goals, and payoffs.

STO Manager:	**TSO:**	**TRADOC POC:**
Wayne Mantay	Drew Orlino	Glenn Harrison
ATCOM/AFDD	SARD-TT	U.S. Army Aviation
804-864-3953	703-697-8434	334-255-2703

III.D.18. Subsystem Technology for Affordability and Supportability (STAS). Demonstrate subsystems technologies directly affecting the affordability and supportability of Army Aviation. Addresses technical barriers associated with advanced, digitized maintenance concepts and real-time, onboard integrated diagnostics. The effort supports the advanced maintenance concept of "Digitized Aviation Logistics" to automate maintenance and move toward an integrated, digitized, maintenance information network. The expected benefits from this STO are reductions in Mean Time to Repair (MTTR), No Evidence of Failure (NEOF) removals, and spare parts consumption, resulting in overall reductions in system life cycle cost and enhanced mission effectiveness. Pursuits include onboard as well as ground-based hardware and software concepts designed to assist the maintainer in diagnosing system faults and recording and analyzing maintenance data and information. On-aircraft technologies will include advanced diagnostic sensors, signal processing algorithms, high density storage, and intelligent decision aids. Ship-side diagnostic and maintenance actions will integrate laptop and body-worn electronic aids, advanced displays, knowledge-based software systems, personal viewing devices, voice recognition technologies, and tele-maintenance network. By FY98, demonstrate seeded fault validation testing. By FY99, demonstrate Fuzzy Logic Fault Isolation technique aid. By FY00, demonstrate dynamic component fault detectors and virtual maintenance tool. Supports reduced Meantime to Repair (MTTR) across all systems by 15 percent, contributing directly to the rotary-wing vehicle TDA goal of 25 percent reduction in maintenance costs per flight hour and payoffs of 10 percent improvement in maintainability, 20 percent increase in reliability, and 5 percent reduction in O&S costs.

Supports: AH-64, UH-60, RAH-66 upgrades; ICH and JTR developments; other service and civil rotorcraft fleet.

STO Manager:	**TSO:**	**TRADOC POC:**
Gene Birocco	Drew Orlino	Glenn Harrison
ATCOM/AATD	SARD-TT	U.S. Army Aviation
804-878-3008	703-697-8434	334-255-2703

III.D.19. Subsystem Technology for InfraRed Reduction (STIRR). The focus of this STO is on the development, integration, and demonstration of improved RWV survivability through total aircraft thermal signature management. Technology objectives aimed at selectively reducing and balancing both the thermal emissions and engine/plume contributors to total aircraft IR signature are key components of this STO. Advances in infrared technologies that include the development of partial and full imaging capabilities on near term threat missile systems coupled with the proliferation of older yet still lethal surface-to-air missile systems have resulted in the need for a better equipped, lower IR signature aircraft. Concurrent with the increasingly lethal battlefield, today's fleet aircraft are assuming additional responsibilities which oftentimes result in additional on-board "heat-producing" equipment and greater engine power requirements.

Several technology initiatives have been identified as priorities based on current and expected future infrared advancements. In support of aircraft thermal emissions reduction, this STO will achieve development and measurement of advanced, multi-spectral (visual-through far-IR) airframe coatings that are compatible with radar absorbing amterials/structures, and development of state-of-the-art, low-cost, lightweight thermal insulative materials by FY99. Efforts to cool helicopter engine/plume contributors have also been identified. Advanced engine suppression concepts will be fabricated and demonstrated on both a sub- and full-scale level by FY00. Balanced thermal signature reduction will be achieved and demonstrated on a RWV by FY01. A goal of 35 percent reduction in aircraft IR signature is attainable and anticipated which will support a RWV payoff of 40 percent increase in the probability of survival.

Supports: AH-64, UH-60, RAH-66 upgrades, ICH and JTR developments as well as other service aircraft.

STO Manager:	**TSO:**	**TRADOC POC:**
Gene Birocco	Drew Orlino	Glenn Harrison
ATCOM/AATD	SARD-TT	U.S. Army Aviation
804-878-3008	703-697-8434	334-255-2703

III.D.20p. 3rd Generation Advanced Rotor Demonstration (3rd GARD). By FY04, develop and demonstrate the next generation rotor system to exploit the full potential of advanced blade configurations and active control systems. Program will advance rotor concepts beyond current performance limits through high lift airfoils/devices, tailored planforms and tip shapes, elastic/dynamic tailoring, active on-blade control methods, and signature reduction techniques. These efforts will achieve technical objectives of increasing maximum blade loading 25 percent, increasing rotor aerodynamic efficiency 10 percent, reducing aircraft loads and vibration loads by 53 percent, and reducing acoustic radiation by 7db. By FY01, conduct advanced active control rotor design. By FY02, initiate test article fabrication. By FY03, complete test article structural tests, and initiate wind tunnel testing. By FY04, complete ground testing, and initiate flight test evaluation of technology. These goals contribute to the RWV TDA system level payoffs of 136 percent increase in range or 98 percent increase in payload, 15 percent increase in cruise speed, 50 percent increase in maneuverability/agility, 45 percent increase in reliability, and 10 percent reduction in O&S costs for attack rotorcraft.

Supports: RAH-66, AH-64, and Fielded System Upgrades, Next Generation Cargo Vehicles (Joint Transport Rotorcraft), collaborative technologies, and Battle Lab OCRs for EELS, CSS, D&SA, DBS and MTD Battle Labs. Contributes to RWV TDA objective, goals and payoffs.

STO Manager:	**TSO:**	**TRADOC POC:**
Wayne Mantay	Drew Orlino	Glenn Harrison
ATCOM/AFDD	SARD-TT	U.S. Army Aviation
804-864-3953	703-697-8434	334-255-2703

III.D.21p. Full-Spectrum Threat Protection (FSTP). By FY05, demonstrate on a fielded AH-64 Apache helicopter the synergistic benefits that can be obtained by integrating state-of-the-art technologies related to advanced active electronic warfare and decoy Countermeasures (CM), advanced passive signature reduction technology, and advanced air crew situational awareness and tactics. The program will capitalize on existing and in-process technical developments while identifying and pursuing advanced technologies necessary to support areas where advanced threat development is expected to surpass current capabilities. The primary challenge of this STO is to integrate active and passive CM that can produce a mission effective, survivable rotary-wing vehicle that is both supportable and affordable. By FY02, select state-of-the art active/passive CM, aircrew situational awareness concepts, and develop preliminary system design. By FY03, perform hardware fabrication and initial software development. By FY04, perform hot bench integration and subsystem flight test. By FY05, perform system flight test and simulation validation demo. The FSTP program will integrate passive features such as radar absorbing airframe and rotor structures, advance canopy and sensor window treatments, innovative IR suppressors, multispectral paints and coatings, lightweight insulative materials, and low glint canopy coatings along with the Advanced Threat Radar Jammer (ATRJ) and the Advanced Threat Infrared Countermeasure (ATIRCM) systems. These technologies will support achievement of the rotary-wing 2005 TDA technology goals of a 40 percent reduction in radar cross section signature, a 50 percent reduction in infrared signature, and a 55 percent reduction in the visual/electro-optical signature. In turn, these will contribute to the system payoff of 60 percent increase in probability of survival. A 50 percent increase in active aircraft survivability equipment effectivenesss will also be achieved.

Supports: UH-60, AH-64, Improved Cargo Helicopter, and future Comanche upgrades and future systems, e.g., Joint Transport Rotorcraft (JTR). Supports MTD, DSA, EEL, CSS, and BC Battle Labs, and contributes to the RWV TDA objectives, goals, and payoffs.

STO Manager:	**TSO:**	**TRADOC POC:**
Gene Birocco	Drew Orlino	Glenn Harrison
ATCOM/AATD	SARD-TT	U.S. Army Aviation
804-878-3008	703-697-8434	334-255-2703

III.D.22p. On-Board Integrated Diagnostic System (OBIDS). By FY04, demonstrate advanced diagnostics and prognostics on an operational helicopter with a high level of on-board systems integration to interface with the maintenance infrastructure. This program will highlight cost benefits and safety improvements. Systems assessments will include operational issues, training requirements, and return on investment as well as expected maintainability and availability improvements. By FY00, initiate development contract. During FY01, complete preliminary and critical design reviews. In FY02, conduct aircraft modifications. In FY03, conduct safety of flight reviews, flight tests, and extended user operations. In FY04, reconfigure aircraft and issue final report. Key technologies will include failure detection, fault isolation and trending, performance and life use monitoring, condition-based maintenance and prognostic methods. Related DoD initiatives include AI software, acoustic sensing, electronic devices, and human-system interface. The improved diagnostics will affect No evidence of Failure (NEOF) removals, false removals, flight mission aborts, flight safety, maintenance downtime, and availability. Logistics will be affected through spare management, engine R&R rates, soft Time Between Overhaul (TBO)/part life extension, and early corrosion and fatigue detection. A combination of DoD S&T, IR&D and commercial (NDI) technologies and products will be integrated for this technology demonstration.

Supports reduced maintenance logistics requirements by 15 percent or greater, contributing directly to Rotary-Wing Vehicle TDA goal of 50 percent reduction in maintenance costs/flight-hour and payoffs of 20 percent improvements in maintainability, 45 percent increase in realiability, and 10 percent reduction in O&S costs.

Supports: AH-64, UH-60, RAH-66 upgrades; ICH and JTR developments; other service and civil rotorcraft fleet.

STO Manager:	**TSO:**	**TRADOC POC:**
Jack Tansey	Drew Orlino	Glenn Harrison
ATCOM/AATD	SARD-TT	US Army Aviation
(804) 878-4108	703-697-8434	334-255-2703

III.D.24p. Low Cost Precision Kill. By 2001, develop and demonstrate innovative strapdown (non-gimballed) seekers, miniature inertial devices, control systems, microprocessor and integration technologies to produce a low cost, accurate (1m CEP) guidance and control retrofit package for the 2.75-inch Hydra-70 rocket. This will provide a stand-off range (>=6 km) capability against specified non-tank targets. In addition, a high single shot probability of hit (Phit >=0.7) against the long range target will be achieved, exceeding the current unguided 2.75-inch rocket baseline by 1 to 2 orders of magnitude, and providing a 4 to 1 increase in stowed kills at one-third the cost per kill compared to current guided missiles. This will be accomplished through a set of 6.2 funded programs and 6.3 funded demonstrations to overcome barriers such as providing a low cost, produceable strapdown mechanism for precision guidance; considerations for guidance package retrofit to current 2.75-inch Hydra-70 rockets; and stand-off range target acquisition and engagement techniques to address current free-rocket launch and flight dispersions.

Supports: Army Aviation, Apache AH-64.

STO Manager:	**TSO:**	**TRADOC POC:**
Charles L. Lewis	Mike Rithmire	(None)
MICOM	SARD-TT	
205-876-7663	703-697-8434	

E. COMMAND, CONTROL, COMMUNICATIONS, AND COMPUTERS (C4)

III.E.01. Joint Speakeasy—Multiband Multimode Radio (MBMMR). Joint Service R&D program to develop the architecture and technology for the objective MBMMR of the future, meeting the requirements of the Army MNS for the Future Digital Radio (FDR). The Phase I SPEAKeasy ADMs proved the feasibility of a programmable MBMMR. Phase II of the SPEAKeasy program was initiated in June 1995 and will develop the final MBMMR "open system architecture" and Advanced Development Models (ADMs), providing a software reprogrammable, simultaneous, 4-channel, multi-band, multi-waveform capability. The reprogrammability will allow rapid change-over of waveforms, frequency bands (2-2000 Mhz), internetworking protocols (cross-channel), voice/data modes, and INFOSEC algorithms (4-channel).

In FY97, two model-1 ADMs will be fabricated and demonstrated during the TF-XXI AWE. In FY98, three model-2 ADMs will be fabricated and integrated into an Army C2V vehicle for participation in a C2V communications field demonstration. Six full capability ADMs will be delivered in FY99 for demonstration in the DBC/RAP ATD. Waveforms to be implemented include SINCGARS SIP, EPLRS VHSIC, UHF SATCOM DAMA, Rocket Data Waveform, HaveQuick I/II, LPI, T1, GPS, cellular phone, and HF SSB, AME, ALE, serial modem, and hopping-AJ. The NTDR data waveform will be implemented, when available. 4-channel internetworking will also provide compatibility with TMG and INC. The "open system architecture" will be industry releasable, modular by function, and facilitate a large reduction in future ILS life cycle costs. In order to facilitate easy insertion of the SPEAKeasy MBMMR into current communications systems, the Model 2 and 3 ADM physical form-factors shall conform to the present vehicular SINCGARS SIP volume and mounting footprint. Results of this effort will transition to PEO-C3S in the FY99/00 timeframe.

Supports: All emerging C3 architectures for "Digitizing the Battlefield." The MBMMR shall be demonstrated during TF-XXI in FY97, a C2V demonstration in FY98, and the DBC/RAP ATD in the FY99 timeframe. Speakeasy architecture and technology will lead to the follow-on development and production of the FDR.

STO Manager:	**TSO:**	**TRADOC POC:**
Donald Upmal	Carolyn Nash	Tom Mims
CERDEC/S&TCD	SARD-TT	BCBL
908-532-0440	697-8432	706-791-2800

III.E.04. Improved Spectrum Efficiency Modeling and Simulation (ISEMS). The STO will focus efforts in support of the Army Enterprise Vision of Winning the Information War and Digitization of the Battlefield. Key to this challenge will be the development of an enhanced communication modeling and simulation environment that provides real time, flexible, DIS compatible, and cost effective capabilities for resolving complex operational problems while ensuring that the synthetic environments reflect the same communications effects that are realized in the live environment. The emphasis will be on real time descriptions of environment phenomena for applications to modeling of dynamic network and communication system performance management, communication equipment characteristics, communications realism and propagation reliability algorithms, spectrum use efficiency, and frequency management techniques. Taguchi design of experiment techniques will be used to reduce the simulation times and improve confidence in results. In FY95, the goal will be to complete development of algorithms used in burst propagation models to support comm realism for M&S products. In FY96, the goal is to produce prototype software and conduct laboratory experiments to develop a functional specification for a high-capacity trunk radio needed to support radio access point requirements and to provide greater capacity for the Army Common User System. By FY97, produce an integrated network model capable of analyzing communications system capacity and performance in support of future global deployment of communication technology. ISEMS will transition key technologies to CAC2, DBC, and other ATDs, including definitions of the dynamic tactical environment and techniques for optimizing large-scale simulations.

*S&TCD Funded, C2SID Executed

Supports: CAC2, Digital Battlefield Communications, BDSD, A2, JTF Communications Planning & Management System (JCPMS), ISYSCON, MSE and Winning the Information War.

STO Manager:	**TSO:**	**TRADOC POC:**
Chandu Sheth	Carolyn Nash	Tom Mims
CERDEC/C2SID	SARD-TT	BC-BL
(908) 427-3588	697-8432	706-791-2800

III.E.06. Battlespace Command and Control (BC2) ATD. The STO objectives are to demonstrate, through simulation and experimentation with the user, a Command and Control and Battlefield Visualization (BV) commander/staff workstation to support Consistent Battlespace Understanding; Forecasting, Planning and Resource Allocation; and Integrated Force Management for the Commander and Staff. The BC2-ATD will develop and model the architectural basis for information transfer to/from higher/lower echelons including interfaces to Joint and Coalition forces to support worldwide, split-based military operations. BC2-ATD will utilize the concepts and results of Staff XXI simulations (Prairie Warrior, etc.) to establish and reline systems requirements for C2 and information visualization and its supporting systems architecture. Alternative technology-based solutions will be evaluated through modeling and simulation. BC2 uses knowledge-based technologies (advanced decision aids, 3D visualization, distributed and shared databases, etc.) to provide faster, more accurate, and more tailorable battlespace information for commanders to assess combat situations. The objectives are to provide software applications on ABCS Systems (MCS/FBCB2) and Systems/Operational Architectures which will reduce reaction/decision times, reduce the time from mission to order preparation, and increase the number of combat options evaluated. Demonstrations focus on multi-echelon (Battalion through Division) Commander's and Staff's C2/BV needs within a command post environment (BCV, C2V, TOCs, etc.) as defined by Battlelabs (BCBL, MMBL, and DBBL). BC2 will conduct prototype demonstrations integrated into the system architecture of the various host experiments. By FY98, BC2 will demonstrate an initial C2/BV product containing database and decision aids. In addition, BC2 will provide the C2/BV applications to the Rapid Battlefield Visualization ACTD. In FY99, BC2 will demonstrate prototype Commander's/Staff's visualization, planning, and rehearsal aids within a command post environment. In FY00, BC2 will demonstrate an enhanced version of the Commander's/Staff's C2/BV Software Tool Set resident on COTS hardware, which will utilized advanced decision aids, battlefield visualization products, and advanced database technologies showing interoperability with allied assets.

Supports: Digitized Battlefield, ABCS, Force XXI, Intel XXI, Battlefield Visualization, Div XXI, Staff XXI, BCV/C2V, Rapid Battlefield Visualization ACTD, Battlefield Awareness Data Dissemination ACTD.

STO Manager:	**TSO:**	**TRADOC POC:**
Allen Ponsini	Carolyn Nash	Tom Mims
CERDEC/C2SID	SARD-TT	BC-BL
908-427-3689	697-8432	706-791-2800

III.E.07. Battlefield Combat Identification (BCID) ATD. This ATD is aimed at solving the combat identification (ID) problem underscored by the lessons learned from Operation Desert Storm. The effort will build upon the Battlefield Combat Identification System (BCIS), which is a millimeter wave question and answer, target ID system developed for ground vehicle platforms. This ATD forms the technical foundation for the FY96 start Combat Identification ACTD, which will demonstrate an integrated ground-to-ground and air-to-ground combat ID capability. An enhanced version of BCIS with digital data link for improved situational awareness and various air-to-ground concepts including direct sensing Target ID, Don't Shoot Me Net, and Situational Awareness Through Sight approaches will be investigated and selected concepts will be demonstrated in the Force XXI Brigade exercise in FY97 and in the ASCIET 97 field exercise to support a milestone decision in FY98. Probability of correct ID of 99 percent to 1.5X the effective range of the weapon, and position location accuracy of 100 meters or better will be demonstrated. In FY98, the ATD will demonstrate through sight concepts that integrate enhanced friendly and hostile ID. Additionally, concepts for lightweight combat identification for the dismounted soldier will be investigated in BLWEs during FY95-97. A laser-based solution for the soldier-to-soldier and potentially vehicle interoperable application will be demonstrated in both a stand-alone version and as an integrated function in the Land Warrior equipment suite to support a milestone decision in FY97.

Supports: BCIS, Land Warrior, Protecting the Force, Digitizing the Battlefield, Winning the Information War.

STO Manager:	**TSO:**	**TRADOC POC:**
Gerry Melendez	Carolyn Nash	Charles Campbell
PM CID	SARD-TT	MBS BL
(980) 427-5970	697-8432	502-624-1963

III.E.08. Aviation Integration into the Digitized Battlefield. Develop pilotage algorithms and platform integration concepts for application onboard Army aircraft to enable avionics integration into the digitized battlefield. Develop a software algorithm that derives flight path guidance information from digitized topographic and threat data, precision navigation data, near field sensed obstacle and wire data, and aircraft survivability equipment data. Provide highly accurate robust worldwide positioning through GPS enhancements, advanced navigation sensors, and digital data bases using advanced algorithms and integration concepts. Stringent performance levels are required to support precision navigation for advanced flight path guidance and situation awareness. Maximum utility of current GPS systems while conducting nap-of-the-earth flight and precision approach/ landing will be investigated. Precision Navigation, integrated with a high integrity digital terrain data base, provides the capability required to navigate in the digitized battlefield. By FY96, demonstrate flight path guidance based on digitized C2 information and realtime updates from onboard sensors. By FY97, demonstrate improved GPS vulnerability reduction methods such as satellite selection algorithms for NOE and Low Level operations, robust integrated navigation concepts, and improved signal acquisition technology. By FY98, demonstrate platform positioning accurate to 1-3 meters to enhance situation awareness in all environments (ECM, NOE). These errors include registration errors between the mapping data base and GPS positioning.

Supports: Digitization of the Battlefield, Battlespace C2, NAV WARFARE ACTD, Precision Strike, RPA, Comanche, PEO Aviation, PEO CCS PEO IEW, PM AEC, PM GPS, PM ATC, Advanced Capabilities and System Upgrades for Soldier, Ground and Air Vehicles, Comanche.

STO Manager:	**TSO:**	**TRADOC POC:**
Paul M. Olson	Carolyn Nash	Charles Campbell
CERDEC/C2SID	SARD-TT	MBS BL
908-427-3912	697-8432	502-624-1963

III.E.09. Digital Battlefield Communications ATD. This ATD will exploit emerging commercial communications technologies to support multimedia communications in a highly mobile dynamic battlefield environment. It will supplement and, in some cases, replace "legacy" military communications systems which are unable to keep pace with the rapidly increasing demand for communications bandwidth and global coverage in support of Digitized Battlefield and split-based operations. It will evolve an integrated communication infrastructure which utilizes commercial protocols and standards to achieve global interoperability. Beginning in FY95, NDI wideband data radios will be evaluated and procured for testing in TFXXI. By FY96, commercial ATM technology will be integrated into actual tactical communications networks to provide "bandwidth on demand" to support multimedia information requirements. BCBL(G) will be supported in the DBC ATM experimentation through DS-3 connection to other service labs from FY96-99. In FY96 and 97, this program will demonstrate Direct Broadcast Satellite technology in support of JWID 96 and TFXXI AWE FY97. In FY97, Multi-Level Security requirements will be addressed by the insertion of TEED hardware into TFXXI and wideband HF technology will be procured, tested in the CECOM DIL, and inserted into the tactical internet. Leveraging from supporting 6.2 technology base programs, low profile SATCOM antenna technology products for both military (UHF, SHF) and commercial (C, Ku, X), and SATCOM OTM from tactical vehicles will be demonstrated in FY96 and 97. By FY99, an integrated phased array antenna will be demonstrated for the RAP. Work will continue on a full sized phased array antenna to address multibeam satellite and terrestrial high data rate communications on the move throughout FY99. Commercial terrestrial PCS will be demonstrated in FY97 and 98, respectively, to exploit both commercial CDMA and BCDMA technology for MSE access. In order to extend ATM services to forward tactical units, a Radio Access Point (RAP) will be prototyped and tested in FY98. The RAP utilizes a high capacity on-the-move trunk radio to feed a variety of mobile subscriber services. By FY98, both manned and unmanned aerial platforms will be fitted with wideband relay packages to support OTM tactical operations, supporting bandwidths of up to 155 Mbps. This effort will be coordinated with and executed in conjunction with DARO. Applicable products found to be acceptable through our commercial communications technology laboratory (C2TL) program and evaluated jointly with TRADOC Battlelabs will be inserted into the DBC program. This ATD will conclude in FY99 with the insertion of appropriate technology products in CORPS XXI AWE in support of high capacity digitized communications and split-based operations.

Supports: PM JTACS Tactical Multinet Gateway, ISYSCON, Task Force XXI, Future Digital Radio (FDR), CGS ATD (Advanced Antenna Technology), PROTEUS, JADE, JWID 94, DIV XXI, Corps XXI

STO Manager:	**TSO:**	**TRADOC POC:**
Paul Sass	Carolyn Nash	Tom Mims
CERDEC/S&TCD	SARD-TT	BC-BL
908-427-2419	697-8432	706-791-2800

III.E.10. Range Extension. Directly support the Army C4 modernization "key azimuth" of Range Extension (Army Modernization Plan, page E-6). This will be achieved by the development and integration of several specific technologies. It will identify and develop key technologies required for airborne applications of a suite of communications packages, designing and integrating specific systems, and conducting system tests and demonstrations. This will be used to demonstrate intra-theatre communications range extension (up to 400 miles) at a variety of data rates. Major technology areas to be addressed are: airborne payload (including antennas) designs, ground terminal adaptations, interoperability/compatibility, and simulation. These technologies will be used to supplement current (and programmed) SATCOM resources at all frequency bands, providing the flexibility to support a broad range of general and mission specific applications. SATCOM terminals will be augmented and enhanced to provide the capability of communicatiing via satellite and/or airborne platforms. Additionally, the utility of SATCOM terminals will be extended by improvements to reduce size and weight, increasing throughput and mobility, and implementing emerging techniques such as DAMA. System design will be supported by enhancing CECOM's in-house satellite link analysis (SATLAB) capability and a Communications Range Extension Testbed will be developed to provide an adaptable testing environment. Major milestones include development of the Range Extension Test Bed and a Tracking and Reporting System (TRS) in FY96, demonstration of the SHF Surrogate Satellite System by FY98, and demonstration of UAV-based EHF and airborne battlefield paging in FY99.

Supports: Army C4 Modernization, JPO UAV TIER II Program, ARPA TIER II+ Program, Joint Precision Strike.

STO Manager:	**TSO:**	**TRADOC POC:**
MAJ Frank Pinkney	Carolyn Nash	Tom Mims
CERDEC/S&TCD	SARD-TT	BC-BL
908-427-3135	697-8432	706-791-2800

III.E.11. Army Communications Integration and Cosite Mitigation (CICM). The objective of this STO is to reduce the size, weight, power and cosite interference problems that occur when multiple radios in either the same or dissimilar frequency bands are integrated within a communications system. The physical space constraints of mobile platforms cause these problems to be even worse. These mobile platforms also have limited locations where antennas can be mounted, further increasing the RFI problems. Target Army platforms include the Command and Control Vehicle (C2V), the Battle Command Vehicle (BCV), the Common Ground Station (CGS), and future systems utilizing the multi-band/waveform Future Digital Radio (FDR). Technology from ongoing developments will be coupled with new efforts to address the problem within the continuous frequency band from 2 Mhz to 2 Ghz while also attacking the cosite interference in the HF, VHF, and UHF bands. Development efforts include VHF and UHF multi-port antenna multiplexers, ancillary cosite mitigation devices, and wideband linear power amplifiers. An initial demonstration will be conducted with SPEAKeasy in a C2V configuration in FY98. Evaluation of an advanced prototype 5-port VHF multiplexer will be completed in FY99. Development of a UHF multiplexer, VHF and UHF wideband power amplifiers, and ancillary cosite mitigation devices/techniques will be completed in FY00. Wideband and multiband antennas developed under the CECOM Antenna STO will also be utilized. Additionally, a multiband communications system will be integrated within a typical Army SICPS shelter mounted on a HMMWV and tests performed to evaluate the resultant performance and enhancements. This testbed shall be exercised throughout the FY99-FY01 period, for evaluation of the individually developed items. A final field demonstration and evaluation of all the developed items, plus the MBMMR/FDR and STO antennas, shall be performed in late FY01. These efforts are considered a natural extension of the size reduction and waveform reconfigurability goals of the Joint SPEAKeasy Multiband Multimode Radio (MBMMR) program.

Supports: All mobile communications systems, i.e., C2V, BCV, CGS, RAP, FDR.

STO Manager:	**TSO:**	**TRADOC POC:**
Donald Upmal	Carolyn Nash	Tom Mims
CERDEC/S&TCD	SARD-TT	BC-BL
908-532-0440	697-8432	706-791-2800

III.E.12p. Universal Transaction Services. The goal is to provide seamless connectivity and integration across communications media resulting in the commander having the ability to exchange and understand information unimpeded by differences in connectivity, processing, or systems interface characteristics. Provides the ability to move information from wherever it exists, in whatever form it exists, to wherever it is needed, in whatever form it is needed. In particular, the following attributes should be able to be developed and demonstrated. (1) Automated interfaces for determining the necessary translations that need to be applied at network nodes where interfaces occur between systems of differing characteristics. (2) Techniques for enhancing the commercially available signal conditioning and for introducing automated brokering of user preferences (profiles) and network characteristics to determine the appropriate type of conditioning. (3) Provision of dynamic profiles and adaptive conditioning in gateways to the tactical extension networks. (4) Automatic, adaptive addressing to allow connections to be made to users completely independent of any knowledge of his location. In FY00, initiate development of automated interfaces and translators. In FY01, develop techniques for enhancing commercial signal conditioning. In FY02, demonstrate adaptive conditioning in gateways to the tactical extension networks. In FY03, demonstrate adaptive addressing to allow connections to users completely independent of knowledge of his location.

Supports: All tactical communications and the tactical internet

STO Manager:	**TSO:**	**TRADOC POC:**
Paul Sass	Carolyn Nash	Tom Mims
CERDEC/S&TCD	SARD-TT	BC-BL
908-427-2419	697-8432	706-791-2800

F. INTELLIGENCE AND ELECTRONIC WARFARE

III.F.04. Orion. By FY98, demonstrate the operational effectiveness of a wide bandwidth SIGINT Electronic Support (ES) package on a short-range UAV platform operating in conjunction with a ground-based IEW Common Sensor (IEWCS) which receives the UAV ES detected signals and performs the intercept/processing tasks to locate high value targets. Thus, by virtue of the UAV platform, the IEWCS capabilities are vastly increased by allowing penetration of the enemy's communications space to detect even low signal levels from directional systems such as multichannel and down-hill comms. Line-of-sight restrictions, mobility restrictions, sensor placement problems, and interference problems from our own close-in relatively high power signals are eliminated and by being in the threat's communications space the CEP for target location improves significantly with advanced algorithms.

Supports: UAV-Short Range, UAV-JPO, IEWCS, CGS, GRCS

STO Manager:	**TSO:**	**TRADOC POC:**
Dave Helm	Carolyn Nash	James Hendley
CERDEC/IEWD	SARD-TT	U.S. Army Air Defense Artillery School
703-349-7299	697-8432	915-568-7611

III.F.05. Tactical Intelligence Data Fusion. Develop and integrate enhanced MI collection and asset management tools, terrain reasoning tools, multiple source correlation and fusion tools, enhanced information dissemination tools and techniques, and Battle Damage Assessment (BDA) tools and techniques. Demonstrate by FY96 enhanced multi-media database interface/sharing techniques to support information dissemination. Demonstrate by FY97 enhanced IEW asset management and Intelligence Preparation of the Battlefield (IPB) tools and techniques. Demonstrate by FY97 enhanced BDA tools and techniques using a multi-source approach. Demonstrate by FY98 multiple source fusion using terrain reasoning tool and techniques and Moving Target Indicator (MTI) automatic tracking. Demonstrate in FY99 advanced airborne planning algorithms and effectiveness tools utilizing IEWCS and integrate into IEWCS multi-sensor tasking and reporting tools using database to database interfaces. In FY00, integrate SIGINT/MTI sensor cross-cueing and situation displays with previously developed FY98 techniques into IEWCS and ASAS.

Supports: ASAS, IEWCS, CGS, BCBL(H), DSABL

STO Manager:	**TSO:**	**TRADOC POC:**
Dave Grubb	Carolyn Nash	LTC Herchell Boyl
CERDEC/IEWD	SARD-TT	BC-BL
703-349-7566	697-8432	520-533-2060

III.F.06. Multi-Mission/Common Modular UAV Sensors. Multi-mission/common modular UAV Sensors will demonstrate low cost, EO/IR, multispectral and lightweight integrated MTI/SAR payloads for future tactical UAVs. Common modular payload will be form/fit/interface compatible and share common electronics, data link, data compression. The radar payload will build upon successes in the current low-cost radar development program and likely will utilize MIMIC. The EO payload will leverage high quantum efficiency, 3-5 micron staring arrays. Sensor payloads will provide enhanced reconnaissance, surveillance, battle damage assessment, and targeting for non-line of sight weapons. By FY97, mission requirements, payload constraints, and common modular interfaces will be determined. By FY98, candidate sensors and signal processor selected and development initiated. By FY99, complete sensor development and payload integration, and initiate captive flight tests. By FY00, complete performance testing and operational demonstration in support of early entry, deep attack, mine detection, and non-line of sight masked targeting mission scenarios.

Supports: Masked Targeting, TUAV, SARD-B, DARO, JPO UAV.

STO Manager:	**TSO:**	**TRADOC POC:**
John Cervini	Carolyn Nash	Bob Bolling
CERDEC/NVESD	SARD-TT	BC-BL
908-427-5815	697-8432	602-538-7500

III.F.07. Digital Communications Electronic Attack (Classified). Provide the capability to intercept and bring under electronic attack advanced communications signals being used by adversarial command and control networks on the digital battlefield. Through electronic attack strategies demonstrated with prototype hardware and software. These digital communications signals will be disrupted, denied, and/or modified to render the communications system ineffective and unreliable to the threat command and control function. By FY97, demonstrate electronic attack against the digital formats being implemented in commercial communications systems, data transmission systems implemented by a variety of modern technologies, and wide bandwidth communications. In FY99, demonstrate the ability to disrupt other commercial communication networks. These communications systems in use today are being further technologically developed and are recognized as threat capabilities which will have to be faced in future conflicts.

These Electronic Attack capabilities developed in parallel with advanced receiver technology upgrades for the IEWCS will provide the commander the ability to dominate the control the modern digital communications spectrum. It will enable the force to wage aggressive information warfare. These efforts will be coupled with Battle Lab experiments and AWE opportunities.

Supports: IEW Common Sensor, ORION.

STO Manager:	**TSO:**	**TRADOC POC:**
T. Dizer	Carolyn Nash	Bob Bolling
CERDEC/IEWD	SARD-TT	BC-BL
703-349-6911	697-8432	602-538-7500

III.F.08. Rapid Battlefield Visualization ACTD. The goal of this ACTD is to integrate and demonstrate capabilities to generate, disseminate, and exploit high resolution digital terrain databases rapidly to provide 3-D visualization of the battlefield to support crisis response and force projection operations. Six elements will be integrated, evaluated, and demonstrated: (1) rapid access to archived data; (2) rapid collection of high resolution terrain elevation data and multi-spectral imagery using a tactically viable platform; (3) semi-automated extraction of terrain features; (4) rapid dissemination of databases over global broadcast; (5) a hierarchical spatial database management system that will accommodate multiple scales, resolutions, and dynamic updates; and (6) visualization workstations that will allow mission planning, rehearsal, course of action analysis, and embedded wargaming. By FY98, demonstrate capability to satisfy Army requirement for 20 km x 20 km terrain data set in 18 hrs and use data to plan crisis operations. By FY99 meet 72 hr requirement for 90 km x 90 km terrain data set, integrate with intelligence and situational awareness data, and wargame courses of action. By FY00, demonstrate ability to collect high resolution digital terrain data over 300 km x 300 km area within 12 days, generate tailored databases, and support battlefield visualization systems to provide overwhelming tactical advantage.

STO Manager:	**TSO:**	**TRADOC POC:**
Christian Moscoso	Harold Britton	MAJ Thomas Nothstein
JPSD-RBV	SARD-TT	ARDEC
703-704-1966	703-697-8434	(201)724-7131

III.F.09. Information Warfare Attack and Protect. Demonstrate the ability to launch effective Command and Control (C2) Attack against Integrated Battlefield Area Communications Systems (IBACS) (threat information systems). Demonstrate the ability to protect the Army's Tactical Internet (TI) information systems and components from modern network attacks. Leverage existing technology—take advantage of modeling and simulation for concept exploration and definition—use C2 attack capabilities against TI information systems and components—for each C2 attack method incorporate a "counter" (C2 Protect) capability. By FY02, provide the ability to selectively control an adversary's use of information, information-based processes, and information systems through the application of offensive capabilities that deny, disrupt, or degrade operations or capabilities. Demonstrate protection of friendly Tactical Internet Command and Control Systems and components.

Supports: Intercept, location, and electronic attack of modern, digital C2 systems; and C2 Protection of Tactical Internet Components and Networks, including radios, routers, and host computers.

STO Manager:	**TSO:**	**TRADOC POC:**
George Morris	Carolyn Nash	(TBD)
CERDEC/IEWD	SARD-TT	
908-427-5545	697-8432	

III.F.10p. Information Warfare. By FY03, provide the Joint Warfighter with the capability to selectively influence an adversary's use of or confidence in information processes and systems through the use of offensive deceptive IW to manipulate the information or information sources which support them. By FY04, provide the capability to selectively destroy an adversary's information or information process through the application of offensive weapons that destroy the information or the capability to use, transport, collect, or access it.

Supports: IEW Common Sensor

STO Manager:	**TSO:**	**TRADOC POC:**
G. Mitchell	Carolyn Nash	(None)
CERDEC/IEWD	SARD-TT	
540-349-7205	697-8432	

G. MOUNTED FORCES

III.G.01. Composite Armored Vehicle (CAV) ATD. By FY98, demonstrate the feasibility of a composite structure and advanced armor solution for a 17- to 22-ton air transportable vehicle weighing at least 33 percent less than an aluminum-based structure and armor of equal protection level. In addition, demonstrate manufacturability, repairability, durability, and large section cutouts/joining of composites as well as integration of signature management. Assess affordability of composite structures for ground combat vehicle applications. By FY96, complete designs of an advanced composite structure with integrated signature management and advanced armor for application to all future lightweight ground combat vehicles. Complete fabrication and assembly of CAV composite hull structure in FY97. Full-up automotive subsystems to be outfitted and CAV ATD delivered Feb 97. Durability/User evaluations 4Q97-4Q98.

Supports: FCS, FIV, Crusader, FSCS.

STO Manager:	**TSO:**	**TRADOC POC:**
Jamie Florence	John Appel	MAJ Paul Begeman
TARDEC	SARD-TT	Armor Center, DFD
(810)574-5473	697-8432	(502)624-8994
DSN: 786-5473	227-8432	464-8994

III.G.06. Hit Avoidance TD/ATD. By FY97, the ATD objective is to demonstrate, in a systems integration laboratory (SIL), a commander's decision aid with software logic to implement fusion between the sensors and countermeasures. The commander's decision aid is a key component of the vehicle protection architecture; it will be developed in FY95/FY96 and evaluated in FY97. By FY97, a low cost near term active protection concept will also be demonstrated to defeat hit-to-kill smart threats. The goal is to reduce hit probability to 0.20 from current 0.80 to 0.90.

Supports: FCS, FSCS ATD, Crusader, M113, Abrams and Bradley Upgrades.

STO Manager:	**TSO:**	**TRADOC POC:**
Steven Caito	John Appel	MAJ Joe Burns
TARDEC	SARD-TT	Mounted Maneuver Battle Lab
810-574-5788	697-8432	(502)624-1963

III.G.07. Advanced Missile Systems Fire Control. By the end of FY97, demonstrate an enhanced missile system engagement capability against low signature targets in clutter and realistic battlefield environments. This activity will address the integration of missile guidance with advanced fire control sensor suites comprised of multispectral sensors. Emphasis will be placed on demonstrating effective handoff of targets from the fire control to a co-located missile system. System benefits include simplification of the operator's task, increased effectiveness, reduced fratricide, and reduced cost.

Supports: D&SA, Mounted, and EELS Battle Labs, CORPS SAM, AVENGER, GBS, UGV, TACAWS, PEO Tactical Missiles, and PEO Missile Defense.

STO Manager:	**TSO:**	**TRADOC POC:**
Jimmy Duke	Mike Rithmire	James Hendley
MICOM	SARD-TT	U.S. Army Air Defense Artillery School
205-876-2536	697-8434	915-568-7611

III.G.08. Target Acquisition ATD. Develop and demonstrate an extended range, multisensor target acquisition suite for combat and tactical vehicles. The multisensor suite will consist of a second generation thermal imaging sight with automated search and aided target recognition, a low cost MTI radar (growth to STI), and a multifunction laser. These enhanced target acquisition capabilities will be coupled with combat identification technologies to significantly improve the light armored combat vehicles' lethality and survivability. By FY97, demonstrate "target finder" capability—multifunction laser and auto target cuer—as a potential fast track acquisition upgrade for Abrams/Bradley and extended range cueing with a millimeter wave ground radar. These capabilities will extend identification range from 2100m to 3500m for exposed targets and from 1200m to 3000m for partially obscured targets. By FY98, demonstrate gimbal scan and automation to reduce search timelines by 60 percent—80 percent over manual search and streamline crew workload for future main battle tanks.

Supports: Abrams M1A2 SEP, Bradley upgrades, Advanced Tank Technologies ATD, AGS Upgrades, RFPI, FMBT, Future Scout Vehicle.

STO Manager:	**TSO:**	**TRADOC POC:**
Tim Watts	Carolyn Nash	Charles Campbell
CERDEC/NVESD	SARD-TT	MBS BL
703-704-1356	697-8432	502-624-1963

III.G.10. Direct Fire Lethality ATD. In FY96, continue component development and, in FY97, demonstrate 120mm KE precursor penetrator to defeat the 2005 Explosive Reactive Armor (ERA) projected threat with an increase of 50 percent in lethality over the M829A2. In FY98, statically demonstrate 120 Smart Target Activated Fire and Forget (STAFF) dual liner Explosively Formed Penetrator (EFP) warhead function to form an ultra-long EFP, and conduct a hardstand dynamic demonstration of a Electric Direct Turret Azimuth Drive (gearless) technology. In FY99, demonstrate Smart Barrel Actuator active damping control of a M256 120mm gun tube in non-firing, dynamic tests. In FY00-01, conduct demonstrations. The ATD exit criteria requires, in FY00, an integrated 120mm KE Cartridge to defeat the 2005 ERA protected threat with 30 percent increase in system accuracy under stationary conditions over the M829A2/M1A2; demonstrate minimum 33 percent increase in armor defeat with a 120 dual liner STAFF warhead. In FY01, demonstrate a 300 percent increase (a 3 Km) in probability of hit over the M1A2 under dynamic scenarios using Smart Barrel Actuators, fully integrated gearless Turret/Gun Direct Drives, and Modern Digital Servo Control. (Note: The Advanced KE Cartridge FAST TRACK Acquisition Program is a joint effort with PM-TMAS. The PM will provide $4.6M in FY98 and $6.8M in FY99 pending an M829E3 technology decision in FY97.)

Supports: All anti-armor weapon systems and weapon platforms: 120mm tank munitions (KE, CE), for Abrams, FCS. Mounted BL.

STO Manager:	**TSO:**	**TRADOC POC:**
Anthony Sebasto	John Appel	A. Winkenhofer
ARDEC	SARD-TT	USAARMC
201-724-6192	697-8432	502-624-8064

III.G.11. Ground Propulsion and Mobility. Ground vehicle mobility advances for the 2001 combat and tactical vehicle fleets will be achieved through cooperative agency electric drive research and high performance ground vehicle running gear technology developments. Running gear advances will apply sensors, intelligence, and new material technologies to tracked and wheeled vehicle suspension systems. These mobility advances will enhance system survivability and operational effectiveness through smaller and lighter systems with improved ride and agility, reduced acoustic (30 to 50 percent reduction and IR signature, and quiet slope operations for reconnaissance/scout type missions.

By 2001, demonstrate the operational effectiveness and survivability enhancements of semi-active suspension and band track technologies applicable to the tracked and wheeled fleet. Fully active and intelligent active suspensions along with band track will be 6.2 funded and evaluated technically on a vehicle demonstrator and operationally in force effectiveness simulations. The integration effort will result in a Ground Propulsion Mobility (GPM) Technology Demonstrator which will be electrically driven, provide superior firing/surveillance platform stability and capable of generating the power demands of an EM Gun and other all-electric vehicle requirements. Through a partnership formed by the Army, Navy, and DARPA, demonstration of electric drive technology for combat vehicles will take place by 2001. Ongoing DARPA and USMC projects on electric drive technology will be leveraged to develop combat vehicle test beds in the Future Scout Vehicle weight class.

Milestones: FY97—Determine ATD vehicle requirements; FY98—Demo high power MOS thyristor, Complete Operational effectiveness simulation payoff predictions; FY99—Track and suspension vehicle demonstration; FY00—Finalize selected energy storage concepts; FY01—MOS controlled thyristors demo in vehicle, performance testing of GPM-TD, and validate operational effectiveness predictions through test.

Supports: FSCS ATD, FCS, Electric Armaments, Future Electrically driven vehicles, Future medium weight combat vehicles, tactical wheeled vehicles, Battle Labs—EEL, MTD, DBS, DSA, CSS. Dual Use Supports commercial electric vehicles and commercial diesel engine technology.

STO Manager:	**TSO:**	**TRADOC POC:**
Dan Herrera	John Appel	MAJ Paul Begeman
TARDEC	SARD-TT	Armor Center, DFD
810-574-6411	697-8432	(502)624-8994

III.G.12. Intra-Vehicle Electronics Suite TD. By FY00, develop and demonstrate in a laboratory the efficient integration of the crew and electronic subsystems. This Intra-Vehicle Electronics Suite TD effort will develop the VETRONICS Open Systems Architecture (electronics integration), a user friendly crew station (crew integration), and advanced digital information handling systems (Battlefield Information Integration) necessary to enable the crew/vehicle to fight and win the information war. The development of the VETRONICS Open Systems Architecture is based on commercial standards and software reusability/transportability will reduce overall system code development time by approximately 50 percent and decrease integration time of vehicle subsystem hardware and software by approximately 30 percent. The Vetronics Operating Services system (VRTOS), which is compliant with the POSIX standard where applicable, allows for portability of application software code across the range of proprietary Ada run-time systems utilized in embedded software development. The VRTOS will be compliant with the Weapon System Technical Architecture portion of the C41 Technical Architecture. This architecture will be used and demonstrated on the Advanced Tank Technologies ATD and Scout Vehicle ATD. The crew station designs defined in the Crewman's Associate ATD program will be developed and integrated into the Open VETRONICS Systems Architecture to demonstrate how crewmen can effectively maneuver their vehicle on the digitized battlefield using advanced SMI. The Battlefield Information Integration will develop the intra-vehicle information handling systems necessary to interface with and manipulate the vast amounts of digital information available on the digital battlefield. This effort will demonstrate through simulation how the crew will be able to significantly increase their information handling capabilities, without a corresponding increase in crew workload, to improve the overall effectiveness of the vehicle on the battlefield. Milestones include: 1QFY96—Initiate integration of VETRONICS Systems Integration Laboratory (VSIL) into lab. 4QFY96—Validate VETRONICS Open Systems Architecture Application Programmers Interface (VTROS & VGUI). 1QFY97—Initiate development of Crewman's Associate ATD crew station using actual H/W and S/W. 4QFY97—Complete integration of VSIL into lab. 3QFY98—Link VSIL with Digital Integrated Lab (DIL). 4QFY98—Complete development of Crew Stations using Target Hardware and Software. 2QFY99—Complete integration of actual Crew Station using Target H/W and SW into VSIL. 2QFY99—VSIL integration of H/W and S/W from the Hit Avoidance, Target Acquisition, and Combined Arms Command and Control ATD Programs. 3QFY99—Execute Warfighter Seat Simulator Experiments. 1QFY00—Execute SIL Experiments on Turret Motion Based System. 2QFY00—Execute ATT SIL Warfighter Experiments. 3QFY00—Warfighter participation in analysis of Experiments. 4QFY00—Demonstrate In-Vehicle DIS experiments and complete Intra-Vehicle Electronics Suite Program.

Supports: Army C4I Technical Architecture, Target Acquisition ATD, Hit Avoidance ATD, M1A2 and M2A3 upgrades, CRUSADER, Digitization of Battlefield, Task Force XXI, Open Systems Task Force.

STO Manager:	**TSO:**	**TRADOC POC:**
Chris Ostrowski	John Appel	MAJ Steve Walker
TARDEC	SARD-TT	Armor Center, DFD
(810)574-6910	697-8432	(502)624-8802

III.G.13. Compact Kinetic Energy Missile (CKEM) Technology. By FY99, develop and demonstrate technology for an insensitive, lightweight, miniature hypervelocity kinetic energy missile (35-40 kg), which is compatible with the LOSAT target acquisition and tracking system and could be compatible with the fire control system, for close combat and short range air defense missions. Demonstrate the missile KE Penetrator achieving M829A2 equivalent kinetic energy at 175 m and maintaining the energy to beyond 5 km, and achieving greater than 3 times the M829A2 penetrator energy at 450 m and maintaining it to 3.5 km. Demonstrate the missile delivering in excess of 30 MJ to the target at a range of less than 500 meters, as well as a range out to 4 km, and 25 MJ at 5 km. Leverage miniaturized guidance and control actuation technology, high fidelity visual digital simulation, advanced composite motor and structure technology, fire control, insensitive—nondetonable propulsion technology, and enhanced lethality characteristics from the LOSAT missile program and the Hypervelocity Missile Guidance STO. Demonstrate increased maneuverability against airborne targets at minimum range with continuous control actuation. Significantly increase missile platform adaptability to include future main battle tanks, helicopters, and multiple lightweight platforms, which are strategically deployable. Demonstrate motor and propulsion concept by FY98, and conduct a flight test in FY98. Demonstration of this miniature hypervelocity missile concept will provide capability for a significant increase in lethality, survivability, and mobility of a dual role close combat and short range air defense hypervelocity guided KE weapon system.

STO Manager:	**TSO:**	**TRADOC POC:**
George W. Snyder	Mike Rithmire	COL Arnold J Canada
MICOM	SARD-TT	DBS-BL
(205)876-3048	697-8434	706-545-2310

III.G.14. Future Scout and Cavalry System (FSCS) ATD. By FY02, this ATD will demonstrate, through virtual prototyping, demonstrator hardware testing and user field experimentation, the feasibility and operational potential of a lightweight scout vehicle platform by integrating scout specific technologies with complementary advanced vehicle technologies. In FY97, design advanced crew station(s). In FY98, build high fidelity crew station simulators, transition virtual prototype, and competitively award the ATD contract. In FY99, develop preliminary designs from the virtual prototype, initiate a vehicle-level Systems Integration Laboratory, and demonstrate scout mobility and survivability technologies in User Warfighting Experiments. In FY00, develop detailed design and initiate subsystem fabrication. In FY01, complete subsystem fabrication and perform demonstrator fabrication/integration. This program addresses issues including sensor capabilities, survivability strategies, and mobility enhancements. The use of virtual prototyping will allow the developer and warfighter to evaluate a variety of configurations prior to demonstration/fabrication. This evaluation will determine the optimal combination of target acquisition, survivability, mobility, lethality, and transportability technologies prior to building the ATD. Specific technologies include: scout sensor suite, advanced crew stations, commercially-based open systems electronic architecture, advanced command and control, advanced survivability systems, electric drive (leveraging DARPA's Hybrid Electric Power Program), semi-active suspension, lightweight track, advanced lightweight structural materials and armors, and medium caliber weapon. This integration effort utilizes technologies developed and demonstrated by the Ground Propulsion and Mobility STO (III.G.11), Target Acquisition, Multi-Functional Sensor Suite, Hunter Sensor Suite, Combined Arms Command and Control, Digital Battlefield Communications, Hit Avoidance, Crewman's Associate, Intra-Vehicle Electronics Suite, and the Composite Armored Vehicle ATDs, as well as DARPA's Hybrid Electric Power Program.

Supports: Scout Integrated Concept Team (ICT) recommendations, Validated Mission Need Statement (MNS), and Draft Operational Requirements Document (ORD) for Future Scout and Cavalry System.

STO Manager:	**TSO:**	**TRADOC POC:**
John Torvinen	John Appel	MAJ Paul Begeman
TARDEC	SARD-TT	Armor Center, DFD
(810)574-5090	697-8432	(502)624-8994

III.G.15p. Future Combat System Distributed Defense. By 4QFY04, demonstrate a distributed defense system that is capable of protecting armored forces against attack by smart and precision guided weapons. This will reduce cost and enhance force survivability by putting select sensors and countermeasures on some rather than all of the vehicles in the force. The strategy that vehicles fitted with various sensors and countermeasures will provide protection to the rest of the vehicles in the force. Data gathered from the distributed sensors would be fused and communicated in real-time to the entire force. This capability would allow for completely coordinated defense for the armored force. Sensors, electronic countermeasures, and active protection will be considered. Most, if not all, Sensor/CM/ Commo technologies will either be COTS available or available from other DoD agencies. By FY01, identify optimal sensor/countermeasure technologies and determine sensor/ countermeasure mix through operational effectiveness analyses studies. By FY02, integrate Distributed Defense technologies in a laboratory environment and perform small-scale field testing of selected technologies. By FY03, conduct DIS experiments. By FY04, conduct field demonstrations and transition Distributed Defense system specifications to PEO-GVSS.

Supports: Abrams, Bradley, Crusader, and FCS.

STO Manager:	**TSO:**	**TRADOC POC:**
Jim Soltesz	John Appel	COL John Kalb
TARDEC	SARD-TT	Armor Center DFD
(810)574-5653	697-8432	(502)624-5050

III.G.16p. Mobility Demo for Future Combat System. By FY05, complete all warfighting experiments with Advanced Mobility Future Combat Systems and complete integration into FCS integrated vehicle demonstrator. This effort will develop and demonstrate an advanced propulsion system which consists of a high power density, low heat rejection, engine (Diesel or Turbine), an electric drive and power conditioning system, an active suspension system, an automatic track tensioning system, and an advanced track. This propulsion system will meet the requirements of the Future Combat System and main weapon. Improvements in operational effectiveness will be field demonstrated. Increased cross country mobility and platform stabilization will be achieved with either a fully active suspension which uses electric actuators or a semiactive/active hydropneumatic suspension. These advanced suspensions will improve lethality and target acquisition by providing improved platform stablilization. Improved survivability and the silent operation capability of the electric drive system will be demonstrated. The development of an electric power architecture where generated power can be delivered according to an established control and precedence strategy will allow mobility and lethality (EM gun) improvements to be demonstrated. Improved vehicle speed and grade climbing ability will be achieved with a high power density, low heat rejection, diesel or turbine engine and an advanced track which has an automatic track tensioning system that reduces rolling resistance and increases track life, resulting in reduced O&S costs. The engine, the electric drive and power conditioning components, the suspension and track components will be designed to be significantly lighter and smaller than present propulsion components. The resulting propulsion system will improve the deployability of the Future Combat System. The electric drive hardware to be integrated will be funded primarily by DARPA and managed jointly by the Army and Marines. The advanced engine, track, and suspension will be developed at TARDEC. By FY06 TARDEC will complete integrated mobility system and durability demonstrations.

Supports: Future Combat System, Crusader Upgrades, Future Infantry Vehicle.

STO Manager:	**TSO:**	**TRADOC POC:**
Dan Herrera	John Appel	MAJ Monroe Harden
TARDEC	SARD-TT	Armor Center DFD
(810)574-6411	697-8432	(502)624-4412

III.G.17p. Future Combat System Integrated Demo. By FY05, demonstrate the integration of the full suite of tank technologies. This will include Distributed Defense, Advanced Mobility, Lightweight Chassis and Turret structures, and fully integrated electronics subsystems. The main thrust of this TD is to demonstrate the high power electric technologies critical to the realization of “leap ahead” capabilities as an integrated system within a combat vehicle. To realize "leap ahead" capabilities requires the implementation of electric power intensive technologies such as electric and hybrid guns, directed energy (DE) devices, electric armor, active protection, signature management, and active suspension. Successful integration depends upon the availability of electrical components capable of storing several megajoules of energy and of delivering and controlling power pulses of several megawatts within the confines of the combat vehicle. Initially, this TD will demonstrate the integration and operation of these electrical components in a combat vehicle and will provide the basis for measuring component performance, evaluating electrical system architectures, and ensuring compatibility with other TDs. Electrical components are inherently modular and can be located in a variety of locations within the vehicle. This feature will be exploited to allow the system to grow to accommodate new components as their technology matures. Any simulated loads will be replaced with the actual hardware as it becomes available. The Integrated Product and Process Development (IPPD) concept will be implemented throughout the TD. By FY01, develop and validate User and Technology Requirements (A-spec). By FY02, develop program plan/release RFP. By FY03, complete system design and development. By FY04, validate electrical/electronic integration, in a laboratory environment (SIL), Distributed Defense, Advanced Mobility, and Advanced Electronics. By FY05, integrate and demonstrate the technologies validated in the SIL in a lightweight chassis/structure testbed.

Supports: FCS and FIV.

STO Manager:	**TSO:**	**TRADOC POC:**
Andy Lijoi	John Appel	MAJ Monroe Harden
TARDEC	SARD-TT	Armor Center DFD
(810)574-6932	697-8432	(502)624-4412

III.G.18p. Advanced Electronics for FCS. By 4Q04, complete transition of integrated electronics package and crewstations to Future Combat Systems (FCS) Integrated Demonstrator. This program will support the on-vehicle integration of the Crewman's Associate ATD (STO III.G.3) crew station and VETRONICS Open Systems Architecture (VOSA) (STO III.G.12) into the FCS Integrated Demo (STO III.G.17p). The VETRONICS Systems Integration Laboratory (VSIL) will be modified to act as an FCS vehicle trainer to allow vehicle test crews to train in the FCS crew stations in a simulated battlefield environment before the actual vehicle is fielded. The Battle Labs/DCDs/PMs will conduct on-vehicle evaluations of the VOSA and Crewman's Associate in field exercises, BLWEs, and Advanced Warfighting Experiments (AWEs). Modifications to the VOSA and Crewman's Associate designs will be implemented as problems are identified. These modifications will be integrated into the VSIL for evaluation before reintegration into the FCS TD for subsequent field trials. Upon completion of both the laboratory experiments and field trials the VOSA/Crewman's Associate Design Handbooks will be updated (FY03). In support of the FCS TD, this program will define the electronic architecture upgrades required to support the FCS TD's integration of ultra-high power electronic components (i.e., electric drive, electric gun, etc.). In FY02, the VSIL will be upgraded to support the integration of high power electronic components and thermal analysis tools. Extensive experiments will be conducted to define the upgrades to the VOSA necessary to support high power requirements of future vehicle developments. This program will be completed in FY05 with the update to the VOSA Design Handbook. By 4QFY01, initiate on-vehicle integration of VETRONICS Open Systems Architecture and Crewman's Associate plans for the FCS TD. By 2QFY02, conduct an electronic power consumption analysis for FCS. By 3QFY03, modify VSIL to act as FCS Trainer. By 1QFY04, participate in FCS on-vehicle experiments. By 4Q04, validate FCS electronic integration via warfighter experiments. By 4QFY04, revise VOSA/Crewman's Associate design. By 3QFY02, upgrade VSIL to integrate High Power Components and thermal analysis/modeling tools. By 4QFY03, validate FCS electronic integration via SIL.

Supports: Army C4I Technical Architecture, Abrams, Bradley, Crusader, and Future Combat System.

STO Manager:	**TSO:**	**TRADOC POC:**
Chris Ostrowski	John Appel	MAJ Monroe Harden
TARDEC	SARD-TT	Armor Center DFD
(810)574-6910	697-8432	(502)624-4412

H. CLOSE COMBAT LIGHT

III.H.02. Hunter Sensor Suite ATD. This ATD will demonstrate the feasibility of a lightweight, deployable and survivable hunter vehicle platform with an advanced, low observable, long range hunter sensor suite. The Hunter Sensor Suite will combine second generation thermal imaging, day TV, eye safe laser rangefinder, embedded aided target recognition, and image compression/transfer technology. Compared to the AN/TAS-6 W/2X lens, this sensor suite will reduce time to detect by 80 percent, increase target recognition range by 30 percent, and allow precision target location to within £ 50m. Critical targeting data and images will be passed over a C3 network to the RFPI "Standoff Killer" weapons in less than 15 seconds. By FY97, complete fabrication of the demonstrator vehicle, integration of signature management technologies and Hunter Sensor Suite mission payload, and demonstrate this survivable "Hunter" capability for the RFPI ACTD.

Supports: Dismounted Battlespace, Mounted Battlespace, Depth and Simultaneous Attack, Battle Command, Early Entry Lethality and Survivability, RFPI Umbrella Program, RFPI ACTD, LRAS3, FSV.

STO Manager:	**TSO:**	**TRADOC POC:**
Tom Smith	Carolyn Nash	Charles Campbell
CERDEC/NVESD	SARD-TT	MBS BL
703-704-1219	697-8432	502-624-1963

III.H.03. Enhanced Fiber Optic Guided Missile ATD. By FY00, demonstrate, through a virtual prototype, flight test, and integrated demonstration, an Enhanced Fiber Optic Guided Missile (EFOGM) as the primary "Killer" within the "Hunter-Standoff Killer" concept of the Rapid Force Projection Initiative (RFPI) demonstration. The EFOGM system is a multi-purpose, precision kill weapon system. The primary mission of the EFOGM is to enable a gunner in defilade to engage and defeat threat armored combat vehicles, other high value ground targets, and hovering or moving rotary-wing aircraft that may be masked from line-of-sight direct fire weapon systems. EFOGM is a day, night, and adverse weather capable system that allows the maneuver commander to extend his battle space beyond his line-of-sight to ranges up to 15 kilometers. The EFOGM program will produce a total of 300 missiles and 16 ground stations for use in demonstrations and as residual hardware for extended user evaluation. The program will emphasize missile unit cost/affordability and the integrated process and product development process.

Supports: RFPI, ACTD/AWE.

STO Manager:	**TSO:**	**TRADOC POC:**
COL Roy D. Millar	Mike Rithmire	Chris Kearns
PM NLOS	SARD-TT	DBL
205-876-7725	697-8434	706-545-6391

III.H.04. Precision Guided Mortar Munition (PGMM) ATD. In FY97, conduct common (120/105mm) seeker CFT. In FY98, demonstrate integrated man-portable fire control system. In FY99, conduct all-up-round demonstrations for 120 mm PGMM. The 120mm PGMM must achieve a range of 12 km using a mass simulant of the PGMM that weighs no more than 40 pounds. The 120mm PGMM must also defeat high value targets. The fire control exit criteria requires the combined weight of the azimuth reference unit and computer to be no more than 30 pounds, have an accuracy of 2 mils, and produce a ballistic solution within 2.5 minutes.

Supports: Rapid Force Projectile Initiative ACTD. 120mm Battalion Mortar System. Dismounted & EELS BLs.

STO Manager:	**TSO:**	**TRADOC POC:**
Dave Panhorst	John Appel	LTC Bourgine
ARDEC	SARD-TT	DBS-BL
201-724-5525	697-8432	706-545-7000

III.H.05. Rapid Force Projection Initiative (RFPI) C2 . RFPI C2 integrates technologies into a demonstration of capabilities required for a light insertion force that is air-deployable and first-to-fight in a forward or remote area. Increased lethality in a light force is supported by information distribution that is optimized for speed and robustness, with non-line-of-sight weapon platforms. Firing loop performance from target acquisition to weapons firing is a critical item. Early threat warning, decisions, assessment, and resource management are critical C2 related functions to be demonstrated for timely control and sustainment of light force capabilities. A limited TOC capability provides central focus for these functions. A robust network, with a high degree of connectivity, allows the commander to adapt the task force structure to concentrate sensors and firepower quickly as needed. RFPI C2 will be consistent with the Army's technical C2 architecture. Several demonstrations are planned for FY96-97. Final demonstration (RFPI ACTD) is 2QFY98.

Supports: RFPI ACTD and CAC2 ATD

STO Manager:	**TSO:**	**TRADOC POC:**
Ed Nell	Carolyn Nash	Chris Kearns
CERDEC/C2SID	SARD-TT	DBL
908-427-5108	697-8432	706-545-6391

III.H.08. Aerial Scout Sensors Integration. By FY98, evaluate and demonstrate sensor technology applicable to the family of UAVs with particular emphasis on the Light Force early entry mission. The program will demonstrate and recommend the proper mix of sensor technology for the RFPI application and for potential upgrades to the Tactical UAV. ASSI will demonstrate accurate, timely, and easily-usable "see over the hill" reconnaissance, surveillance, target acquisition, and battle damage assessment information from airborne scout platforms to augment the capabilities of ground-based scouts. A variety of sensors (FLIR, TV, Wide-Area Sensors, MTI Radar, etc.) will be demonstrated on one or more manned surrogate airframes. As appropriate to the individual sensor under demonstration, real-time digital data links, advanced data compression techniques, and workstation techniques will be explored or demonstrated.

Supports: Mounted Battlespace, Depth and Simultaneous Attack, Battle Command, Early Lethality and Survivability, RFPI Umbrella Program, Tactical/Maneuver/Pointer UAVs, and Precision Strike Korea.

STO Manager:	**TSO:**	**TRADOC POC:**
Jim Matheny	Carolyn Nash	Charles Campbell
CERDEC/NVESD	SARD-TT	MBS BL
703-704-1256	697-8432	502-624-1963

III.H.11. 155mm Automated Howitzer. Develop and demonstrate an automated, digital, fire control system for a 155mm towed artillery system for the Light Forces. The goal of the AH prototype will be to demonstrate advanced fire control, gun emplace, and lay automation (25 percent faster). In FY97, fabricate advanced fire control for M198 Howitzer. In FY98, participate in and provide multiple equipment for the Rapid Force Projection Initiative (RFPI) ACTD and provide technical support for residual hardware in the field in FY99.

Supports: Ten sets of hardware for Rapid Force Projection Initiative ACTD, DemVal Phase for the Joint USA/USMC Light Weight Howitzer program, DSA Battlespace BLs.

STO Manager:	**TSO:**	**TRADOC POC:**
MAJ Thomas Nothstein	John Appel	MAJ Don Huntley
ARDEC	SARD-TT	Depth and Simultaneous Attack
(201)724-7131	697-8432	405-442-2927

III.H.12. Precision Offset, High Glide Aerial Delivery of Munitions and Equipment. Demonstrate revolutionary technologies for the reliable precision guided delivery of combat essential munitions/sensors and equipment using high glide wing technology and incorporating a low cost, modular GPS guidance and control system. This technology will provide a 6:1 or better glide ratio. By the end of FY96, develop a modular GPS guidance package and demonstrate precision high glide capability of a 500 pound payload using semi-rigid wing technology. By the end of FY99, demonstrate precision high glide of a 5,000 lb. payload, with a goal of a 10,000 lb. payload, using an advanced guidance package and high glide wing. High glide technology will significantly enhance the military aerial delivery capability through substantially higher glide ratios than are possible with ram air parachutes and will directly benefit the initial deployment of Early Entry Forces.

Supports: Advanced Development-RA02/63804/D266-Airdrop; Engineering Development-RA02/64804/D279-Airdrop; EELS and CSS Battle Labs.

STO Manager:	**TSO:**	**TRADOC POC:**
Sean Wellman	Bill Brower	Ken Foley
NRDEC	SARD-TT	Early Entry Battle Lab
508-233-4082	697-8432	804-727-5854

III.H.13. Rapid Force Projection Initiative (RFPI). The RFPI Program will demonstrate the combat worth of a new Army operational concept pairing forward sensors ("hunters") with an array of standoff weapons ("killers"). The RFPI Technology Program will provide unique items to facilitate integration of systems which are not currently in production, by utilizing commercial-off-the-shelf items. By FY98, provide simulation analysis activities to support developmental requirements as well as changes and upgrades of tactics, techniques, and procedures and demonstrate in a large scale field experiment. By FY99, through the use of the thirteen participating Advanced Technology Demonstrations/ Technology Demonstrations, address the optimum operational capability requirements of the Early Entry Forces.

Supports: Battle Command, Depth and Simultaneous Attack, Dismounted Battle Space, Early Entry Lethality, and Survivability Battle Labs.

STO Manager:	**TSO:**	**TRADOC POC:**
Emily H. Vandiver	Mike Rithmire	COL Arnold J Canada
MICOM	SARD-TT	DBS-BL
205-876-4857	703-697-8434	706-545-2310

III.H.14. Counter Active Protection Systems (CAPS). Overall objective: Develop and demonstrate technologies which can be applied to anti-tank guided weapons (ATGW) for improving their effectiveness against threat armor equipped with active protection systems (APS). Current technology development is concentrated in the following three areas: a. RF Countermeasure (RFCM) technology for jamming or deceiving APS sensors used for detection, acquisition, and tracking; b. long standoff warheads for shooting from beyond the range of APS fragment producing countermunitions; c. ballistic hardening of ATGW to reduce vulnerability to fragment impact.

RF Countermeasures: MICOM RDEC is developing concepts for deceiving and jamming APS sensors. By end of FY97, a digital model of an APS radar will be completed, passive and active RFCM breadboards will be designed and fabricated, and a test radar will be designed and fabricated. By FY98, bench test and evaluate RFCM breadboards. By FY99, demonstrate prototypes of selected RFCM concepts.

Warhead Countermeasures: MICOM RDEC, ARDEC, and ARL-WTD are currently working together in developing CAPS LSW technology for ATGW. The ultimate objective of these efforts is to demonstrate the target defeat of Turret Front armor with LSW fired from outside the range of threat APS. In FY96, MICOM will complete an investigation of jet particle dispersion at 10m standoff. In FY97, MICOM will test and evaluate current LSW at 6 and 10 m. In FY96, ARL will refine a current Steady-State-Jet design, test it, and design a 2-stage warhead. In FY97, build and test 2-stage warhead to investigate sequenced jets and design multi-stage warhead. In FY98, build and test multi-stage warhead and evaluate alternative liner material. In FY96, ARDEC will demonstrate a LSW at 30 CD. In FY97, 45 CD. In FY98, 60 CD.

Supports: Dismounted Battle Space, Early Entry Lethality and Survivability Battle Labs; PEO Tactical Missiles, CCAWS AMS-H, Javelin, BAT.

STO Manager:	**TSO:**	**TRADOC POC:**
Donald E. Lovelace	Mike Rithmire	Chris Kearns
MICOM	SARD-TT	DBL
205-876-8609	703-697-8434	706-545-6391

III.H.15. Multi-Function Staring Sensor Suite (MFS3) (Proposed ATD). Demonstrate a modular, reconfigurable Multi-Function Staring Sensor Suite (MFS3) that integrates multiple advanced sensor components including staring infrared arrays, multifunction laser, and acoustic arrays. The MFS3 will provide ground vehicles, amphibious assault vehicles, and surface ships with a compact, affordable sensor suite for long range non-cooperative target recognition, mortar/sniper fire location, and air defense against low signature UAVs and long range helicopters. By FY98, complete sensor component risk reduction, and develop reconfigurable sensor backplane that fully integrates aperture, power, and signal processing requirements for multiple platform applications. By FY99, complete design of medium format staring array capable of being reconfigured for either visible through 5 micron or 8-12 micron operation. By FY00, integrate staring FLIR, multi-function laser, and acoustic cueing components and processing with common backplane, and demonstrate the capability for automated surface-to-surface, surface-to-air, and air-to-ground search, acquisition, and non-cooperative identification. By FY01, integrate weapons/fire location processing and demonstrate capability to detect and accurately locate hostile mortar/sniper fire.

Supports: Future Scout Vehicle, Bradley Stinger Fighting Vehicle-Enhanced, Advanced Amphibious Assault Vehicle.

STO Manager:	**TSO:**	**TRADOC POC:**
Steve Holt	Carolyn Nash	Chris Kearns
CERDEC/NVESD	SARD-TT	DBL
703-704-1233	697-8432	706-545-6391

III.H.16p. Airborne Insertion for Operations in Urban Terrain. Develop and demonstrate advanced airborne insertion technologies providing ultra-high altitude insertion of individuals and small units with the ability to accurately reach drop zones from increased stand-off distances during night and limited visibility conditions. These technologies will enhance the covert mobility of early entry forces in urban terrain areas and greatly improve lethality and survivability. Technology breakthroughs will include personnel parachutes with high glide capabilities based on 3-D non-linear modeling, personnel miniaturized GPS/INS airborne navigation capabilities, improved high altitude life support technologies, and the application of innovative materials for enhanced reliability, maintainability, and safety. By FY02, define accurate characterizations of decelerator aero-coefficients/ performance and demonstrate 50 percent increase in airborne insertion offset distance. By the end of FY04, demonstrate enhanced integrated high altitude life support and airborne personnel navigation capabilities.

STO Manager:	**TSO:**	**TRADOC POC:**
Edward Doucette	Bill Brower	Chris Kearns
NRDEC	SARD-TT	DBL
508-233-4636	697-8432	706-545-6391

I. SOLDIER

III.I.01. Objective Individual Combat Weapon (OICW) ATD. Demonstrate technologies for the Objective Individual Combat Weapon yielding dramatically improved hit probability and terminal effects. Specific goals include demonstration of brassboard exhibiting hit probability greater than 0.5 out to 500 meters and 0.3 to 0.5 out to 1,000 meters in 1996. Effectiveness against personnel and light armor targets, given a hit, will be greater than those of the M433 High Explosive Dual Purpose cartridge fired from the M203 Grenade Launcher and the M855 cartridge fired from the M16A2 rifle. The OICW Joint Service ATD will comprise operational testing, analysis, and assessments of the OICW's operational utility and technological maturity. Specific goals include: hardware build for six complete weapon systems and associated ammunition in FY98; demonstrate a 0.5 probability of incapacitation to 300 meters (point target) and a 0.2 probability of incapacitation to 300 meters (defilade target) in FY99.

Supports: Land Warrior, MOUT ACTD, replacement for M16A2, M203, and M249. Transitions to PM-Small Arms funded 6.4 program.

STO Manager:	**TSO:**	**TRADOC POC:**
Vern Shisler	John Appel	Chris Kearns
ARDEC/JSSAP	SARD-TT	DBL
(201) 724-6009	697-8432	706-545-6391

III.I.03. Rapid Deployment Food Service for Force Projection. By the end of FY96, demonstrate equipment components of a modular, field food service system based on advances in diesel combustion and heat transfer technologies. By the end of FY98, demonstrate integral power generation, advanced insulative materials, and non/low powered regenerative refrigeration. By the end of FY99, fully integrate these technologies for the demonstration of a highly mobile, rapidly deployable field feeding system that is more reliable (50 percent increase in MTBF), more efficient (50 percent decrease in fuel), that can be operational in minutes instead of hours, and that expands the range of tactical situations (by 40 percent) in which hot meals can be prepared and delivered.

Supports: Joint Service Food Program; Advanced Development-RJS2/63747/D610-Food Adv. Dev.; Engineering Development-RJS2/64713/D548-Military Subsistence Systems; Army Field Feeding Equipment 2000 (MNS).

STO Manager:	**TSO:**	**TRADOC POC:**
Don Pickard	Bill Brower	Herbert Russakoff
NRDEC	SARD-TT	CSS Battle Lab
508-233-5036	697-8432	804-734-0599

III.I.04. Force XXI Land Warrior (FXXI LW). By FY98, perform an Early User Test (EUT) to validate the improvements of advanced component technologies for the Land Warrior (LW) system. The FXXI LW will demonstrate the improved individual and small unit operational effectiveness afforded by the modular integration of advanced components onto the Land Warrior platform. The FXXI LW program will also perform risk reduction efforts in support of the Land Warrior program to ensure timely fielding of the LW system. Technologies to be pursued include: lighter weight helmet materials and designs, modeling and simulation, wireless weapon and sensor interfaces, integrated sight, enhanced navigation, packet relay protocols for soldier radios, system voice control, combat ID functions, helmet mounted display upgrades, handheld color displays, head orientation sensor. In addition to these technologies, integration of 21st Century Land Warrior components onto the LW platform will also be accomplished for the EUT. By FY00 revolutionary upgrades to the LW system will also be performed. These technologies include electronically coupled indirect night vision, digital image processing, optimized computer architecture concepts, and interfaces to future infantry systems such as the Objective Individual Combat Weapon (OICW).

Supports: Land Warrior, PM-Soldier, U.S. Marine Corps, DARPA and SOCOM, Advanced Development: RJS1/63747/D603-Enhanced Land Warrior, Engineering Development: RJS1/64713/D667-Enhanced Land Warrior; DBS, EELS, BC Battle Labs.

STO Manager:	**TSO:**	**TRADOC POC:**
Patrick Snow	Bill Brower	Richard Wright
NRDEC	SARD-TT	TSM-Soldier
508-233-5436	697-8432	706-545-1020

III.I.06. Batteries for the Individual Soldier. Reduce the physical burden on the soldier, and reduce O&S costs by using lighter weight primary (30 percent more energy, 1996) and rechargeable (50 percent more energy, 1998) batteries. The deliverable will be achieved through a combination of new primary-battery chemistries (sulfuryl chloride or zinc-air), improved rechargeable-battery chemistries (nickel metal hydride or lithium-ion). The primary "pouch" batteries delivered in 1996 will be used in the FY96 21CLW Soldier System demo, and will be the pilot models of batteries required for the FY98 field demo.

Supports: CECOM, PEO-COMM, SORDAC, PM-SINCGARS, PM-SOLDIER, and NRDEC. 21st Century Land Warrior, Intelligent Mine Field, and Remote Entry ATDs, Dismounted Battlespace Battle Lab, CSS Battle Lab.

STO Manager:	**TSO:**	**TRADOC POC:**
Robert Hamlen	Carolyn Nash	Chris Kearns
CERDEC	SARD-TT	DBL
908-427-2084	697-8432	706-545-6391

III.I.07. Helmet Mounted Displays. Research, study, and analyze the device physics and operational performance parameters of new technological approaches and production methodologies for field emission displays (FED), active matrix electroluminescence (AMEL), and single crystal active matrix liquid crystal (XSiLCD) devices. This research is coordinated with and leverages DARPA-financed display programs. Research other display technologies such as deformable mirror devices (DMD) and miniature cathode ray tubes (CRT) and integrated display device technologies including phosphors, back lights, and driver electronics. Developmental solutions will be sought and evaluated for current head mounted display problems (e.g., limited resolution, cumbersome appliance structures, limited fields of view). Perform research to reduce power drain; increase luminance/ chromaticity/uniformity; improve high speed refresh rates; expand gray scale gradations; enhance contrast; eliminate viewing angle anomalies; expand operating temperature range parameters; reduce cost; and increase display life. Technology developments permit fabrication of chip size, 1000 line/inch, 1024 x 1280 pixel display devices (40 deg FOV). Measure, characterize, and evaluate these devices in both monochrome (FY95) and color (FY96). RDECS will use resulting data to develop head mounted displays for specific applications (e.g., dismounted soldier). Continue device physics research to support device developer's needs in their development of 2000 line/inch devices (60 deg FOV) by FY96. Demonstrate high efficiency, low power operation and optimal electrical interfaces to user systems by FY97.

Supports: NRDEC/CERDEC Force XXI Land Warrior (Vision Systems) and CERDEC High Resolution Display Systems (HRDS) Program.

STO Manager:	**TSO:**	**TRADOC POC:**
Robert Miller	Catherine Kominos	Chris Kearns
ARL-SED	SARD-TR	DBL
908-544-4144	697-3558	706-545-6391

III.I.08. Military Operations in Urban Terrain (MOUT). By the end of FY00, demonstrate a full spectrum, robust MOUT operational capability for small units that seamlessly integrates and aggregates the technologies of participating ATDs, TDs, and other technology developments in the areas of MOUT C4I, Survivability, Engagement, and Modeling & Simulation (M&S). Joint field exercises will be conducted with participation by dismounted soldiers, Special Operations Forces, and the Marine Corps. Demonstrations will include tactically realistic scenarios which will test individual and small unit performance in stressful MOUT environments to assess the operational interoperability of the MOUT system of systems. M&S will be used to facilitate mission planning and rehearsal, and augment quantification of performance enhancements. Minimum goals include: 50 percent increase in situational awareness at all levels and 20 percent increase in force survivability. Through FY01 and FY02, provide follow-on technical support to MOUT ACTD residuals. This STO is an integrated component of the MOUT ACTD.

Supports: Upgrades to Land Warrior

STO Manager:	**TSO:**	**TRADOC POC:**
Carol Fitzgerald	Bill Brower	Chris Kearns
NRDEC	SARD-TT	DBL
703-704-1427	697-8432	706-545-6391

III.I.09p. Future Warrior Technologies. By the end of FY05, demonstrate the integration of and supportability of technology insertions into the Land Warrior, Air Warrior, and Crew Warrior systems. The technology insertions will further enhance the various platforms in the areas of improved miniaturization, improved power management, improved C4I integration, low observables, improved mobility, and improved vision systems. Another focus of this demonstration will be the applicability of current technologies to various systems in order to reduce unit costs and increase producibility. The target goal of 20 percent reduction in unit production cost while providing the increased capabilities will be assessed during this demonstration. The concept of cost as an independent variable will be used to meet this objective. By the end of FY03, the highest payoff technologies will be validated through modeling and simulation and virtual prototyping. Early designs for the various warrior systems will be produced using virtual prototyping techniques. All systems will be designed for maximum commonality to reduce the overall logistics burden and unit costs. The program will exploit emerging commercial technology trends to ensure the final products, the upgraded warrior systems, are technologically superior to any potential adversary.

STO Manager:	**TSO:**	**TRADOC POC:**
Patrick Snow	Bill Brower	Chris Kearns
NRDEC	SARD-TT	DBL
508-233-5436	697-8432	706-545-6391

J. COMBAT HEALTH SUPPORT

III.J.01. Shigella Vaccines. By FY96, determine molecular features required for protective immunity against *Shigella* species. By FY97, select the best methodology for vaccine development. By FY97, transition to advanced development a candidate *Shigella sonnei* vaccine to protect 80 percent of immunized troops from dysentery caused by *S. sonnei.* By FY99, transition to advanced development a candidate *S. flexneri* vaccine to protect 80 percent of immunized troops from dysentery caused by *S. flexneri* in deployed forces worldwide.

Supports: Army Modernization Plan, Medical Annex O—Project, Sustain, and Protect the Force. The Medical Threat Facing a Force Projection Army (1994). Food and Drug Administration regulatory requirements.

STO Manager:	**TSO:**	**TRADOC POC:**
COL W. H. Bancroft	MAJ Mark Seymour	Herbert Russakoff
MRMC	SARD-TM	CSS Battle Lab
301-619-7567	703-695-5615	804-734-0599

III.J.02. Vaccines for the Prevention of Malaria. By FY96, transition to advanced development a candidate blood stage *Plasmodium falciparum* vaccine to reduce incidence of severe clinical malaria by 70 percent. By FY97, transition a vaccine to prevent *P. falciparum* infection in 70 percent of immunized troops. By FY98, transition to advanced development a candidate blood stage *Plasmodium vivax* vaccine to protect 70 percent of immunized troops from *vivax* malaria.

Supports: Army Modernization Plan, Medical Annex O—Project, Sustain, and Protect the Force. The Medical Threat Facing a Force Projection Army (1994). Food and Drug Administration regulatory requirements.

STO Manager:	**TSO:**	**TRADOC POC:**
COL W. H. Bancroft	MAJ Mark Seymour	Herbert Russakoff
MRMC	SARD-TM	CSS Battle Lab
301-619-7567	703-695-5615	804-734-0599

III.J.04. Antiparasitic Drug Program. By FY98, transition to advanced development antiparasitic drugs capable of preventing or treating malaria or leishmaniasis. Candidates include arteether (parenteral treatment of severe drug resistant malaria), FY96; topical paromomycin/gentamicin (cutaneous leishmaniasis treatment), FY96; Floxacrine analog (malaria treatment), FY98; atovoquone-proguanil (malaria prophylaxis), FY97; artemisinin analog (malaria prophylaxis), FY01.

Supports: Army Modernization Plan, Medical Annex O—Project, Sustain, and Protect the Force. The Medical Threat Facing a Force Projection Army (1994). Food and Drug Administration regulatory requirements.

STO Manager:	**TSO:**	**TRADOC POC:**
COL W. H. Bancroft	MAJ Mark Seymour	Herbert Russakoff
MRMC	SARD-TM	CSS Battle Lab
301-619-7567	703-695-5615	804-734-0599

III.J.05. Dengue Virus Vaccines. By FY97, select the best methodology for vaccine development. By FY99, transition to advanced development a candidate polyvalent dengue virus vaccine to protect 80 percent of immunized troops from dengue fever caused by dengue virus types 1, 2, 3, and 4.

Supports: Army Modernization Plan, Medical Annex O—Project, Sustain, and Protect the Force. The Medical Threat Facing a Force Projection Army (1994). Food and Drug Administration regulatory requirements.

STO Manager:	**TSO:**	**TRADOC POC:**
COL W. H. Bancroft	MAJ Mark Seymour	Herbert Russakoff
MRMC	SARD-TM	CSS Battle Lab
301-619-7567	703-695-5615	804-734-0599

III.J.07. Minimizing Blood Loss and Optimizing Fluid Resuscitation. Provide information and transition to development products to enhance capabilities for control of and resuscitation from hemorrhage. By FY96, complete evaluation of commercially available local hemostatic agents to assess potential for field use in controlling bleeding; determine whether nondevelopmental item investment strategy is appropriate or if additional research and development are needed. By FY96, transition to development a field intraosseous infusion device. By FY96, transition to development an improved thawed or fresh blood preservative. By FY97, transition to development a field-portable fluid infusion-warming device suitable for battlefield use. By FY98, define mechanisms of toxicity of blood substitutes and complete evaluation of status of commercial blood substitute development to define future research and development needs. By FY00, define optimum perfusion pressures for hemorrhaging individuals. By FY04, transition to development an improved platelet preservative or platelet substitute. By FY04, transition to development a second generation plasma substitute.

Supports: Army Modernization Plan, Medical Annex O—Project, Sustain, and Protect the Force—Far Forward Surgical Care. Products include an advanced resuscitation solution, oxygen-carrying blood substitute, advanced physiologic sensors, more wound dressings, advanced physiologic sensors, novel wound dressings, and intraosseous infusion device. Food and Drug Administration regulatory requirements.

STO Manager:	**TSO:**	**TRADOC POC:**
LTC D. Calcagni	MAJ Mark Seymour	Herbert Russakoff
MRMC	SARD-TM	CSS Battle Lab
301-619-7591	703-695-5615	804-734-0599

III.J.08. Treatments to Prevent Secondary Damage After Hemorrhage or Major Injuries. Transition to development or operational use the materiel and information required to reduce complications and death resulting from massive blood loss or major injuries, including measures to minimize irreversible damage during potentially prolonged evacuation. By FY96, transition a pharmacologic intervention capable of blocking the early steps in development of brain and/or spinal cord injury that occur secondarily to trauma, reducing irreversible damage by at least 20 percent. By FY98, transition a pharmacologic intervention that will reduce ischemia/reperfusion injury by 20 percent under conditions in which definitive treatment is delayed by up to 24 hours. By FY00, transition an intervention that will prevent or reduce by 35 percent trauma induced immunosuppression and related sepsis. By FY04, transition an intervention that interrupts the immunological and biochemical events leading to cell death and organ failure after hemorrhage or major trauma allowing a reduction in deaths by 20 percent under conditions where treatment is delayed by up to 24 hours. By FY04, transition an intervention for far-forward use which reduces the metabolic demands of casualties by 50 percent, providing protection against shock.

Supports: Army Modernization Plan, Medical Annex O—Project, Sustain, and Protect the Force—Far Forward Surgical Care. Products include a therapeutic antibody for the treatment of sepsis and a recombinant delta opioid (DADLE) for use in the delay or prevention of multiple organ failure. Food and Drug Administration regulatory requirements.

STO Manager:	**TSO:**	**TRADOC POC:**
LTC D. Calcagni	MAJ Mark Seymour	Herbert Russakoff
MRMC	SARD-TM	CSS Battle Lab
301-619-7591	703-695-5615	804-734-0599

III.J.14. Nutritional Strategies. Identify and demonstrate nutritional strategies to maintain health and enhance soldier performance. Assess efficacy of selected nutrients, food components, and feeding strategies in enhancing physical and mental performance and promoting nutritional health of soldiers during sustained and continuous operations at all climatic extremes. By FY95, determine efficacy of modified garrison dining facility menus and nutritional health and fitness education materials in promoting the consumption of a healthy diet. By FY97, complete animal and human laboratory studies of selected performance enhancing nutrients and food components (i.e., carbohydrate electrolyte beverages, glycerol, caffeine, tyrosine). By FY98, in collaboration with the Natick Research, Development and Engineering Center, conduct an initial field demonstration of performance enhancing ration components.

Supports: Guidelines for development of performance optimizing rations; Army Modernization Plan, Medical Annex O—Project, Sustain, and Protect the Force—prevent environmental injury and degradation of soldier performance; DoD Executive Agent for Nutrition.

STO Manager:	**TSO:**	**TRADOC POC:**
Dr. Fred Hegge	MAJ Mark Seymour	LTC Dunham
MRMC	SARD-TM	CSS Battle Lab
301-619-7301	703-695-5615	405-442-5647

III.J.18. Medical Countermeasures for Yersinia pestis. Develop medical countermeasures against the biological threat of *Yersinia pestis*, the causative agent of plague. By FY95, complete an assessment of the efficacy of the Cutter vaccine against an aerosol challenge of *Yersinia pestis*. By FY98, transition to development a vaccine that will protect 80 percent of immunized personnel against an aerosol challenge of *Yersinia pestis* and will induce minimum reactogenicity in soldiers when immunized.

Supports: Army Modernization Plan, Medical Annex O—Project, Sustain, and Protect the Force by Development of NBC Agent Preventive Measures. Provides for the exploration, demonstration, and validation of biological defense vaccines as outlined by the DEPSECDEF (26 Aug 91) and the Joint Requirements Oversight Council (31 Aug 92)

STO Manager:	**TSO:**	**TRADOC POC:**
Dr. Anna Johnson-Winegar	MAJ Mark Seymour	CPT Ensor
MRMC	SARD-TM	CSS-BL
301-619-7439	703-695-5615	706-545-5994

III.J.19. Medical Countermeasures for Encephalomyelitis Viruses. Develop medical countermeasures against the biological warfare threat of the encephalomyelitis viruses, a group of viruses that cause disorientation, convulsions, paralysis, and death. Vaccines will protect 80 percent of the immunized population against an aerosol exposure of the virus and will induce minimum reactogenicity in soldiers when immunized. By FY96, transition to development an improved vaccine effective against Venezuelan equine encephalomyelitis (VEE) virus stereotypes 1 A/B/C. By FY98, construct analogous vaccines for Eastern equine encephalomyelitis (EEE) and Western equine encephalomyelitis (WEE). By FY00, develop a multivalent VEE vaccine that includes serotypes 1E and III.

Supports: Army Modernization Plan Objectives, Medical Annex O—Project, Sustain, and Protect the Force by Development of NBC Agent Preventive Measures. Provides for the exploration, demonstration, and validation of biological defense vaccines as outlined by the DEPSECDEF (26 Aug 91) and the Joint Requirements Oversight Council (31 Aug 92).

STO Manager:	**TSO:**	**TRADOC POC:**
Dr. Anna Johnson-Winegar	MAJ Mark Seymour	CPT Ensor
MRMC	SARD-TM	CSS-BL
301-619-7439	703-695-5615	706-545-5994

III.J.20. Medical Countermeasures for Brucellosis. Develop medical countermeasures against the biological warfare threat of Brucella, the causative agent of brucellosis, a systemic bacterial disease characterized by fever, weakness, depression, and generalized aching. By FY97, demonstrate the feasibility of producing a vaccine against brucellosis using one species as the model approach (milestone 0). By FY99, transition to advanced development a vaccine that will protect 80 percent of immunized personnel against an aerosol challenge of any species of Brucella and will induce minimum reactogenicity in soldiers when immunized (milestone 1).

Supports: Army Modernization Plan, Medical Annex O—Protect, Sustain, and Protect the Force by Development of NBC Agent Preventive Measures. Provides for the exploration, demonstration, and validation of biological defense vaccines as outlined by the DEPSECDEF (26 Aug 91) and the Joint Requirements Oversight Council (31 Aug 92).

STO Manager:	**TSO:**	**TRADOC POC:**
Dr. Anna Johnson-Winegar	MAJ Mark Seymour	CPT Ensor
MRMC	SARD-TM	CSS-BL
301-619-7439	703-695-5615	706-545-5994

III.J.23. Medical Countermeasures for Ricin. Develop medical countermeasures against the biological warfare threat of ricin toxin. By FY97, conduct a Milestone 0 transition of a second generation vaccine. By FY99, transition to advanced development a second generation vaccine which will protect 90 percent of the immunized population against an aerosol challenge and will induce minimum reactogenicity in soldiers when immunized (Milestone 1).

Supports: Army Modernization Plan, Medical Annex O—Project, Sustain, and Protect the Force by Development of NBC Agent Preventive Measures. Provides for the exploration, demonstration, and validation of biological defense vaccines as outlined by the DEPSECDEF (26 Aug 91) and the Joint Requirements Oversight Council (31 Aug 92).

STO Manager:	**TSO:**	**TRADOC POC:**
Dr. Anna Johnson-Winegar	MAJ Mark Seymour	CPT Ensor
MRMC	SARD-TM	CSS-BL
301-619-7439	703-695-5615	706-545-5994

III.J.24. Medical Countermeasures for Staphylococcal Enterotoxin B (SEB). Develop medical countermeasures against the biological warfare threat of SEB toxin. By FY96, transition to advanced development a vaccine which will prevent 80 percent of the immunized animals from death against a lethal aerosol challenge of SEB (milestone 1 transition). By FY96, demonstrate the feasibility of producing a secondary generation vaccine which will protect 90 percent of the immunized animals against both a lethal and incapacitating aerosol challenge of SEB (Milestone 0 transition). By FY00, transition to advanced development the second generation vaccine (Milestone 1 transition).

Supports: Army Modernization Plan, Medical Annex O—Project, Sustain, and Protect the Force by Development of NBC Agent Preventive Measures. Provides for the exploration, demonstration, and validation of biological defense vaccines as outlined by the DEPSECDEF (26 Aug 91) and the Joint Requirements Oversight Council (31 Aug 92).

STO Manager:	**TSO:**	**TRADOC POC:**
Dr. Anna Johnson-Winegar	MAJ Mark Seymour	CPT Ensor
MRMC	SARD-TM	CSS-BL
301-619-7439	703-695-5615	706-545-5994

III.J.25. Medical Countermeasures for Botulinum Toxin. Develop medical countermeasures against the biological warfare threat of botulinum toxin. By FY97, transition to advanced development a recombinant vaccine that will protect 80 percent of immunized personnel against an aerosol challenge, provide protection against all serotypes, and induce minimum reactogenecity in immunized soldiers (milestone 1).

Supports: Army Modernization Plan, Medical Annex O—Project, Sustain, and Protect the Force by Development of NBC Agent Preventive Measures. Provides for the exploration, demonstration, and validation of biological defense vaccines as outlined by the DEPSECDEF (26 Aug 91) and the Joint Requirements Oversight Council (31 Aug 92).

STO Manager:	**TSO:**	**TRADOC POC:**
Dr. Anna Johnson-Winegar	MAJ Mark Seymour	CPT Ensor
MRMC	SARD-TM	CSS-BL
301-619-7439	703-695-5615	706-545-5994

III.J.26. Reactive Topical Skin Protectant/Decontaminant. By FY95, demonstrate proof-of-principle of the reactive topical skin protectant concept. By FY97, demonstrate efficacy of a reactive topical skin protectant. Demonstrate, by FY99, safety and efficacy sufficient for a Milestone O transition of a reactive component for a topical skin protectant that will provide protection against penetration and will detoxify both vesicant and nerve chemical warfare agents.

Supports: Development of Food and Drug Administration-licensed reactive skin protectant; Program Manager-Soldier; Draft MNS (11 Sep 92); Operational and Organizational Plans (Feb 95, Aug 85, Dec 86, May 87, Aug 90); Joint Service Agreement (14 Dec 93)—Project, Sustain, and Protect the Force by Development of NBC Agent Preventive Measures.

STO Manager:	**TSO:**	**TRADOC POC:**
LTC D. Moore	MAJ Mark Seymour	Charles Campbell
MRMC	SARD-TM	MBS BL
301-619-7201	703-695-5615	502-624-1963

III.J.27. Medical Countermeasures Against Vesicant Agents. By FY96, exploit pathophysiology database and new technologies for prophylaxis, pretreatment, and antidote strategies which will provide significant protection against vesicant injury. By FY97, demonstrate efficacy of a vesicant countermeasure. Demonstrate by FY00, safety and efficacy of a candidate medical countermeasure sufficient for a Milestone 0 transition.

Supports: Development of Food and Drug Administration-licensed protectants, pretreatments, and therapies for vesicant agents; Program Manager-Soldier; Operational and Organizational Plans (Mar 87); Draft MNS (11 Sep 92); Joint Service Agreement (14 Dec 93)—Project, Sustain, and Protect the Force by Development of NBC Agent Preventive Measures.

STO Manager:	**TSO:**	**TRADOC POC:**
LTC D. Moore	MAJ Mark Seymour	Charles Campbell
MRMC	SARD-TM	MBS BL
301-619-7201	703-695-5615	502-624-1963

III.J.29. Advanced Anticonvulsant. By FY97, demonstrate safety and efficacy sufficient for a Milestone 0 transition of an advanced anticonvulsant adjunct or component for the soldier/buddy-use nerve agent antidote. Advanced anticonvulsant will overcome deficiencies of current anticonvulsant, Convulsant Antidote for Nerve Agent (CANA); i.e., will be more effective in stopping ongoing convulsive seizures, preventing their recurrence, and protecting against nerve-agent-induced, seizure-related brain damage. It will also demonstrate less abuse potential than CANA. Achieve Milestone 1 transition by FY99.

Supports: Development of Food and Drug Administration-licensed anticonvulsant for nerve agent therapy; Program Manager-Soldier; Operational and Organizational Plans (Mar 87); Draft MNS (11 Sep 92); Joint Service Agreement (14 Dec 93)—Project, Sustain, and Protect the Force by Development of NBC Agent Preventive Measures.

STO Manager:	**TSO:**	**TRADOC POC:**
LTC D. Moore	MAJ Mark Seymour	Charles Campbell
MRMC	SARD-TM	MBS BL
301-619-7201	703-695-5615	502-624-1963

III.J.30. Chemical Agent Prophylaxes. By FY97, demonstrate the feasibility of a reactive/catalytic scavenger pretreatment effective against chemical agents. By FY99, demonstrate safety and efficacy sufficient for a Milestone 0 transition of a reactive/catalytic scavenger pretreatment which reduces chemical agent toxicity without operationally significant physiological or psychological side effects.

Supports: Development of Food and Drug Administration-licensed reactive/catalytic protectants for nerve agents; Program Manager-Soldier; Operational and Organizational Plans (Nov 86); Draft MNS (11 Sep 92); Joint Service Agreement (14 Dec 93)—Protect, Sustain, and Protect the Force by Development of NBC Agent Preventive Measures.

STO Manager:	**TSO:**	**TRADOC POC:**
LTC D. Moore	MAJ Mark Seymour	Charles Campbell
MRMC	SARD-TM	MBS BL
301-619-7201	703-695-5615	502-624-1963

III.J.31. Computer-Aided Diagnosis and Treatment. This concept seeks to integrate all of the various individual soldier medically-oriented advanced technology and route the data gathering, calculation, decision-making, and communication through the Soldier Individual Computer common to all 21st Century Land Warriors. The approach is to develop medical overlays to tactical computing/communicating capability already under development, in order to assess performance without injure, and to compare data post-injury to pre-injury ("control") data for individualized injure severity assessment. Research efforts will develop a variety of non-invasive vital sign sensor (most utilizing infrared or near infrared technology) to determine deep tissue microvascular blood flow, tissue oxygenation, lactate and CO2 build-up, and tissue pH. Additional efforts will develop interfaces and controllers between these sensors and the Soldier Individual Computer. Finally, R&D efforts will focus on the development of medical decision assist algorithms which will aid the combat medic in diagnosing and selecting appropriate treatments. Such algorithms will be capable of up-dating every minute, to provide assessment of treatment effectiveness or continued medical threat. By FY97, transition to advanced validation studies non-invasive vital sign sensors for combat trauma diagnostics and monitoring; by FY99 transition vital sign sensor interface to Soldier Individual Computer (21CLW); by FY00 transition medical decision assist algorithm.

Supports: Early Entry, Dismounted, Mounted, Battle Command, and Combat Service Support Battle Labs. Supports Army Modernization Plan objectives "Project and Sustain the Force."

STO Manager:	**TSO:**	**TRADOC POC:**
LTC D. Calcagni	MAJ Mark Seymour	Herbert Russakoff
MRMC	SARD-TM	CSS Battle Lab
301-619-7591	703-695-5615	804-734-0599

III.J.32. Biological Warfare Agent Confirmation Diagnostic Kit. Description: Develop the capability to confirm the initial field diagnosis obtained with the forward deployable diagnostic kit. These tests will differ from forward deployed tests by being more specific, more sensitive, and using independent biological markers. By FY98, transition to development confirmation techniques for all biological warfare (BW) agents in the theater of operations.

Supports: DEPSECDEF guidance (26 AUG 91); Joint Requirements Oversight Council guidance (31 AUG 92); Combat Service Support and Dismounted Battle Labs.

STO Manager:	**TSO:**	**TRADOC POC:**
Dr. Anna Johnson-Winegar	MAJ Mark Seymour	CPT Ensor
MRMC	SARD-TM	CSS-BL
301-619-7439	703-695-5615	706-545-5994

III.J.33. Filoviridae. Description: Filoviridae Objective: Develop medical countermeasures against the biological warfare (BW) threat of Filoviridae, which includes Marburg virus and Ebola virus. By FY01, transition to advanced development a bivalent vaccine effective against Marburg and Ebola viruses.

Supports: Army Modernization Plan Objectives, Medical Annex O—Project, Sustain, and Protect the force by Development of NBC Agent Preventive Measures. Provides for the exploration, demonstration, and validation of biological defense vaccines as outlined by the DEPSECDEF (26 Aug 91) and the Joint Requirements Oversight council (31 Aug 92).

STO Manager:	**TSO:**	**TRADOC POC:**
Dr. Anna Johnson-Winegar	MAJ Mark Seymour	CPT Ensor
MRMC	SARD-TM	CSS-BL
301-619-7439	703-695-5615	706-545-5994

III.J.34. Medical Countermeasures for Variola. Develop medical countermeasures against the biological warfare threat of variola, the causative agent of smallpox. By FY97, confirm the use of an animal model for the purpose of demonstrating the efficacy of the current licensed vaccine against aerosol-delivered variola. FY98, perform relevant preclinical testing of new cell culture-derived vaccinia vaccine directed towards variola. By FY99, develop rapid and highly specific diagnostic devices for clinical specimens. By FY00, explore the feasibility of using human monoclonal antibodies to replace vaccinia immune globulin (VIG). By FY01, screen and identify effective antiviral drugs for post-exposure treatment. Note: all of the studies conducted at USAMRIID will not utilize variola itself, instead the studies will employ the use of an appropriate orthopox virus substitute.

STO Manager:	**TSO:**	**TRADOC POC:**
Dr. Anna Johnson-Winegar	MAJ Mark Seymour	CPT Ensor
MRMC	SARD-TM	CSS-BL
301-619-7439	703-695-5615	706-545-5994

K. NUCLEAR, BIOLOGICAL, CHEMICAL (NBC)

III.K.03. Integrated Biodetection ATD. By FY97, demonstrate biological point detection of Bio Agents using technologies such as DNA Probes, electrospray mass spectrometry, planar waveguides, and flow cytometry with more stable reagents and simpler identification chemistry. These technologies will provide an order-of magnitude enhanced sensitivity to toxins and add a virus identification capability while providing significantly improved logistics, such as 10x faster response times, trainable algorithms, 5x size/weight reductions, and increased environmental operating range. Also, by FY98, demonstrate standoff biological agent detection and identification using technologies such as vibrational circular dichroism, Mueller matrix scattering, and the application of near-infrared and ultraviolet laser light scattering. By FY99, products will be demonstrated separately and as an integrated entry in future Battle Lab advanced warfighting experiments.

Supports: Joint Biological Point Detection System (JBPDS) and Joint Biological Standoff Detector System (JBSDS).

STO Manager:	**TSO:**	**TRADOC POC:**
Richard Smardzewski	Denise Pobedinsky	Robert Mosebar
ERDEC	SARD-TT	AMEDD C&S
410-671-1832	614-7298	

III.K.04. Millimeter Wave Screening. By FY98, demonstrate the capability of obscurant materials to block or defeat enemy RSTA assets in the millimeter wave region of the electromagnetic spectrum. Exit criteria will include defeat of actual or simulated threat radar, reduction of logistics burden via RAM improvements, and reduction of environmental impact due to degradability of the materials. By FY95, demonstrate a MMW screening material that degrades to non-harmful residues after completing its intended mission. By FY96, conduct modeling and simulations of MMW screening defeat mechanism of smart weapons.

Supports: This technology supports the Multispectral Expendable Obscurant Generating System and the XM56 MMW Module P3I.

STO Manager:	**TSO:**	**TRADOC POC:**
Jeff Hale	Denise Pobedinsky	Curt Gladden
ERDEC	SARD-TT	U.S. Army Chemical School
410-671-2607	614-7298	

III.K.05. Joint Service Chemical Miniature Agent Detector (JSCMAD). By FY98, demonstrate a small lightweight detector for chemical agents using technologies such as ion mobility spectrometry or surface acoustic wave sensors. By FY96, complete testing of initial breadboard systems. By FY97, deliver final detection system. This technology will allow the individual to be equipped with a lightweight chemical agent detector.

Supports: 21st Century Land Warrior and the GEN II Soldier ATD.

STO Manager:	**TSO:**	**TRADOC POC:**
D. G. Parekh	Denise Pobedinsky	Curt Gladden
	SARD-TT	U.S. Army Chemical School
410-671-5624	614-7298	

III.K.06p. Chemical/Biological (C/B) Protective Duty Uniform. By the end of FY00, demonstrate the concept of a lightweight C/B duty uniform, based on advanced selectively permeable membrane/fabric technology, which eliminates the need for an overgarment while providing equivalent protection. The C/B duty uniform will be launderable, 30 percent lighter in weight, and less bulky than the standard duty uniform/overgarment system (JSLIST) with equivalent durability. To reduce the logistics burden and costs, by the end of FY02, demonstrate the efficacy and durability of this novel C/B duty uniform.

STO Manager:	**TSO:**	**TRADOC POC:**
Eugene Wilusz	Bill Brower	Chris Kearns
NRDEC	SARD-TT	DBL
508-233-5486	697-8432	706-545-6391

L. AIR DEFENSE

III.L.01. Guidance Integrated Fuzing. The potential exists for the use of Guidance Integrated Fuzing to increase the probability of kill for missile and air defense systems. By FY97, collect non-far field target signatures from millimeter wave, monopulse instrumentation radar. Generate high fidelity target models to support highly accurate seeker-based fuzing simulations to validate robust fuzing algorithms. By FY99, demonstrate algorithms which can use guidance information from RF and Imaging IR seekers, autopilots, and/or auto pilot instruments to direct and fuze aimable warheads to maximize damage to ballistic missiles, cruise missiles, unmanned air vehicles, and aircraft targets. Guidance Integrated Fuzing could double missile system lethality and decrease costs over conventional fuzing configurations by 25 to 50 percent.

Supports: PEO-MD, PAC-3, CORPS SAM, and FAADS PM/STINGER.

STO Manager:	**TSO:**	**TRADOC POC:**
Donald E. Lovelace	Mike Rithmire	James Hendley
MICOM	SARD-TT	U.S. Army Air Defense Artillery School
205-876-8609	697-8434	915-568-7611

III.L.04. Electronic Integrated Sensor Suite for Air Defense. Demonstrate electronically integrated sensor suite to provide passive, automated volume search, target detection, tracking and identification, and low probability of intercept laser ranging of fixed wing, rotary, and cruise missile aircraft. Perform cost-benefit operations analysis of single detector/dewar focal plane, cooler, and electronics using standardized components (IRFPA/SADA) for IRST as a low cost, passive approach to air defense. Examine configuration alternatives and affordability improvements associated with the functional combination of IRST, FLIR imaging, and identification (over limited target class) technologies. By FY95, conduct static demonstration in an operational air defense environment at standoff ranges. By FY96, complete platform integration and collect data on-the-move for non-real time algorithm evaluation and sensor configuration studies. By FY97, perform limited non-real-time, assessment of on-the-move sensor and algorithm performance.

Supports: Bradley Stinger Fighting Vehicle-Enhanced, USMC LAV-AD, GBR, Masked Targeting.

STO Manager:	**TSO:**	**TRADOC POC:**
Ted Doepel	Carolyn Nash	James Hendley
CERDEC/NVESD	SARD-TT	U.S. Army Air Defense Artillery School
703-704-1216	697-8432	915-568-7611

III.L.05. 2.75-Inch Anti-Air Technology Demonstration. Develop and demonstrate adapting an imaging IR seeker for a small diameter missile airframe. By the end of FY97, conduct captive carry testing of form factored seekers with breadboard electronics. By the end of FY99, develop form factored electronics packages, conduct ground test, develop signal processing algorithms with IR Counter-countermeasures, and develop hardware-in-the-loop simulations.

Supports: EELS, Mounted and Dismounted Battlespace Battle Labs, GRAM and ATAM Project Offices.

STO Manager:	**TSO:**	**TRADOC POC:**
Ted Peacher	Mike Rithmire	Chris Kearns
MICOM	SARD-TT	DBL
205-876-3484	697-8432	706-545-6391

M. ENGINEER AND MINE WARFARE

III.M.03. Rapid Obstacle Creation, Reduction, and Planning. Provide the capability to effectively plan and execute engineer countermobility missions within the maneuver commander's decision window, while reducing troop requirements by 50 percent, time by 75 percent, and quantities of explosives (for selected mission) by 60 percent. By the end of FY95, develop techniques or methodologies of rapid obstacle creation immediately following last use by friendly forces. By the end of FY96, demonstrate the technologies required to enable combat engineers to rapidly create or reduce obstacles at bridges, bunkers, and in urban environments, reducing troop risk, troops required (2-4 vs 5-10) and deployment time (15-30 vs 30-120 minutes). By the end of FY97, provide a suite of software algorithms that accurately evaluates the effect of different engineer countermobility employment options for incorporation into Maneuver Control System.

Supports: Requirements from the U.S. Army Special Operations Command; PM OPTADS–ABCS, TECCS; and design criteria, material specifications, and technical guidance for the update cycle of FM 5-2-250 "Explosives and Demolitions," FM 5-34 "Engineer Field Data," FM 5-25 "Engineer Logistics and Field Data," FM 31-100 "Denial Operations and Barriers," and TM 43-0001-38 "Army Ammunition Data Sheets for Demolitions Materials."

STO Manager:	**TSO:**	**TRADOC POC:**
William Marcuson	Don Artis	Bill Adams
WES	SARD-TR	ATSE-CD
601-634-2234	697-3558	(573)563-4076

III.M.04. Field Fortifications. Develop technology required for expedient protective systems that will reduce manpower, material, and logistic requirements for survivability missions. By the end of FY95, develop protective measures that will increase the survivability of Brigade and Division size command centers without interfering with their mobility and operational requirements. By the end of FY97, develop a family of protective systems using advanced materials and design procedures that will increase the survivability of troops (in fighting positions), weapons systems, materials, and equipment.

Supports: Design criteria, materials specifications, and construction guidance for the criteria update cycle of FM 5-103 "Survivability," FM 5-34 "Engineer Field Data," "Field Fortifications," and TM 5-302 "Army Facilities Component System."

STO Manager:	**TSO:**	**TRADOC POC:**
W. Huff	Donald Artis	Bill Adams
WES	SARD-TR	ATSE-CD
601-634-2755	(703)697-3558	(573)563-4076

III.M.06. Vehicle-Terrain Interaction. Develop technologies required to provide accurate and reliable high-resolution mobility predictions, assessments, and representation to: the battlefield commander in the Army Command and Control System; the combat developer in Army models and simulations; and the materiel developer in synthetic environments for evaluation of vehicle designs and demonstrators. By the end of FY95, develop a stochastic mobility model with capabilities of quantifying the reliability of predictions and measures of risks. By the end of FY97, develop automated methods to rapidly derive, from standard available data, the high resolution input mobility factors required by mobility models. By the end of FY97, complete development of a theoretical model incorporating non-linear and hysteretic vehicle-terrain interactions. The model will be capable of analyzing the mobility performance of existing or proposed wheeled and tracked vehicles without requiring extensive collection of actual vehicle performance data.

Supports: PM OPTADS–TEM; PEO–IEW; PM CTIS; PM CSSCS; PM DAMMS-R; PM Grizzly DARPA Virtual Proving Ground; National Automotive Center.

STO Manager:	**TSO:**	**TRADOC POC:**
N.R. Murphy	Donald Artis	Bill Adams
USAEWES	SARD-TR	ATSE-CD
601-634-2477	(703)697-3558	(573)563-4076

III.M.07. Intelligent Minefield ATD. In FY96, initiate the integrated IMF ATD demo including advanced acoustic sensors and complete the ATD in FY97. ATD exit criteria is to communicate, command, and control WAM with a 50 percent increase in minefield performance. A control station will have the ability to interface with the Maneuver Command System (MCS) while controlling two minefields consisting of 20-40 WAMs from a range of 10 km. The advanced acoustic sensors will have a detection range of 2-3 km and an ability of tracking up to 7 target vehicles.

Supports: WAM P3I, RFPI ACTD, Mounted and EELS BLs

STO Manager:	**TSO:**	**TRADOC POC:**
Jamie Florence	John Appel	Charles Campbell
TARDEC	SARD-TT	MBS BL
(810)574-5473	697-8432	502-624-1963

III.M.08. Vehicular Mounted Mine Detector ATD. By FY98, demonstrate down and forward looking sensor technologies including ground penetrating radar and infrared for use on a vehicle mounted system to detect metallic and non-metallic AT mines. Detection performance improvement of 100 percent is expected when compared to the current metallic mine detector. Additionally, detection speed enhancements of up to 2500 percent (5 mph vs 0.2 mph). Stand-off detection distances of 30 to 75 feet, an automatic mine recognition/marking system, and teleoperation will be demonstrated.

Supports: Mounted Battlespace, Early Entry Lethality and Survivability, Combat Service Support, Dismounted Battlespace, Ground Stand-off Mine Detection System.

STO Manager:	**TSO:**	**TRADOC POC:**
Tom Broach	Carolyn Nash	Charles Campbell
CERDEC/NVESD	SARD-TT	MBS BL
703-704-1035	697-8432	502-624-1963

III.M.09. Mine Hunter/Killer (Proposed ATD). Mine Hunter Killer will demonstrate an integrated system concept for autonomous detection and destruction of mines at maneuver speeds. By FY96, demonstrate an infrared detection scheme on a combat vehicle and transition to Vehicle Mounted Mine Detector ATD. By FY97, test and evaluate explosive neutralization technologies and select baseline concept for Mine Hunter Killer demonstration. By FY98, complete design of explosive neutralizer. By FY99, complete enhancements to detection sensors and integrate these pieces into a single system for static testing. By FY00, integrate Mine Hunter Killer system onto a surrogate tactical platform and demonstrate the ability to both detect and kill mines at a standoff range. This integration can provide a 10 fold increase in neutralization range (5 meters to 50 meters) and a two fold increase in breaching speed (5 mph to 10 mph). This system will be capable of detecting unexploded ordnances (UXOs) as well as mines.

Supports: Joint Countermine ACTD, Hit Avoidance, FCS.

STO Manager:	TSO:	TRADOC POC:
Ricky Stanfield	Carolyn Nash	Charles Campbell
CERDEC/NVESD	SARD-TT	MBS BL
703-704-2452	697-8432	502-624-1963

III.M.10. Advanced Mine Detection Sensors. By FY97, evaluate enhancements to forward looking radar and integrate this technology into a single system for static testing against anti-tank and anti-personnel mines with a 98 percent probability of detection with a false alarm rate of < 0.2 per meter of forward progress. By FY98, demonstrate potential payoffs for increased standoff detection in all weather conditions using advanced FLIR and MMW radar. By FY99, investigate acoustic and seismic technologies as an additional means of enhancing the performance of ground based detection systems. BY FY00, demonstrate multi-sensor ability to detect mines remotely at speeds of 5-20 Km/hr. By FY01, integrate these technologies onto a surrogate ground-based platform and conduct advanced mine detection demonstration.

Supports: Early Entry Lethality and Survivability, Mounted and Dismounted Battlespace Battle Labs, Combat Service Support.

STO Manager:	**TSO:**	**TRADOC POC:**
Robert Barnard	Carolyn Nash	Charles Campbell
CERDEC/NVESD	SARD-TT	MBS BL
703-704-1066	697-8432	502-624-1963

III.M.11. Lightweight, Airborne Multi-Spectral Countermine Detection System. By FY98, explore innovative concepts and technology to support a lightweight airborne stand-off mine detection capability for limited area (point) detection, limited corridor route reconnaissance and detection of nuisance mines along roads. Investigate a variety of new component and focal plane array technologies such as 3-5um Staring FPAs, multi/hyperspectral, passive polarization, active sources, and electronic stabilization to support a lightweight, limited capability for future tactical UAVs. By FY99, complete study efforts and initiate critical component development. By FY00, complete development of sensors, mine detection algorithms, and processor modifications. By FY01, complete integration on a tactical UAV and conduct a demonstration of the system.

Supports: Mounted and Dismounted Battlespace.

STO Manager:	**TSO:**	**TRADOC POC:**
Robert Barnard	Carolyn Nash	Charles Campbell
CERDEC/NVESD	MBS BL	
703-704-1066	697-8432	502-624-1963

N. FIRE SUPPORT

III.N.05. Ultra-wide Bandwidth Radar. By FY97, develop and demonstrate the technology to detect and discriminate tactical targets concealed by foliage, using emulation of an airborne radar and algorithms to separate targets from clutter. The major thrust of this effort is to provide reliable and accurate targeting in support of deep fires. By FY97, this technology will be available to transition to CECOM.

Supports: CECOM/NVESD UWB proposed Tech Demo.

STO Manager:	**TSO:**	**TRADOC POC:**
Jeffrey Sichina	Catherine Kominos	MAJ Don Huntley
ARL-SED	SARD-TR	Depth and Simultaneous Attack
301-394-2530	697-3558	405-442-2927

III.N.11. Guided MLRS ATD. By the end of FY98, demonstrate a low cost guidance and control package for the MLRS rocket. At extended ranges, large quantities of baseline rockets are required to defeat the target. With the addition of a guidance system, an improved delivery accuracy will be achieved. The number of rockets required to defeat the target will be reduced to one-sixth the current quantity at maximum ranges. The goal of the program is to conduct test flights in FY97-FY98. Technologies that will be integrated include a low cost inertial measurement unit, GPS receivers and antennas, and a canard or ring thruster control package, all of which must be housed in the forward section of the MLRS rocket.

Supports: MLRS Family of Munitions and Rapid Force Projection Initiative (RFPI) ACTD, technology options for Joint Directed Attack Munition, Precision Strike–Korea.

STO Manager:	**TSO:**	**TRADOC POC:**
Alan Gamble	Mike Rithmire	LTC Dunham
MICOM	SARD-TM	CSS-BL
205-876-2511	697-8434	405-442-5647

III.N.14. Autonomous Intelligent Submunition (AIS). Develop and demonstrate an advanced low cost, sensor suite for smart submunition that provides large footprint (1.0 KM^2) and will be effective against moving ground targets. In FY96, fabricate/test real time algorithms/sensor. Develop advanced sensor suite for CFT for use in RFPI ACTD in FY97.

Supports: RFPI ACTD, SADARM P31, ER MLRS, Autonomous Intelligent Submunition (DARPA) MSTAR Candidate.

STO Manager:	**TSO:**	**TRADOC POC:**
Anthony Pezzano	John Appel	Charles Campbell
ARDEC	SARD-TT	MBS BL
201-724-4829	697-8432	502-624-1963

III.N.17. Ducted Rocket Engine. By FY98, develop and demonstrate a ducted rocket engine for a medium surface-to-air missile to significantly increase the intercept envelope against aircraft, cruise missiles, and tactical ballistic missiles when compared to surface-to-air missiles using current solid rocket propulsion technology. Component technology development will focus on the design and testing of a minimum signature, insensitive munitions compatible booster, supersonic air inlets, and a solid fuel gas generator which provides for high impulse, minimum signature ramburner operation. In FY96, complete Heavyweight integration and initiate Flightweight propulsion system development. In FY97, complete Flightweight development and conduct ground testing. In FY98, complete ground testing and data reduction.

Supports: Battle Command, Depth and Simultaneous Attack, and Early Entry Lethality, and Survivability Battle Labs.

STO Manager:	**TSO:**	**TRADOC POC:**
Michael Schexnayder	Mike Rithmire	LTC Dunham
MICOM	SARD-TM	CSS-BL
205-876-3483	697-8434	405-442-5647

III.N.18. Indirect Precision Fire (IPF) ATD. The IDF Program consists of two concepts: the Auto-Registration System (ARS), with a 140m CEP Accuracy goal at 35km; and the Self-Correcting System (SCS), with a 10m CEP accuracy goal at ranges up to 35 km. Design, fabrication, and testing of subsystems for ARS begin in FY96 for a system demonstration in FY98. Also, in FY96-98, continue critical component development for SCS to lay the foundation for a proposed four-year ATD, leveraging key Navy technology programs, to develop and demonstrate the STO technologies in a 9-inch, 3-volume, GPS/INS guidance, 2-dimensional control system with a fuzing capability. In FY01, conduct full-up-around ATD for SCS.

Supports: XM982 ERA, Depth & Sim Attack BL.

STO Manager:	**TSO:**	**TRADOC POC:**
R. Sicignano	John Appel	MAJ Don Huntley
ARDEC	SARDA-TT	Depth and Simultaneous Attack
201-724-3194	697-8432	405-442-2927

III.N.20p. Intelligent Ammunition Supply Point (IASP). In FY 01, demonstrate tasking of materials handling equipment to locate an ammo stack and connect into optical fiber cable teleoperation control grid. Demonstrate teleoperation control grid; evaluate technology options for high bandwidth connection between materials handling equipment and the teleoperated control grid; convert a tasking instruction, munitions stack location, and route into an instruction set for the machine to follow. In FY02, demonstrate software simulation of the IASP operations. Demonstrate layouts optimized for the operation and the man-machine interfaces necessary to operate multiple machines in a serially tasked environment. In FY03, demonstrate teleoperations of a single piece of materials handling equipment within the automated IASP environment. Demonstrate combined components of the program in a technology demonstration with inert ammo. In FY04, qualify the use of automated operations of teleoperated machines to handle live munitions. Provide the warfighting CINCs with the technologies to operate an automated ammunition supply area to increase munitions throughput, and reduce manpower using robotics and teleoperation.

SUPPORTS: CSS Battle Lab

STO Manager:	**TSO:**	**TRADOC POC:**
Gerald Goble	John Appel	MAJ Tim Raney
AMMOLOG Activity	SARD-TT	CASCOM
201-724-2021	697-8432	

O. LOGISTICS

III.O.01. Tactical Electric Power Generation. Demonstrate efficient man-portable power source technology operable on middle distillate fuel for tactically mobile use. These man-carry or man-handleable units will support implementation of the "one fuel forward" policy, in addition to eliminating the need to use MHE equipment for loading/unloading/ siting of low power generator sets. By FY95, demonstrate medium distillate fuel conditioning, ignition, and combustion enhancing technologies in modified lightweight spark ignition engines which are suitable for integration with high speed permanent magnet generators rated at 1 kW at 28 Vdc. By FY98, demonstrate a signature suppressed, multi-purpose engine generator set producing 3 kW at 120 Vac for 60 pounds (dry weight); GOAL: obtain an operational life expectancy of 1,000 hours for the engine by incorporating ceramic coatings and components.

Supports: Less than 3 kW Power Requirements for SOF, Combat Service Support (CSS), MARINE CORPS/NSA, JPO-UAV.

STO Manager:	**TSO:**	**TRADOC POC:**
Selma J. Nawrocki	Carolyn Nash	Herbert Russakoff
CERDEC/C2SID	SARD-TT	CSS Battle Lab
703-704-3377	697-8432	804-734-0599

III.O.02. Environmentally Compliant Protective Coatings. Develop and demonstrate chemical agent resistant coatings (CARC) and military coatings which conform to the Federal and State EPA regulations and have expanded spectral characteristics. By FY97, establish feasibility of saline and saturated aliphatic hydrocarbon chemistry to produce low observable coatings in the extended infrared region. All CARC coatings developed shall have equal or better agent resistance than current CARC.

Supports: All Combat Vehicles.

STO Manager:	**TSO:**	**TRADOC POC:**
Kes Chesonis	Catherine Kominos	Herbert Russakoff
ARL-WMR	SARD-TR	CSS Battle Lab
703-704-1982	697-3558	804-734-0599

III.O.04. Emerging Petroleum Quality Technologies. Demonstrate advanced technology petroleum quality assessment devices/systems to ensure quality petroleum products in support of airland operational doctrine. The field transportable petroleum testing equipment will use new technologies in design automation analytical compositional methods, computers, and software. The new petroleum testing equipment will provide rapid, on-the-spot (field) analysis of bulk petroleum products supplied from either CONUS or host nation support. By the end of FY97, demonstrate, transition, and integrate Fourier Transform Infrared spectroscopy (FTIR) and Gas Chromatography (GC) technologies with NIR to determine all fuel properties.

Supports: Replaces existing petroleum laboratories and test kits.

STO Manager:	**TSO:**	**TRADOC POC:**
Maurice LePera	John Appel	Herbert Russakoff
TARDEC	SARD-TT	CSS Battle Lab
703-704-1819	697-8432	804-734-0599

III.O.09. Lines of Communication (LOC)—Construction Materials and Methods. Provide the capability for rapid construction and repair of the in-theater transportation and facilities infrastructure to sustain a deployed force with limited engineer resources. By the end of FY95, develop methods for rapid stabilization of loose dry soils in arid regions to provide operating surfaces (paved or unpaved) for contingency military operations. By the end of FY97, provide the technologies required to reduce current equipment and materials to construct operating surfaces in soft soils and environments by 25 percent and construction time by 35 percent. By the end of FY98, develop models, methods, and technology required to construct and maintain operating surfaces in cold and transitional environments using limited material and equipment resources.

Supports: Design criteria, materials specifications, and construction guidance for the criteria update cycle of TM 5-430-001/2 "Planning and Design of Roads, Airfields, and Heliports in the Theater of Operations," and TM 5-402-001/2 "Army Facilities Component System."

STO Manager:	**TSO:**	**TRADOC POC:**
William Marcuson	Donald Artis	Bill Adams
WES	SARD-TR	ATSE-CD
601-634-2234	(703)697-3558	(573)563-4076

III.O.11. Total Distribution ATD. The success of the Log Anchor Desk (LAD) in satisfying the logistics user's needs for decision support software coupled with the advances made in the Common Operating Environment (COE) and in the architecture of the Command and Control (C2) System has resulted in a merger of the LAD efforts with the Total Distribution Advanced Technology Demonstration (TD ATD). The goal of the merger is to continue the development of the functionality of the LAD while integrating it with data sources as they develop and integrating it into the C2 System's architecture. This approach provides two products for the logistics community: (1) Technology transfers into the logistics command and control systems such as the Combat Service Support Control System (CSSCS) and the logistics component of the Army Global Command and Control System (AGCCS) as they are developing their capability packages. (2) An interim leave-behind workstation for the user that will enhance his "go-to-war" capability while it evolves from a stand alone system to a fully integrated capability in the C2 systems. The ATD will utilize the Prairie Warrior Exercises in FY95, 96, and 97 building up to Task Force XXI in FY97 to allow the operational user to further define requirements in order to increase the functional capabilities of the LAD. These will be integrated with the Capability Packages of the logistics portion of AGCCS and the software development of CSSCS. The logistics workstation will progress from a stand alone workstation (FY95) into a client-server based architecture of the C2 system (FY96) with a final goal of a complete integration into the legacy systems (AGCCS, CSSCS) (FY97). The Battle Lab at CASCOM has defined the Measures of Effectiveness in the areas of improving response time for planning and execution of logistics tasks, improving the synchronization of the closure of the warfighting force with the sustainment force to support the operational plan.

Supports: CSSCS, AGCCS, TAV.

STO Manager:	**TSO:**	**TRADOC POC:**
Kenneth Jensen	LTC Toney Mooney	Herbert Russakoff
CERDEC/C2SID	SARD-TS	CSS Battle Lab
908-532-6687	695-4261	804-734-0599

III.O.12. Food Stabilization in Environmental Extremes. By the end of FY96, determine the heat stability, acceptability, consumption, nutrient requirements, and nutritional bioavailability of rations distributed, stored, and used in high heat scenarios and demonstrate improved rapid assay techniques for measuring storage stability under various climatic conditions. By the end of FY97, demonstrate improved rations/consumption with a 15 to 20 percent increase in nutrient bioavailability of heat stressed rations to meet the increased nutritional needs of soldiers in high heat environments.

Supports: Joint Service Food Program, Advanced Development-RJS2/63747/D610-Food Adv. Dev, Engineering Development-RJS2/64713/D548-Military Subsistance Systems, Army Combat Rations 2000 (MNS).

STO Manager:	**TSO:**	**TRADOC POC:**
Gary Shults	Bill Brower	Herbert Russakoff
NRDEC	SARD-TT	CSS Battle Lab
508-233-4778	697-8432	804-734-0599

III.O.14p. 5kW Advanced Lightweight Portable Power System (ALPPS). Demonstrate an efficient, portable engine driven generator set operable on multiple fuels for tactically mobile use. The design shall be based on the integration of commercially available engines and state-of-the-art alternator and power electronic technologies. The goal is to enhance electrical generation, storage, and conditioning capabilities required to support TOCs, communication/weapons systems, and sensors of the 21st Century Battlefield. By FY01, demonstrate a signature suppressed, multi-fuel burning, electronically controlled/ conditioned generator set that is capable of producing 5000 Watts of continuous power at 60 Hz in all extreme, hostile environments. The target weight for this system is 350 pounds (dry weight). The basic design of this lightweight power system shall support implementation of and increase the Army's ability to achieve it's Power On the Move and Rapid Force Projection Initiatives.

Supports: 5 kW, 60 Hz Power Requirements for Signal Corps, Tactical Force Support, Battlefield Training Support

STO Manager:	**TSO:**	**TRADOC POC:**
Selma J. Nawrocki	Carolyn Nash	Herbert Russakoff
CERDEC/C2SID	SARD-TT	CSS Battle Lab
703-704-3377	697-8432	804-734-0599

III.O.15p. Silent Energy Source for Tactical Applications (SIESTA). Demonstrate silent, lightweight liquid fueled fuel cell power sources in the 50-150 watt range for various soldier applications. These power sources will offer lighter, more energetic power sources than are currently available and would extend mission time, reduce weight, and decrease the logistic burden associated with batteries. This effort is essential to leverage the efforts at DARPA, ARL, and JPL. By FY00, using the best available methanol/air Proton Exchange Membrane (PEM) Fuel Cell Technology demonstrate a fuel cell power source providing 2000 watt-hours per Kg of fuel. By FY02, using the best available liquid fueled PEM technology demonstrate a 150 watt/5000 watt-hour fuel cell power source weighing less than 5 Kg.

Supports: Power Requirements for DBBL, SOF, CSS, Marine Corps/NSA, Soldier System, Sensors, Battery Charging.

STO Manager:	**TSO:**	**TRADOC POC:**
Richard Jacobs	Carolyn Nash	Herbert Russakoff
CERDEC/C2&SID	SARD-TT	CSS Battle Lab
703-704-2637	697-8432	804-734-0599

P. TRAINING

III.P.02. Unit Training Strategies. By FY97, this program will demonstrate innovative training strategies which will provide practical guidance to unit commanders for effective use of training aids, devices, simulators, and simulations. In FY93, demonstrated a prototype performance assessment and training feedback system for the Close Combat Tactical Trainer (CCTT). In FY94, provided training strategies for Reserve Component (RC) units, including an Armor gunnery training program optimized for RC use. In FY95, conducted a front-end analysis of peacekeeping and operations other than war training requirements. In FY96, validate a training approach designed to use CCTT. In FY97, demonstrate prototype unit training strategies for training in digitized synthetic environments for the combined arms and light forces.

Supports: TRADOC: CAC & TSM CATT; STRICOM: PM CATT; USAREUR: 7ATC

STO Manager:	**TSO:**	**TRADOC POC:**
Stephen Goldberg	Michelle Sams	COL Robert Reddy
ARI	SARD-TR	
(407) 380-4690	703-614-7298	(804) 728-5726

III.P.03. Joint Training Readiness. By FY01, develop and demonstrate, in support of ground combat, new training and performance assessment methods that use synthetic distributed environments most effectively for Army, multi-Service, and Joint units. Included are metrics for how well forces communicate, coordinate, and synchronize resource and firepower. Leveraging other Service and OSD funding, methods will be developed for units to achieve training readiness in 30 percent less time, more precisely measure readiness, and show a 50 percent increase in the number of warfighting tasks performed effectively during exercises. Demonstrations will use the Fire Support mission (air, ground, sea, and C41). In FY97, provide distributed training methods for planning and executing the fire support mission from Brigade through Corps JTF. In FY99, develop and test methods for planning and conducting systematic, vertical (multi-site, multi-Service, multi-echelon) After-Action Reviews. In FY00, provide methods for linking performance of Brigade and above units to estimates of training effectiveness and readiness.

Supports: III CORPS; TRADOC; CAC; Joint Warfighting Center; OUSD(R)

STO Manager:	**TSO:**	**TRADOC POC:**
Robert Seidel	Michelle Sams	LTG Schwartz
ARI	SARD-TR	Cmdr, III Corps
(703) 617-8838	703-614-7298	(817) 287-2206

Q. SPACE

III.Q.02. Theater Laser Communications. Develop and demonstrate critical technologies required for a theater laser communications network. This activity will transition technologies developed under BMDO to tactical Army applications. Technologies will provide up to a 50x increase in throughput for communications links, at one-third the power and with low probability of intercept/jam. Potential applications include Airbourne reconnaissance missions (manned and unmanned aircraft and aerostatic vehicles) where large communications bandwidth is required at low volume, weight, and power. Other possible applications include helicopter-to-helicopter, helicopter-to-ground, and ground-to-ground communications from point to point. In FY96, conduct a study to determine the viability of using this laser communications technology for space-to-ground links. In FY97, demonstrate air-to-ground laser communications link using existing BMDO terminals. In FY98, demonstrate space-to-ground link using BMDO satellite platform. In FY99, integrate into Battle Command Battle Lab and Depth and Simultaneous Attack Battle Lab for evaluation and requirement generation.

Supports: Battle Command Battle Lab and Depth and Simultaneous Attack Battle Lab.

STO Manager:	**TSO:**	**TRADOC POC:**
George Edlin	Ron Norris	Tom Mims
USASSDC	SARD-TS	BC-BL
205-955-3802	703-695-1447	706-791-2800

III.Q.03. Laser Boresight Calibration. The laser calibrator will provide a known ground registration point for space-based sensors resulting in an improved impact area and launch point prediction for Theater Ballistic Missiles (TBM). It will reduce command and control time lines and improve the overall responsiveness of Joint Precision Strike and Theater Missile Defense forces. This capability will be integrated into the Joint Tactical Ground Station (JTAGS) P31. By FY97, demonstrate improved near real time determination of TBM launch point and trajectory parameters by using a compact, in-theater, tunable laser calibration system for space-based Defense Support Program satellite sensors. The improved line-of-sight target accuracy will result in higher quality missile warning, alerting, and cueing information. The theater ballistic missile search box to detect launch systems is significantly reduced. This capability will be extensively field tested with the theater warfighter in FY96-97 and will be transitioned to JTAGS P31 in FY98.

Supports: Joint Precision Strike ATD, Theater Missile Defense AWE, Depth and Simultaneous Attack Battlelab, Dismounted Battle Space Battlelab, Mounted Battlespace Battlelab, PM-JTAGS, PM-Army Tactical Missiles, CINCSPACE.

STO Manager:	**TSO:**	**TRADOC POC:**
George Edlin	Ron Norris	LTC Dunham
USASSDC	SARD-TS	CSS-BL
205-955-3802	703-695-1447	405-442-5647

III.Q.04. Battlefield Ordnance Awareness (BOA). Objective is to demonstrate a near real time ordnance reporting system using onboard processing with space sensors. This technology will provide near real time battlefield visualization of friendly and enemy ordnance fires and cruise missile launches. It addresses the need to target ordnance delivery for counterfire purposes, a major battlefield deficiency. While systems exist to locate and track vehicle traffic and radio frequency transmitters for intelligence preparation of the battlefield, no system currently exists that reports type, time, and sightings of either red or blue ordnance. The BOA capability will identify the ordnances by type and provide position information for counter fire opportunities, as well as Battle Damage Assessment, blue forces ordnance inventory, information for dispatch of logistical and medical support, and search and rescue. It also has the potential to type classify launch systems using the time domain intensity information in specific spectral bands. Advanced processor technology will be used with state-of-the-art staring focal plane arrays to provide critical information to battlefield commanders. By FY97, acquire ordnance data by type and develop algorithms for near real time processing. By FY98, demonstrate near real time ordnance reporting with the BOA space sensor/processor package from a fixed platform. In FY99, develop a space qualified BOA sensor package with state-of-the-art near real time, on board processing. Demonstrate airborne units in warfighting exercises by FY00. In FY01, complete space qualification and integrate into DoD Tri-Service Space Test Program Launch Vehicle. In FY02, demonstrate BOA capability from space platform and transition to the Defense Airborne Reconnaissance Office (DARO) and Army PEO-Field Artillery Systems.

Supports: USCENTCOM, USEUCOM, Depth and Simultaneous Attack Battle Lab, and PEO Field Artillery Systems.

STO Manager:	**TSO:**	**TRADOC POC:**
George Edlin	Ron Norris	CPT Aaron Walter
USASSDC	SARD-TS	DSA-BL
205-955-3802	703-695-1447	405-442-2935

SCIENCE AND TECHNOLOGY OBJECTIVES (STOs) FOR CHAPTER IV: TECHNOLOGY DEVELOPMENT

C. AEROSPACE PROPULSION AND POWER

IV.C.01. Integrated High Performance Turbine Engine Technology (IHPTET). Demonstrate, by FY94, a 25 percent reduction in specific fuel consumption (SFC) and 60 percent increase in power-to-weight ratio over current modern production engines via Joint Turbine Advanced Gas Generator–I (JTAGG-1) demonstration. By FY97, demonstrate improvements of 30 percent reduction in SFC and 80 percent increase in power-to-weight ratio via JTAGG-II demonstration. Develop for future demonstration gas turbine engine technology to effectively double the propulsion system capability for turboshaft engines through a 40 percent reduction of SFC and 120 percent increase in power-to-weight ratio. Demonstrate emerging technologies related to IHPTET goals in areas of structures, controls, aerodynamics, advanced materials, and accessories which provide reduced vulnerability and improved reliability and maintainability.

Supports: RAH-66 Comanche, AH-64 Apache Improvement, Joint Transport Rotorcraft (JTR), and system upgrades, EELS, D&SA, MBS, and CSS Battle Labs. Dual use potential.

STO Manager:	**TSO:**	**TRADOC POC:**
Hank Morrow	Drew Orlino	Charles Campbell
ATCOM/AATD	SARD-TT	MBS BL
804-878-4130	703-697-8434	502-624-1963

IV.C.03. Structural Crash Dynamics Modeling and Simulation. By FY98, develop modeling and simulation family of codes that can be used to optimize design for rotorcraft crashworthiness from system concept exploration/preliminary design stage through the air vehicle's life cycle. The effort will include accurate modeling of the performance of composite structures and energy absorption components such as landing gear, seat attenuators, and cockpit airbags during the dynamics of a crash. By FY99, the prediction codes will be demonstrated and validated through laboratory component and full-scale testing. These modeling and simulation tools will enhance the potential for credibly developing and demonstrating compliance of aircraft systems with required crashworthiness design criteria. Additionally, the modeling and simulation codes will also be used in assessing crash impact conditions for Class A mishaps of current fielded aircraft through damage assessment.

Supports: RAH-66 Comanche, Joint Transport Rotorcraft (JTR), System Upgrades, future advanced concepts, dual use potential, EELS, CSS, and MTD Battle Labs.

STO Manager:	**TSO:**	**TRADOC POC:**
Gene Birocco	Drew Orlino	Ted Hundley
ATCOM/AATD	SARD-TT	U.S. Army Aviation Center and School
804-878-3008	703-697-8434	334-255-2571

IV.C.04p. Integrated High Performance Turbine Engine Technology (IHPTET) Joint Turbine Advanced Gas Generator (JTAGG) Phase III. Complete in FY98 the IHPTET technologies affordability analysis and initiate the third phase of the Joint Turbine Advanced Gas Generator (JTAGG) program. By FY00, complete component testing of JTAGG III technologies. By FY03, effectively double the propulsion system capability through demonstration of a 40 percent reduction in specific fuel consumption and a 120 percent increase in SHP/wt. ratio. Emerging technologies critical to achievement of IHPTET goals in the areas of structures, controls, aerodynamics, advanced materials, and accessories are demonstrated to assure durability, reliability, and maintainability are built into the engine design, providing high levels of readiness and mission success.

Supports: Precision Strike, Advanced Land Combat, Technology for Affordability, RAH-66 Comanche, AH-64 Apache Improvement, NRTC, and system upgrades, EELS, D&SA, MBS, and CSS Battle Labs. Dual-use potential.

STO Manager:	**TSO:**	**TRADOC POC:**
Hank Morrow	Mike O'Connor	Ted Hundley
ATCOM/AATD	SARDA-TT	Avn Center (DCD) ATZQ-CD
804-878-4130 DSN 927-4130	703-697-8434 DSN 227-8434	334-255-3370/3489 DSN 558

D. AIR AND SPACE VEHICLES

There are no STOs for this section.

E. CHEMICAL, BIOLOGICAL DEFENSE (CBD) AND NUCLEAR

There are no STOs for this section.

F. INDIVIDUAL SURVIVABILITY AND SUSTAINABILITY

IV.F.01. Small Arms Protection for the Individual Combatant. Develop armor material system to minimize penalties associated with small arms protective body armor (e.g., excess weight, thickness, and cost; rigidity of materials; manufacturing methodology). By the end of FY96, determine viability of "flexible" ballistic protective vest for small arms protection. By the end of FY98, demonstrate advanced material system for protection against combined fragmentation and small arms threats (known ball threats up to and including 0.30 caliber), to be measured by a 20 to 30 percent reduction in areal density (weight for given area) over current small arms protection without significantly increasing other penalties.

Supports: Force XXI Land Warrior, Military Operations in Urban Terrain ACTD, Department of Justice, Advanced Development-RJS1/63747/D669-Clothing and Equipment, Engineering Development-RJS1/64713/DL40-Clothing and Equipment.

STO Manager:	TSO:	TRADOC POC:
Wesley Goodwin	Bill Brower	Chris Kearns
NRDEC	SARD-TT	DBL
508-233-4538	697-8432	706-545-6391

IV.F.02. Thermal Signature Reduction for the Individual Combatant. By the end of FY97, demonstrate textile materials that reduce the contrast between the soldier's thermal signature and the background by 30 percent, without significant degradation of the current level of visible or near-infrared camouflage protection. By the end of FY99, demonstrate combat uniform systems that reduce the soldier's thermal signature by 50 percent from background levels, providing multispectral camouflage protection to the Dismounted Land Warrior. The technical challenge entails integrating signature reducing materials/ technologies into a textile substrate while maintaining basic fabric characteristics (durability, flexibility, breathability, etc.) and other soldier's operational capabilities.

Supports: Force XXI Land Warrior, Military Operations in Urban Terrain ACTD, Advanced Development-RJS1/63747/D669-Clothing and Equipment, Engineering Development-RJS1/64713/DL40-Clothing and Equipment.

STO Manager:	TSO:	TRADOC POC:
Thomas Pease	Bill Brower	Chris Kearns
NRDC	SARD-TT	DBL
508-233-5546	697-8432	706-545-6391

IV.F.03. Agent Impermeable Membranes for Lightweight Chemical Protection. By the end of FY96, demonstrate the technical feasibility of eliminating/reducing carbon in the chemical protective ensemble through the use of advanced semipermeable membrane technology. The resulting advanced material system will be 20 percent lighter in weight than the standard FY96 battledress overgarment material system, allow selective permeation of moisture while preventing passage of common vesicant agent, provide protection against penetration by toxic agents in aerosolized form, and provide at least the current level of protection against other toxic vapors and liquids. By the end of FY98, demonstrate via Dismounted Battlespace Battle Lab (DBBL) warfighting experiment and JSLIST P^3I, the efficacy and durability of novel, lightweight chemical protective garments and clothing systems utilizing these agent impermeable membranes

Supports: Force XXI Land Warrior, Advanced Development-RJS1/63747/D669-Clothing and Equipment, Engineering Development-RJS1/64713/DL40-Clothing and Equipment.

STO Manager:	**TSO:**	**TRADOC POC:**
Eugene Wilusz	Bill Brower	CPT Ensor
NRDEC	SARD-TT	CSS-BL
508-233-5486	697-8432	706-545-5994

IV.F.05. Improved Water Purification. By the end of FY96, investigate emerging technologies such as aerogels, reverse osmosis membranes made from poly-imides (as opposed to poly-amide) and polyphosphazenes, and polyphosphazene coatings. Compare to other technologies such as mosaic membranes and polymeric microgels, and select those for further investigation. By the end of FY97, optimize the properties of the selected technologies to meet or exceed the performance of existing reverse osmosis membranes. Ultimately, the goal is to prove the feasibility of a new technology with a 300 percent increase in operating and storage life, a 50 percent increase in water flux, and tolerance to 5 ppm of chlorine, temperatures up to 165 degrees F, and pH from 5.0 to 9.5 when compared to conventional reverse osmosis membranes. The new technology will be applicable to military water treatment equipment ranging from individual purifiers to division and corps level units, and to municipal desalting plants. By the end of FY98, demonstrate an innovative water purification technology for providing drinking water to troops in the field.

Supports: Future and advanced water purification systems, and possibly wastewater treatment systems, commercial water treatment systems (dual-use, technology transfer), and Combat Service Support Battle Lab.

STO Manager:	**TSO:**	**TRADOC POC:**
Thomas Bagwell	John Appel	Herbert Russakoff
TARDEC	SARD-TT	CSS Battle Lab
703-704-3346	697-8432	804-734-0599

IV.F.06. Multifunctional Fabric System. The objective of this effort is to enhance the flame and thermal protection levels of combat uniforms without compromising other protective characteristics. The technical challenge entails the integration of low-cost flame/thermal protection into other multiple threat systems to include capabilities such as electrostatic, environmental, chemical, and signature reduction. Potential technologies for use in the system are polyphenolic material coatings, microencapsulation of flame suppressants, and electrospun fibers. By the end of FY99, demonstrate combined protection with an improved aramid fiber. By the end of FY01, demonstrate combined protection using non-aramid fibers resulting in a fabric system, with a 50 percent decrease in the cost of flame protection, that will provide an increase in overall soldier survivability.

Supports: Upgrades to Land Warrior, Air Warrior, and Mounted Warrior

STO Manager:	**TSO:**	**TRADOC POC:**
Thomas Pease	Bill Brower	Chris Kearns
NRDEC	SARD-TT	DBL
508-233-5546	697-8432	706-545-6391

IV.F.07. Biomimetic Materials for Soldier Protection. By the end of FY98, demonstrate a tenfold increase in expression level of spider-silk-like polymer (100 mg/liter as compared to current 10 mg/liter levels). At that time a production partner from industry will have been engaged and a data base of the ballistic protective performance of silk yarns and fibers will have been established. By the end of FY99, incorporate second generation spider silk based fibers with improved ballistic protective properties and producibility into fabrics providing a 20 percent reduction in weight in comparison with present materials of equal ballistic strength. The significant technical barriers include expression of the proteins at high levels and defining the proper genetic modifications to simultaneously improve mechanical properties and processability.

Supports: Joint service program with the Air Force, Wright Patterson AFB; Ballistic Protective Armor and Equipment

STO Manager:	TSO:	TRADOC POC:
Jean Mayer	Bill Brower	Chris Kearns
NRDEC	SARD-TT	DBL
508-233-4405	697-8432	706-545-6391

IV.F.08. Advanced Parachute and Soft Landing Technologies. By the end of FY97, demonstrate a parachute with a novel design that achieves a 20 percent reduction in weight, bulk, and manufacturing costs (compared to fielded parachutes) and provides equivalent flight performance. By the end of FY98, demonstrate a parachute retraction system using clustered parachutes that provides a less than 10 ft/sec soft landing capability. By the end of FY00, demonstrate a less than 10 G (gravitational force) soft landing airbag system that provides an all weather, rapid roll-on/roll-off airdrop capability for the future Army.

Supports: Advanced Development - RA02/63804/D266 - Airdrop; Engineering Development - RA02/64804/D279 - Airdrop

STO Manager:	**TSO:**	**TRADOC POC:**
Calvin Lee	Bill Brower	Ken Foley
NRDEC	SARD-TT	Early Entry Battle Lab
508-233-4267	697-8432	804-727-5854

IV.F.09p. Ballistic Protection for Improved Individual Survivability. Develop and insert advances in materials technology that will increase the protection and performance of armor systems for the individual warfighter. Specifically, by the end of FY99, integrate and transition improved technologies for the current Small Arms Protection STO (IV.F.1) or best available technology (sources could include DARPA, Army, Navy, Industry) to development and/or as technology insertions to modify existing individual protective systems. By the end of FY00, demonstrate/insert protective materials technology that will provide a reduction in casualties at 35 percent less system weight of 1996 individual countermine protective systems. By the end of FY03, demonstrate an improved material system prototype (over FY99 insertions) for second generation multiple ballistic threat protection (with either 10 percent decrease in weight, 10 percent increase in protection or a combination, depending on user input). Technologies with potential to satisfy this STO(p) will include advances in polymeric materials through modification of existing fibers (copolymerization of aramid, PBO), bioengineered protein-based fibers, and the synthesis of new polymers. Improved rigid materials are anticipated through DARPA, ARL, and SBIR programs. These could include low cost, high performance boron carbide, new metal alloys, metal matrix composites, and potentially other new ceramics/composites.

STO Manager:	**TSO:**	**TRADOC POC:**
Wesley Goodwin	Bill Brower	Chris Kearns
NRDEC	SARD-TT	DBL
508-233-4538	697-8432	706-545-6391

G. COMMAND, CONTROL, AND COMMUNICATIONS

IV.G.01. Integrated Photonic Subsystems. Integrated Photonic subsystems will be developed by FY97 for application to optical control of single beam phased array antennas and fiber optic point-to-point links, local area networks, and antenna remoting systems. By FY99, subsystems will be developed for optical control of multi-beam phased array antennas. These sub-systems will reduce size, cost, and power consumption while increasing the performance of high speed fiber optic systems. Fiber optic phased array control systems, which can be scalable to any desired frequency, will enable communications on-the-move by utilizing multiple beams with acquisition and tracking capability. Demonstration of the photonically controlled single panel phased array antenna will be conducted during FY99. Demonstration of a photonically controlled multi-panel phased array antenna will be conducted during FY00.

Supports: Local Area Communications, Satellite Communications, Radio Access Point Antenna.

STO Manager:	**TSO:**	**TRADOC POC:**
Louis Coryell	Carolyn Nash	Tom Mims
CERDEC/S&TCD	SARD-TT	BC-BL
908-427-3640	697-8432	706-791-2800

IV.G.02. Protocol Specifications for Digital Communications on the Battlefield. Through research in executable protocol specifications, create methods for implementing specifications in the IEEE/ANSI/DOD/FIPS approved hardware description language known as VHSIC Hardware Description Language (VHDL). Research and test various narrow band (e.g., Mobile Subscriber Equipment) and broadband ISDN [e.g., Asynchronous Transfer Mode (ATM)] switches. The implementation will be an unambiguous, validatable, and simulation capable description of the interface which can be tested as software. Once described in the hardware description language, the specification can be used to automatically generate hardware using commercially available CAD tools. The resulting hardware is guaranteed to comply with the original specifications because it was derived from the description language. The procedure will be verified using existing military and commercial standards. By FY95, complete a model to describe the All Digital Tactical-to-Strategic Gateway, MIL-STD-188-105. By FY96, further demonstrate the hardware description model by testing the newly emerging ATM standard in conjunction with DISA. By FY97, demonstrate the capability of VHDL to generate hardware by creating hardware implementation. By FY98, demonstrate interoperability of dissimilar COTS/GOTS ATM equipment on the battlefield.

Supports: CAC2 ATD, Digitization of the Battlefield.

STO Manager:	**TSO:**	**TRADOC POC:**
John Gowens	Catherine Kominos	Tom Mims
ARL-IST	SARD-TR	BC-BL
404-894-3136	697-3558	706-791-2800

IV.G.03. Information Warfare On-The-Move. The objective is to evaluate through simulations and laboratory demonstrations substantial advances to conduct information warfare operations on-the-move. The STO concentrates on three key technology areas: (1) Phased Array HF Antenna with shortened overall physical parameters of height and separation to allow Direction Finding from one platform, and (2) Information Processing on-the-move; receiving, correlating, and transmitting information while on-the-move, (3) Terrain and Tactical software. In FY95, the Antenna effort concentrated on shortening the antenna height using HTSC Technology to support OTM Jamming. Terrain and feature servers were developed and software functionality demonstrated. Motion sickness and advanced status display experiments were completed. In FY96, the information Warfare Critical Electronic Warfare components and HF Antenna technology will be developed and laboratory tested to show the concept of shortened physical baseline for Direction Finding. Terrain and Environmental Reasoning database and TER/TEDS laboratory breadboard will be demonstrated. Studies will be performed for C2V degradation of performance when on the move. Advanced visualization concepts are also being studied. In FY97, the TER/TEDS will be enhanced, the design documented, and metrics for evaluating the TER and TEDS technologies will be developed. Additional OTM adaptive interface-crew performance studies will be performed.

Supports: Rapid Battlefield Visualization ACTD, JSTARS, PM C2V, PEO C3S, CAC2, LAD ACTD, BV ATD, and Digitize the Battlefield.

STO Manager:	**TSO:**	**TRADOC POC:**
Robert Foresta	Carolyn Nash	Tom Mims
CERDEC/IEWD	SARD-TT	BC-BL
908-427-5503	697-8432	706-791-2800

IV.G.04. Personal Navigation and Reporting. Integrate state-of-the-art digital compass and altimeters with the latest technologies of hand held computers, miniaturized displays, digital terrain data, and miniaturized GPS receivers to offer, for the first time, worldwide, all-weather, all-terrain personal navigation and reporting which is not susceptible to jamming. This integration of technologies will enable an individual, dismounted soldier to lay out routes for advance, input these routes into the personal POS/NAV device, and then follow this route to his objective, independent of terrain, weather, seeing conditions, etc. The product of this work will be a prototype of a navigation and reporting device capable of being integrated with the soldier computer which will drive the helmet-mounted heads-up display. Field demonstration will occur in late FY96 and FY97.

Supports: 21st Century Land Warrior, PM Soldier.

STO Manager:	**TSO:**	**TRADOC POC:**
Richard Marth	Donald Artis	MAJ Harold Webb
TEC	SARD-TR	DBS-BL
703-428-2799	(703)697-3558	706-545-7000

IV.G.05. Networking and Protocols. Program will integrate and evaluate emerging commercial high speed network technology and protocols (e.g., Sonet, ATM) for performance and for achieving seamless communications with tactical and commercial systems. Commercial network management products will be analyzed and enhanced to ensure compatibility with military-specific requirements and Army legacy communications systems. Will participate in various commercial/academic forums to influence emerging protocols/products for dual use capabilities. Tactical multinet gateways will be evolved by modification and enhancement of commercial-off-the-shelf (COTS) router products to allow ATM and non-ATM based networks to communicate. Hierarchical video routing to allow the network to automatically route a limited picture of the battlefield (i.e., still frame, slow scan) to users with limited bandwidth while at the same time allowing users with higher available bandwidth to receive a higher class of service (i.e., real-time video). Long term focus will address dynamic and fault tolerant protocol functionality to provide enhanced network survivability and greater capability for communication on the move. Dynamic network reconfiguration without user intervention will be demonstrated. By FY96, establish prototype broadcast ATM capability and monitoring and control functions for mobile networks. By FY97, demonstrate hierarchical video routing between ATM and IP multicast networks and integrate broadcast protocol with the radio access point. By FY98, demonstrate protocol enhancements for large networks, across services, and across media. For FY00, demonstrate dynamic network survivability through protocol adaptation to external environment (e.g., weather, threat, network congestion) and evolve protocols to accommodate next-generation communications architecture.

Supports: Winning the Information War, Digitizing the Battlefield, Battlespace Command and Control, Digital Battlefield Communications, JTF Communications Planning and Management System (JCPMS), ISYSCON.

STO Manager:	**TSO:**	**TRADOC POC:**
John Strange	Carolyn Nash	Tom Mims
CERDEC/S&TCD	SARD-TT	BC-BL
908-427-2873	697-8432	706-791-2800

IV.G.06. Battle Planning (BP). The Battle Planning effort will develop, integrate, and demonstrate emerging technologies to significantly enhance battlespace visualization and enable collaborative planning, rehearsal, execution, and monitoring (including real-time intelligence/operations) on the digital battlefield. The focus is on the commander's interface to the battlespace and the embedded software "tools" which will allow the commander and his staff to collaborate electronically in a rapid and effective manner. This STO is leveraging basic research being performed at Army Research Laboratories (ARL) in the area of real time three-dimensional (3D) graphical representations, and advanced techniques for image utilization and management (to include zoom in/out, perspective from any viewpoint, and overlays of actual imagery, modeled objects, or symbols). Expert systems and natural speech recognition algorithms will aid the commander and staff in rapidly generating and evaluating courses of action. These integrated capabilities will enable the commander to quickly grasp the situation and react to the dynamically changing battlespace. By FY97, demonstrate real-time collaborative planning between the commander and his intelligence and operations staff elements. By FY98, demonstrate capability to perform planning and real time rehearsal, demonstrate speaker independent, continuous speech recognition, and exploit direct broadcast (DBS) imagery and terrain data distribution. By FY00, demonstrate a fully integrated capability to allow the commander and staff to perform "end-to-end" collaboration to include: split-based operations, course of action evaluation aids, "hands-off" user interface using "natural language" speech input, and real-time 3D depiction of the battlefield.

Supports: Battle Command and Mounted Battlespace Battle Labs, Force XXI and follow-on Division and Corps AWEs, XVIII Airborne Corps AWEs, Battlespace Command and Control ATD, Rapid Battlefield Visualization ACTD, Consistent Battlespace Understanding (IST DTO 12), Forecasting, Planning and Resource Allocation (IST DTO 13), and Integrated Force Management (IST DTO 14).

STO Manager:	**TSO:**	**TRADOC POC:**
Hal Gorman	Carolyn Nash	(TBD)
CERDEC/C2&SID	SARD-TT	
908-427-4603	697-8432	

IV.G.07. Antennas for Communications Across the Spectrum. The objective of this STO is to develop, leverage, and apply emerging antenna technology to reduce the number of antennas, reduce the visual signature (conformal), reduce the cosite and control problems, and increase efficiencies and radiation patterns in the ranges of 2MHz to 2GHz. A second goal is to provide On-The-Move (OTM) SATCOM antenna capabilities in the Triband (C, X, Ku) and EHF bands. Five different technologies will be explored to address different applications. For SPEAKeasy applications, wideband technology will be exploited. For air and ground vehicles, Structurally Embedded Reconfigurable Antenna Technology (SERAT) and structure tuned antenna techniques will be used. SHF and EHF low profile, self steering, On-The-Move (OTM) antenna technology will be applied to the SATCOM applications. The initial thrust will be to address the broadband requirements for SPEAKeasy. Following this, the effort will be expanded to pursue the remaining efforts concurrently. By FY98, a wideband SPEAKeasy antenna will be demonstrated. A UHF Conformal antenna (SERAT) will also be demonstrated in FY98 on a Blackhawk, followed by a demonstration on a selected ground platform in FY99. A structured tuned VHF antenna will be fabricated and demonstrated in FY99 on a ground vehicle. A Triband (C, X, Ku) OTM self steering SATCOM antenna capability will be demonstrated in FY00. In FY01, an OTM self-steering EHF SATCOM antenna capability will be demonstrated.

Supports: SPEAKeasy, Future Digital Radio, Tactical Airborne and Ground Vehicles, Direct Broadcast Satellite, DSCS, and MILSTAR.

STO Manager:	**TSO:**	**TRADOC POC:**
Joe Onufer	Carolyn Nash	Tom Mims
CERDEC/S&TCD	SARD-TT	BC-BL
908-532-0462	697-8432	706-791-2800

IV.G.08. Advanced Command, Control, and Communications (C3) Modeling and Simulation. Objective is to provide modeling and simulation (M&S) tools that accurately represent dissemination, processing, and transmission of information generated and collected on the battlefield. Approach includes developing systems performance models (SPMs) to support the introduction of emerging high-speed information transport technologies, including Near-Term Digital Radio (NTDR), asynchronous transfer mode (ATM) switching, personal communications systems (PCS), High-Capacity Trunk Radio (HCTR), and Radio Access Point (RAP); developing distributed interactive simulations focused on supporting the development of integrated, survivable, and adaptive information networks; and adopting the High Level Architecture (HLA) to develop a Common Modeling Environment (CME) capable of supporting all M&S domains. By FY98, provide integrated division/corps SPM, which includes all Battlefield Information Transmission System (BITS) elements. By FY99, provide virtual communications systems models that support man-in-the-loop evaluation and training for Force XXI. By FY00, transition existing virtual and systems performance models to CME to facilitate model enhancements for BITS acquisition/fielding and to realize cost/benefit ratio improvements in use of M&S. By FY01, complete transition to CME and demonstrate next-generation tools for initialization, management, and data reduction that will reduce time required to setup, execute, and analyze results of simulations and user-interface technology that supports use by the Warfighter for mission planning/training. S&TCD Funded, C2SID Executed.

Supports: Digital Battlefield Communications (DBC) and Battlespace Command and Control (BC2) Advanced Technology Demonstration (ATD) programs and Battlefield Information Transmission System (BITS).

STO Manager:	**TSO:**	**TRADOC POC:**
Chandu Sheth	Carolyn Nash	Tom Mims
CERDEC/C2SID	SARD-TT	BC-BL
(908) 427-3588	697-8432	706-791-2800

IV.G.09. Personal Communications System for the Soldier. The objective of this STO is to develop the next generation Land Warrior Radio Technology by adapting commercial cellular PCS (CDMA and W-CDMA) technology to support the needs of the dismounted soldier. A second goal is to satisfy the Joint Service requirements for dismounted WARFIGHTER communications. This technology offers significant advantages in Multipath performance (MOUT application) and Anti Jam/Low Probability of Detection protection. This effort also eliminates the fixed cellular infrastructure on which the other PCS initiatives are based. This STO will build on technical and operational experience acquired with CDMA and W-CDMA technology in various frequency bands acquired during our activities in support of the DARPA's Commercial Communications Technology Testbed (C2T2) and CECOM's C2TL programs. This STO will develop peer-to-peer and multihop packet relaying protocols on an attached handheld computer, leading to a demonstration of a non-cellular PCS handset exploiting commercial chipsets and ASICS used in CDMA and W-CDMA systems. In FY97, the RF multipath environment for dismounted soldiers moving in urban terrain and other constrained terrain will be characterized. By FY98, a plug-and-play host computer interface will be defined to enable protocol development on an attached handheld computer. In FY00, peer-to-peer and multihop packet relaying will be demonstrated with commercial CDMA and W-CDMA handsets modified for use without cellular base stations. In FY00, FORTEZZA COMSEC developed under the CONDOR program will be used to demonstrate Small Unit Operations for the DARPA SUO program and MOUT ACTD. The final year's demo in FY01 will demonstrate a technology upgrade for the Land Warrior soldier platform. Benefits of CDMA and W-CDMA technology for tactical applications will be evaluated and demonstrated throughout the program.

Supports: Military Operations in Urban Terrain (MOUT), DARPA Small Unit Operation, Land Warrior Soldier Program, USMC Urban Warrior.

STO Manager:	**TSO:**	**TRADOC POC:**
Joseph Staba	Carolyn Nash	MAJ Kevin Hackney
CERDEC/S&TCD	SARD-TT	DBBL
908-427-3988	697-8432	706-545-5207

H. COMPUTING AND SOFTWARE

IV.H.01. Rapid Prototyping for a System Evolution Record. The objective of this STO is to develop a System Evolution Record (SER), using the Computer-Aided Prototyping System (CAPS) Rapid Prototyping Environment, which will provide a "cradle to grave" repository for all artifacts and information produced during software evolution. The SER will be modeled using CAPS, then each part of the software development process will be modeled in the same way to allow integration over the SER. In FY96, the modeling of the System Evolution Record will be completed, and the first attempts will be made to integrate the Evolvable Legacy Systems process developed at the MICOM Life Cycle Software Engineering Center (LCSEC). In FY97, the Cleanroom Software Engineering Process from the TACOM-Picatinny LCSEC will be integrated into the SER, and graphical analysis techniques will be analyzed to accelerate air worthiness reviews of flight control software. In FY98, a Requirements Validation tool being developed at ATCOM's LCSEC will be integrated into the SER. In FY99, the Domain Analysis and Software Reuse process develop at CECOM's LCSEC will be integrated into the SER. This project will improve the way we evolve Army software systems, providing the commander with the enhanced ability to see, hear, know, communicate, kill the enemy, and protect his/her own soldiers.

Supports: AMC Life Cycle Software Engineering Centers (ATCOM, MICOM, CECOM, TACOM, and VASTC ATD), DISC 4, Battle Command Battle Lab, CSS Battle Lab, DSA Battle Lab.

STO Manager:	**TSO:**	**TRADOC POC:**
MAJ David A. Dampier	Catherine Kominos	Tom Mims
ARL-IST	SARD-TR	BCBL (Ft. Gordon)
404-894-1809	697-3558	706-791-2800

IV.H.02. Software Infrastructure Technology. To provide support for evolutionary prototyping of real-time systems that increases productivity, decreases cost, and minimizes defect insertion and post development software support (PDSS). The technology has the potential to reduce PDSS costs of Army systems by 5 percent. FY95—Implement a testbed that incorporates a rapid prototyping environment developed by the Naval Post-graduate School. Test and evaluate the ability of this environment to generate correct Ada code from high-level specifications for several actual real-time control models. FY96—Transition these tools to the Life Cycle Software Engineering Centers (LCSEC) at RDECs; in the testbed, incorporate and demonstrate automated selection of reusable modules from a small reuse repository; demonstrate and evaluate the use of graphical representation of code and specifications during product analysis and assessment. FY97—Complete and test a process model and implement a testbed for groupware support of collaborative software development. This testbed will incorporate automated support for formal inspection of software products (requirements, design, code, test plans, documentation) as well as quality and process metrics.

Supports: AMC Life Cycle Software Engineering Centers (ATCOM, MICOM, CECOM, and AMCCOM), ISC Software Development Center.

STO Manager:	**TSO:**	**TRADOC POC:**
Glenn Racine	Catherine Kominos	Tom Mims
ARL-IST	SARD-TR	BC-BL
404-894-3110	697-3558	706-791-2800

I. CONVENTIONAL WEAPONS

IV.I.01. Anti-Armor Materials. Demonstrate anti-armor terminal ballistic performance from tungsten material equivalent to that of depleted uranium (DU). FY96, identify the components of the tungsten material that will achieve enhanced ballistic performance. Demonstrate performance of tungsten penetrators by subcaliber ballistic testing in FY97.

Supports: Cannon Caliber Ammo, XM919, KE Tank Ammo, Mounted Battlespace BL.

STO Manager:	**TSO:**	**TRADOC POC:**
K. Willison	John Appel	Charles Campbell
ARDEC	SARD-TT	MBS BL
201-734-3932	697-8432	502-624-1963

IV.I.03. Insensitive Munitions (IM) Minimum Smoke Propellants. Develop propulsion systems comprised of energetic materials and inert components for current and future Army tactical missile systems that meet the policy of the Joint Services Requirement for Insensitive Munitions (JSRIM). By the end of FY96, load IM motor cases with minimum signature solid propellant and complete IM testing. By FY97, identify MS formulations with survivable inert case concepts. By FY99, demonstrate the integration of an MS propellant and response-mitigating inert components in a tactical scale motor.

Supports: Mounted Battlespace Battle Lab, Dismounted Battlespace Battle Lab, HELLFIRE, JAVELIN and LOSAT, system upgrades and advanced concepts.

STO Manager:	**TSO:**	**TRADOC POC:**
W. Stephens	Mike Rithmire	Chris Kearns
MICOM	SARD-TT	DBL
205-876-3732	697-8432	706-545-6391

IV.I.04. Multi-Purpose Individual Munition (MPIM). By the end of FY96, demonstrate through an advanced warhead static firing and through all-up missile firings, the technologies capable of meeting the User's ROC requirements for lethality and safely firing from enclosures. The challenge by the end of FY97 is to integrate the USMC SRAW flight module and MPIM warhead technologies into a system with a carry weight of $\leq$ 20 lbs., meet the lethality and fire from enclosure requirements, and be affordable. Measure of performance is lethality against a variety of diverse targets, thus requiring the soldier to carry only one weapon in lieu of three weapons.

Supports: MPIM ROC, 21st Century Land Warrior, SRAW, and Congressional Direction in 94 Budget.

STO Manager:	**TSO:**	**TRADOC POC:**
William Zecher	Mike Rithmire	Chris Kearns
MICOM	SARD-TT	DBL
205-842-8769	697-8432	706-545-6391

IV.I.05. Objective Crew Served Weapon (OCSW). Develop and demonstrate an ultra-light, two-man portable, crew served weapon system yielding improved suppression and incapacitation probabilities to 2,000 meters against protected personnel, and having a high potential to damage light and lightly armored vehicles, water craft, and slow moving aircraft to 1,000 meters. Specific goals include: (1) In FY97, demonstrate penetration range (R50) of 1,000 meters against lightly armored vehicles. (2) In FY98, demonstrate high probability of suppression and incapacitation to 2,000 meters against protected personnel with the following system configuration: weapon <38 lbs; mount <12 lbs; ammunition <0.35 lbs; and fire control <7 lbs. (3) In FY00, conduct troop tests to demonstrate operational utility and technological maturity.

Supports: Replacement for MK 19, M2; Secondary Armament (Crusader, HMMWV, etc.); Transitions to PM-Small Arms funded 6.4 program.

STO Manager:	**TSO:**	**TRADOC POC:**
Vern Shisler	John Appel	MAJ Monroe Harden
ARDEC/JSSAP	SARD-TT	Armor Center DFD
(201) 724-6009	697-8432	(502)624-4412

IV.I.06. Laser Igniter for Artillery Munition. By FY97, demonstrate the firing of a large caliber 155 mm howitzer with a laser-based ignition system. Benefits include direct ignition of the propelling charge without the aid of conventional primers of igniter materials, a solution to ignition at large charge stand-off, replacement of electrical wires with non-conducting glass optical fibers for safety, and computer control of the laser firing unit.

Supports: ARDEC, PEO-FS, PM-PALADIN, PM CRUSADER, ASPA-XM297.

STO Manager:	**TSO:**	**TRADOC POC:**
Brad Forch	Catherine Kominos	Herbert Russakoff
ARL-WMR	SARD-TR	CSS Battle Lab
410-278-7067	697-3558	804-734-0599

IV.I.09. Warheads for Armor Defeat. In FY96, develop and demonstrate a wide area shaped charge penetrator warhead to provide a 4 fold increase in lethal area against lightly armored target. In FY97, conduct evaluation of more lethal main charge warhead for heavy armor defeat utilizing more powerful explosive and advanced liner material. In FY98, demonstrate warhead design which has selective mode to either defeat a heavy armored target (15 to 20 percent increase in performance compared to Javelin) or a lightly armored target (4 fold increase in lethal area compared to standard Shaped Charge.)

Supports: Javelin, BAT, TACAWS, etc. Dismounted Battlespace BL.

STO Manager:	**TSO:**	**TRADOC POC:**
J. Orosz	John Appel	MAJ Harold Webb
ARDEC	SARD-TT	DBS-BL
201-724-2360	697-8432	706-545-7000

IV.I.10. Polynitrocubane Explosives. In FY96, initiate the synthesis of a more powerful polynitrocubane explosive. In FY97, scale up the polynitrocubane explosive to pound level. In FY98, scale up the polynitrocubane explosive to pilot plant quantity and initiate formulation study for anti-armor warhead (Shaped Charge or explosively Formed Penetrator) loading. In FY99, conduct static warhead test using the polynitrocubane explosive to show increase in energy performance by up to 25 percent and with comparable sensitivity to LX-14.

Supports: BAT AIS, TACAWS, Mounted and Dismounted Battlespace Bls.

STO Manager:	**TSO:**	**TRADOC POC:**
S. Iyer	John Appel	Charles Campbell
ARDEC	SARD-TT	MBS BL
201-724-3135	697-8432	502-624-1963

IV.I.11. High Energy/High Performance Propellant Formulations for Tank Guns. In FY96, initiate small scale evaluation of the high energy gun propellant composition. In FY97, scale up pilot plant processing technology and perform preliminary gun firings. In FY98, conduct final evaluation and demonstrate high performance propellant in live firing to increase impetus values by 10 to 20 percent over JA2 and muzzle velocities by 5 to 10 percent over M829A2 to enhance lethality.

Supports: Adv KE Cartridge, Novel Penetrators, Mounted Battlespace BL.

STO Manager:	**TSO:**	**TRADOC POC:**
B. Strauss	John Appel	Charles Campbell
ARDEC	SARD-TT	MBS BL
201-724-3317	697-8432	502-624-1963

IV.I.13. ETC and EM Armaments for Direct Fire. Demonstrate the technical feasibility of Electrothermal Chemical (ETC) propulsion for the near term (2005–2010) and Electromagnetic (EM) launch for far term (2015–2020) integration into direct and indirect fire weapon systems. EM offers potential for hypervelocity launch at >17MJ with increased and flexible lethality against advanced threat defensive systems, increased hit probability, reduced firing signature, propellant elimination and synergism with an all-electric vehicle system. ETC offers potential of increased muzzle energy and improved accuracy at an order of magnitude less pulse power requirement than EM. ETC will provide current 140mm lethality for projectiles fired from a 120mm, XM291 cannon. EM focus through FY99 will be on maintaining a robust pulse power development effort with subscale rotor demonstration of 1.5 J/g energy density in 4thQ FY97 and next generation near full scale compulsator (compensated pulsed alternator-CPA) demonstration of 3 J/g energy density in 4thQ FY99. Also in FY99, demonstrate integrated launch packages (ILP) with <50% parasitic mass launched at 2.5 km/s with muzzle energy of 7MJ. ETC focus through FY99 will be on effective coupling of electrical energy into improved propellants and controlling propellant burn temperature with demonstration of 14 MJ muzzle energy from M256, 120mm cannon in FY98 and 17MJ muzzle energy from XM291, 120mm cannon in FY99. For both EM and ETC, systems analysis and critical tests will show benefits in terms of improved battlefield effectiveness, no accuracy barriers and no fatal flaws.

Supports: TRADOC, PM-TMAS, ARDEC, TARDEC, PEO-ASM, Future Combat System

STO Manager:	**TSO:**	**TRADOC POC:**
Edward M. Schmidt	Catherine Kominos	COL John Kalb
ARL-WMRD	SARD-TR	DFD, Ft. Knox
410-278-3786	703-697-3558	502-624-7955

J. ELECTRON DEVICES

IV.J.01. Advanced Optics and Display Applications. Develop and demonstrate a family of core optics and sensors and display technologies for future head-mounted high resolution display/sensor systems (HRDS). By FY96, select and develop state-of-the-art optics (defractive, aspheric, hybrids, etc.), sensors (CCD or Image Intensified CCD), and display (AMEL, FED, FLCD, etc.) technologies for integration into high performance, low weight/cg head-mounted vision systems. Utilize concurrent development of sensor read-out and display driver electronic architectures for power/bandwidth optimization. By FY97, develop laboratory concept demonstrator for integrated high resolution, 60° FOV, low power HRDS components.

Supports: Mounted Warrior, 2nd Gen FLIR HTI, AI2 ATD, Comanche, Advanced Helicopter Pilotage.

STO Manager:	**TSO:**	**TRADOC POC:**
Phil Perconti	Carolyn Nash	Tom Mims
CERDEC/NVESD	SARD-TT	BC-BL
703-704-1369	697-8432	706-791-2800

IV.J.03. Army ATR Evaluation . This program provides the baseline technical/operational evaluation of algorithms developed by industry/academia/government against established data sets to ensure the functional performance of ATRs meets established requirements. By FY96: (1) establish a beta site for RASSP and intiate architectural assessments of ATRs operating in tanks and ground stations; and (2) define open system processing architecure based on commercial and MIL-STD practices, and assess 2nd Gen FLIR algorithms to cue operators to targets. By FY97, extend algorithm assessment to millimeter wave radar and demonstrate rapid prototyping of processor modules utilizing computer-aided design techniques and commercial/DARPA developed tool sets to reduce the development time by 30 percent and reduce module cost by a factor of 10. By FY98, implement critical target acquisition algorithms at the module level. By FY99, extend algorithm assessment to multi-sensor fusion and integrate and demonstrate advanced ATR algorithms integrated with a multi-module processor and smart focal plane array.

Supports: Dismounted Battlespace, Mounted Battlespace, Depth and Simultaneous Attack, Battle Command, Early Entry Lethality and Survivability, Target Acquisition ATD, Aerial Scout Sensors Integration TD.

STO Manager:	**TSO:**	**TRADOC POC:**
Lynda Graceffo	Carolyn Nash	Tom Mims
CERDEC/NVESD	SARD-TT	BC-BL
703-704-1745	697-8432	706-791-2800

IV.J.04. Soldier Individual Power Source. By FY96, using the best available hydrogen-air Proton Exchange Membrane (PEM) Fuel Cell technology: (1) Demonstrate a fuel cell powered battery charger which can provide 1200 watt-hr of charging per Kg of fuel. (2) Evaluate pressurized hydrogen/oxygen PEM fuel cell systems and determine whether further development of such systems will be advantageous over the more near-term hydrogen/air systems. Demonstrate a 50 watt/200 watt-hour fuel cell power supply weighing 2 Kg and characterize a unit capable of 500 watt-hours. By FY98, using best available hydrogen/air, hydrogen/oxygen, or liquid fueled PEM fuel cell technology, demonstrate a 50 watt/200 watt-hour fuel cell power supply that weighs less than 1 Kg and 150 watt/600 watt-hour unit weighing less than 2.5 Kg.

Supports: Generation II Solider, 21 CLW, DBBL, SOF.

STO Manager:	**TSO:**	**TRADOC POC:**
Richard Jacobs	Carolyn Nash	Chris Kearns
CERDEC/C2&SID	SARD-TT	DBL
703-704-2637	697-8432	706-545-6391

IV.J.06. Ferroelectric Phase Shifter Materials. The cost of phase array antenna is predominantly dependent on the cost of its microwave phase shifter. This STO will develop the processing methodology to produce a microwave phase shifter from a low cost, low power dissipation, voltage driven ferroelectric composite ceramic and thereby reduce the cost of a phase shifter element from $5000 to $200. By FY96, demonstrate thick film low-low phase shifter material for use at 15GHz. By FY97, demonstrate a thick film phase shifter material for use at 25GHz. By FY98, demonstrate a thick film, low cost phase shifter material in phased array antenna operating at 35GHz. The product of this STO will be a prototype replacement for the "ferrite phase shifter element" designed in mid-higher communication frequency for the "geodesic cone antenna component" in the following systems: Ground-Based Common Sensor; Air Reconnaissance Low; Aerial Common Sensor; Advanced Quickfix; Guardrail.

Supports: Technology for Affordability, PEO-IEW, Battle Command Battle Lab.

STO Manager:	**TSO:**	**TRADOC POC:**
Louise Sengupta	Catherine Kominos	Bob Bolling
ARL-WMR	SARD-TR	BC-BL
617-923-5190	697-3558	602-538-7500

IV.J.07. High Energy, Cost-Effective Primary and Rechargeable Batteries. Modify cost-effective commercial technologies so that they can be used for both training and combat. By FY99, produce a low-cost, pseudo-rechargeable, environmentally benign battery (less than $0.05/Wh) for use in training and low-rate applications, with the possibility of recharging these for limited numbers of cycles before discarding. By FY00, provide prototypes for field trials of long cycle life rechargeable batteries, used for both training and Special Operations missions, having an energy content 20 percent greater than the existing nickel-metal hydride battery. The goals will be to reduce manufacturing cost, while maximizing performance and safety. By FY01, demonstrate proof-of-principle prototypes of the most cost effective, safe high performance primary battery with greater than 300 Wh/kg.

Supports: PEO-C3S, SOCOM, PM-TRCS, PM-SOLIDER, SSCOM, Land Warrior, Air Warrior, Dismounted Battlespace Battle Lab, Task Force XXI

STO Manager:	**TSO:**	**TRADOC POC:**
Robert Hamlen	Carolyn Nash	Herbert Russakoff
CERDEC/ASD	SARD-TT	CSS Battle Lab
908-427-2084	697-8432	804-734-0599

K. ELECTRONIC WARFARE/DIRECTED ENERGY WEAPONS

IV.K.02. Non-Comm ESM/ECM Techniques. Development of the advanced techniques to intercept, identify, and geolocate modern low probability of intercept signals. These developments will allow for the location and subsequent deception/jamming/spoofing of threat emitters and electronic surveillance equipment on the battlefield. By FY94, demonstrate an advanced ESM receiver with increased sensitivity and multiple IF receivers to provide more accurate pulse descriptions. By FY96, develop coordinated roadmap for navigational/radar/ELINT deception. By FY98, demonstrate advanced radar system simulator to support PM battlefield deception. By FY99, demonstrate ESM capability against impulse radars.

Supports: Advanced Quickfix, Ground Based Common Sensor Heavy and Light, Guardrail Common Sensor.

STO Manager:	**TSO:**	**TRADOC POC:**
Frank Elmer	Carolyn Nash	Bob Bolling
CERDEC/IEWD	SARD-TT	BC-BL
908-427-5956	697-8432	602-538-7500

IV.K.05. Advanced EO/IR Countermeasures. Advanced EO/IR Countermeasures will develop multifunction countermeasures to protect Army aircraft and ground vehicles from advanced EO/IR guided missiles and smart munitions. Technology development will focus on key components such as sources/optics, pointing/tracking devices, missile plume and laser sensors and include advanced jamming techniques against passive homing, command to line of sight, and beamrider missiles. Particular emphasis will be on horizontal technology integration of ATIRCM architecture infused with low cost and adapted NDI components for ground vehicle protection and transition to the Hit Avoidance ATD. By FY95, develop a band IV detector for PIP to the AN/AVR-2 to detect 9-11 micron threats. By FY96, demonstrate beam coupler for active tracking system, threat missile warning, beam steering, and advanced jamming techniques for transition to the Multispectral Countermeasures (MSCM) Demonstration. By FY97, develop countermeasures against top attack threats to ground vehicles and laser-based jamming techniques for use on MSCM/ATIRCM. By FY98, develop and test countermeasures against advanced imaging and laser beamrider missiles directed at low flying platforms and ground vehicles.

Supports: PM-AEC, Tri-Service ATIRCM/CMWS, Hit Avoidance ATD, Armored Systems Modernization, Mounted Battlespace, Depth and Simultaneous Attack, Early Entry Lethality.

STO Manager:	**TSO:**	**TRADOC POC:**
Joseph O'Connell	Carolyn Nash	Bob Bolling
CERDEC/NVESD	SARD-TT	BC-BL
908-427-4870	697-8432	602-538-7500

IV.K.06. Advanced RF Countermeasures. By FY95, demonstrate jamming techniques against single and multi-spectral top attack smart munitions. By FY96, demonstrate an RF sensor and ECM modulator with the capability to locate, deceive, and jam monopulse and phased array radars from UHF through millimeter wave. Demonstrate the use of fiber optics to remote sensors and jamming modules from UHF through millimeter wave. By FY98, demonstrate low cost finger-printing for signal sorting and combat ID assist. By FY99, improve direction finding accuracy by 10x for precision targeting by radar warning systems, develop jamming techniques against bistatic, impulse, and advanced low probability of intercept radars.

Supports: Dismounted Battlespace, Mounted Battlespace, Depth and Simultaneous Attack, Battle Command, Early Entry Lethality and Survivability, RPA ATD, Hit Avoidance ATD, Integrated Situational Awareness and Countermeasures Tech Demo, and PM-AEC Suite of Integrated RF Countermeasures.

STO Manager:	**TSO:**	**TRADOC POC:**
Ray Irwin	Carolyn Nash	Charles Campbell
CERDEC/NVESD	SARD-TT	MBS-BL
908-427-4589	697-8432	502-624-1963

L. CIVIL ENGINEERING AND ENVIRONMENTAL QUALITY

IV.L.01. Installation Restoration. Provide cheaper and more effective technologies for cleanup of soil, sediment, groundwater, and surface water contaminated with hazardous and toxic wastes from past military activities. Provide technologies to reduce explosives contaminated site remediation costs by 50 percent using biological degradation as an alternative to incineration by the end of FY95. By the end of FY96, provide technologies to reduce the costs of decontaminating organics contaminated soil and ground water by 30 percent using innovative chemical, biological, and physical processes. By the end of FY97, provide technologies to reduce the cost of remediating heavy metals contaminated soils by enhanced physical separation processes. By the end of FY98, develop concept guidance on the implementation of in situ biological processes for remediation of explosives contaminated soils.

Supports: Tri-Service Environmental Quality Strategic Action Plan.

STO Manager:	**TSO:**	**TRADOC POC:**
Dr. J. Keeley	Donald Artis	Bill Adams
USAEWES	SARD-TR	ATSE-CD
601-634-3477	(573)563-4076	(703)697-3558

IV.L.03. Conservation Pillar. Develop technologies to maintain and manage training and testing ranges and lands; identify, minimize, and mitigate impacts and effects on natural and cultural resources through the Integrated Training Area Management (ITAM) Version 2.0. By the end of FY96, plant and soil data indices for carrying capacity; by the end of FY96, revegetation species selection software to enhance training realism and traffic hardiness; by the end of FY97, protocols for threatened and endangered species (TES) inventory and evaluating impacts of maneuver disturbance and smokes and obscurants on TES; and, by the end of FY97, basic natural resources carrying capacity simulation. By the end of FY97, all components of ITAM 2.0 will be available for demonstration.

Supports: In full or in part Army Directorate of Environmental Program user requirement priorities 1 through 4 in the Conservation Pillar. Supports the ability of military units to train and support in peace as they would in war or other actions.

STO Manager:	**TSO:**	**TRADOC POC:**
William Goran	Donald Artis	Bill Adams
CERL	SARD-TR	ATSE-CD
217-373-6735	(703)697-3558	(573)563-4076

IV.L.04p. Sustainable Military Use and Stewardship of Army Lands. The goal of this technology effort is to improve military access to and stewardship of training/testing lands through improved knowledge bases and tools that integrate multiple landscape factors into dynamic decision aids for land use planning and scheduling. By the end of FY01, provide an integrated modeling framework linking land capacity, land rehabilitation, and species impact models. Application of the integrated modeling framework will enable the Army to reduce the trend in land usage restrictions by up to 50 percent (at present, approximately 2 million acres are constrained). By the end of FY99, develop measures to match land use and land capacity in selected ecoregions. By the end of FY01, provide simulation tools for land rehabilitation options to restore damaged lands to a higher readiness condition. By the end of FY01, provide models to simulate mission impacts on key protected species, which will provide a better understanding of cause-effect relationships of military impacts.

Benefits include improved training realism and safety, reduced maintenance costs for equipment and land, increased flexibility in land use, up to 50 percent reduced constraints on access to land, and reduced fines due to environmental compliance.

Supports: National Environmental Policy Act, Endangered Species Act, Historic Preservation Act, Clean Water Act, Clean Air Act.

This proposed STO has been endorsed by the Assistant Chief of Staff for Installation Management. ACSIM POC is Raul Marroquin (703-693-0680).

STO Manager:	**TSO:**	**TRADOC POC:**
William Goran	Donald Artis	Bill Adams
CERL	SARD-TR	ATSE-CD
217-373-6735	(703)697-3558	(573)563-4076

IV.L.05p. Installation Environmental Compliance Technology. The goal is to develop industrial installation compliance technologies to enable Army industrial facilities to maintain production capability while achieving a 20 to 30 percent reduction in compliance costs under existing and projected effluent limitations. By the end of FY01, advanced maintenance technologies to reduce the cost of operating energetic manufacturing facility pollution control equipment by 20 to 30 percent, and increased pollution control efficiency through improved equipment reliability and more efficient operations.

By FY00, reductive electrochemical processes for treating energetic (propellants, explosives, and pyrotechnics) waste streams contaminated with nitro-aromatics, nitramine or nitrate esters which will meet discharge permit limits with a lower cost and greater operational flexibility than conventional technology. By the end of FY01, sequential bioreactor technology for treatment of energetic contaminated industrial facility waste to substantially reduce the capital and operating costs of Army industrial facilities. Current treatment/disposal costs range from $200 to $300 per ton, the goal is a 20 percent reduction in treatment costs. One installation alone can generate in excess of 4,500 tons of energetic contaminated waste per year. These technologies will provide the capability to maintain mission readiness.

Supports: Department of Defense "Measures of Merit"—By CY 1999, reduce disposal of hazardous waste by 50 percent from 1992 baseline; By CY 1999, reduce total releases and offsite transfers of toxic chemicals by 50 percent from the 1994 toxic release baseline. Clean Air Act Amendments of 1990. Resource Conservation and Recovery Act (RCRA). Federal Facilities Compliance Act of 1992. Project Reliance.

This proposed STO has been endorsed by the Assistant Chief of Staff for Installation Management. ACSIM POC is LTC Allen Kraft (703-693-0545)

STO Manager:	**TSO:**	**TRADOC POC:**
Gary Schanche	Donald Artis	Bill Adams
CERL	SARD-TR	ATSE-CD
217-373-3478	(703)697-3558	(573)563-4076

IV.L.06p. Airfields and Pavements to Support Force Projection. The objective is to support force strategic deployment from CONUS and operational employment in TO by providing improved reliable airfields and pavements. By the end of FY02, provide improved pavement criteria for design/repair/material systems that will result in reduced DoD pavement costs (approximately $72M/yr in FY95 dollars) and reduced pavement construction effort in the TO (reduce construction effort by 72,500 manhours for prototype medium load airfields). By the end of FY98, provide criteria for reliable airfields and pavements to support current generation of military and Civilian Reserve Air Force (CRAF) aircraft and vehicles through the use of local materials (which may be of inferior quality) and pavement binder modifications. This will extend the functional life of pavement by 1 year ($250,000 savings based on a 10,000 ft long runway). This objective will require new technologies for non-linear visco-elastic and visco-plastic materials behavior affecting airfield and pavement performance. By the end of FY99, provide criteria for construction/ design/repair systems to decrease construction effort by 10 percent for expedient surfaces in TO for military aircraft and vehicles. By the end of FY02, provide criteria for reliable airfields and pavements to support multiple passes of proposed future generation aircraft and military vehicles. Design, construction, and rehabilitation of Army and Air Force airfields is an Army Corps of Engineers responsibility; additionally, science and technology related to airfields and pavements is an Army responsibility under Project Reliance. This effort supports DTO MP.16.11AFN.

Supports: Force XX1 Global Force Projection, Engineer School, CE Districts and Divisions, Project Reliance, Army Modernization Objective "Project and Sustain."

This STO (Proposed) was ranked as 31 of 86 on the integrated priority list published by TRADOC as the result of the April 96 STO Review.

STO Manager:	**TSO:**	**TRADOC POC:**
William Marcuson	Donald Artis	Bill Adams
WES	SARD-TR	ATSE-CD
601-634-2234	(703)697-3558	(573)563-4076

IV.L.07p. Environmental Restoration. Provide cheaper and more effective technologies for site assessment and treatment of soils and groundwater contaminated with explosives and energetics (TNT, HMX, and RDX) and heavy metals (lead). By the end of FY99, construct explosives/energetics exposure and effects models for use during site environmental risk assessments reducing cleanup design costs by 20 percent by cutting risk analysis time in half (reduce from years to months). By the end of FY01, develop in-situ heavy metals extraction for lead allowing reduced treatment costs from the previous $100-300/ton of soil to $50-150/ton and allowing treatment below existing structures which is currently not possible. Also, by the end of FY01, develop in-situ biotreatment processes for TNT reducing costs from $100-500/cu.yd. in FY98 to $25-75/cu.yd. By the end of FY01, develop fate and transport risk assessment models and simulations for explosives and energetics that provide rapid contaminant fate predictions, improved risk assessment, and reduced design costs allowing all risk assessment completed on-site. By the end of FY02, develop advanced groundwater remediation technologies for TNT providing increased treatment efficacy and flexibility with overall cost reduction from $1-5/kgal in FY95 to $0.10-2.00/kgal. By the end of FY02, develop advanced visualization supporting on-site assessment during all cleanup phases providing a 50 percent reduction in time (reduce from months to weeks) for data analysis and treatment selection.

Supports: DoD Reliance Defense Technology Area Plan and the Tri-Service Environmental Quality Strategic Action Plan.

This is a STO (Proposed). This Proposed STO has been endorsed by the Army Chief of Staff for Installation Management. ACSIM POC is LTC Jeffrey Bemis (703-693-0643).

STO Manager:	**TSO:**	**TRADOC POC:**
Dr. J. Keeley	Donald Artis	Bill Adams
USAEWES	SARD-TR	ATSE-CE
601-634-3477	(703)697-3558	(573)563-4076

M. BATTLESPACE ENVIRONMENTS

IV.M.01. Target Area Meteorology. Exploit data from all available sources on the battlefield to include meteorological satellites, and through mesoscale modeling fuse these data with digital terrain data to produce 4-D weather forecast information at temporal and spatial resolutions adequate to characterize target area meteorology. By FY95, develop an automated 12-hour forecasting capability to support Joint and Combined Operations and generation of target area decision aids. By FY96, exploit satellite and ground-based remote sensors such as wind radars, lidars, and radiometers to characterize the atmosphere and analyze available upper air met data to produce a "best met" for any user within the battlefield area. Leverage advances in tactical observing, computer architecture, artificial intelligence, and numerical methods to extend forecast capability to 24 hours by FY97, and 48 hours by FY99. Develop met software for automatic fire control procedures by FY98 and integrate with the ballistic module in the artillery fire control center by FY99.

Supports: PM EW/RSTA, PM AF, CERDEC Development of Target Area Meteorological Sensor System (TAMSS), PEO CCS—Project Director (PD) IMETS, Joint Precision Strike ATD.

STO Manager:	**TSO:**	**TRADOC POC:**
James Harris	Catherine Kominos	MAJ Don Huntley
ARL-IST	SARD-TR	Depth and Simultaneous Attack
505-678-4207	697-3558	405-442-2927

IV.M.02. Digital Terrain Data Generation and Update Capability. Develop software and special processor cards, and techniques to provide the field commander the ability to update digital terrain information provided by the Defense Mapping Agency or to develop his own, high resolution data base of an area of critical interest not covered by DMA. By the end of FY97, provide the technology and capability to automate the delineation of features and to simplify the capability so it can be used by soldier terrain analysts to support the special data needs of the commander.

Supports: Joint Precision Strike, Terrain Feature Generation, PEO/CTIS, LAM, RBV-ACTD.

STO Manager:	**TSO:**	**TRADOC POC:**
Paul Logan	Donald Artis	LTC Doug Campbell
TEC	SARD-TR	U.S. Army Engineer School
703-428-6803	(703)697-3558	314-563-4077

IV.M.03. Automated Weather Decision Aids. Create and demonstrate an Integrated Weather Effects Decision Aid (IWEDA) which uses artificial intelligence techniques and knowledge of atmospheric effects to enhance and expand current weather decision capabilities in FY95. Additionally, for FY95, develop a threat weather effects module for the IWEDA enabling commanders to compare weather-based advantages/disadvantages of friendly and threat systems. Implement these capabilities on Army common hardware/software (CHS) with automated four dimensional (4D) weather input. Demonstrate an "Owning the Weather" capability using IWEDA during the ATLANTIC RESOLVE 96 Advanced Warfighting Experiment (AWE) in FY96. Complete the horizontal and seamless integration of the IWEDA into the Army Battle Command System (ABCS) Battlefield Automated Systems (BASs) and demonstrate during the Brigade Task Force XXI AWE in FY 1997.

Supports: CERDEC Battlefield Digitization, Precision Strike ATD, PEO CCS-IMETS Block III.

STO Manager:	**TSO:**	**TRADOC POC:**
James Harris	Catherine Kominos	Lee Garrison
ARL-IST	SARD-TR	BCBL (Ft. Leavenworth)
505-678-4207	697-3558	913-684-2366

IV.M.04. Weather Effects and Battlescale-Forecasts for Combat Simulation and Training (WEB-FCST). Integrate improved battlescale forecasting, real-time weather, and environmental effects models to provide common, unified weather effects, features, and representations for: Force XXI Advanced Warfighting Experiments (AWE); the Intelligence Electronic Warfare (IEW) Technology Investment Strategy; TRADOC combat models and Distributed Simulations such as the Synthetic Theater of War (STOW) Campaign Plan; and for Brigade Task Force XXI mission rehearsal. In FY97, within the IEW Common Operating Environment (COE) extend the Battlescale Forecast Model to provide weather forecast data for Distributed Interactive Simulation (DIS). By FY98, implement advanced algorithms for acoustic-propagation, illumination and visibility, terrain-coupled transport/diffusion and EO propagation effects at multiple levels of fidelity for environmental representations, Integrated Weather Effects Decision Aids (IWEDA), and battlefield visualization tools to support simulations and Division XXI mission planning. By FY99, incorporate an Improved Battlescale Forecast Model for forecast representations of clouds, fog, severe weather (rain), and improved battlefield aerosol diffusion at tactical scales. By FY00, assess improvements provided by shared battlescale weather forecasts, distributed weather processing for M&S, and physics-based atmospheric feature and effects models. By FY01, demonstrate interoperability of verified/validated Unified Battlescale Weather and Battlescale Atmospheric Effects Models as a real-time Own the Weather capability for FORCE XXI situation awareness, mission planning, and training.

Supports: Brigade XXI and Division XXI AWEs, IEW Technology Investment Strategy, and Synthetic Theater of War (STOW) Campaign Plan.

STO Manager:	**TSO:**	**TRADOC POC:**
James Harris	Catherine Kominos	Lee Garrison
ARL-IST	SARD-TR	Battle Command Battle Lab (Ft. Leavenworth)
505-678-4207	697-3558	913-684-2366

IV.M.05. Weather-Impacts and Decision Aids for Mission Rehearsal, Training, and Battlefield Execution. Improve battlefield Weather-Impacts and Decision Aids (WIDA) so that current forecast weather and predicted impacts on systems and operations produced by the fielded IMETS are also usable in mission rehearsal, training, and combat simulations and so that we "train as we fight." Quantify weather impacts to improve current qualitative "red-yellow-green" stop-light outputs from integrated Weather Effects Decision Aids (IWEDA), developed under STO IV.M.3 for the fielded Integrated Meteorological System (IMETS) and the Army Battle Command System (ABCS) Battlefield Automated Systems (BAS). Weather effects decision aids are included under the Defense Technology Area Plan (DTAP) SE35, Combat Weather Support. In FY98, extend IWEDA rule-based warnings and qualitative weather impacts by upgrading its artificial intelligence techniques to incorporate quantitative atmospheric effects and system performance. By FY99, incorporate quantified impacts of acoustics, illumination, propagation, smoke obscuration, terrain-coupled wind transport, and weather forecasts. By FY00, extend weather-impact models and decision aids to produce quantitative, four-dimensional (4D) weather impacts incorporating improved battlescale forecasts and atmospheric effects on weapons systems and operations. By FY01, upgrade models for characteristics and weather impacts on threat platforms and weapons. By FY02, integrate improvements back into IMETS to upgrade tactical Army Battle Command System weather-impacts and decision aids.

Demonstrate during Division Task Force XXI Advanced Warfighting Experiment (AWE) in FY98, Corps Task Force XXI and follow-on AWEs, incorporating Battlescale Weather forecasts and effects for consistent play of real-time Own the Weather capability for Force XXI situation awareness, mission planning, and combat training.

Supports: PEO C3S, ABCS, TFXXI, IEW Technology Investment Strategy, Synthetic Theater of War (STOW) Campaign Plan

STO Manager:	**TSO:**	**TRADOC POC:**
Douglas Brown	Catherine Kominos	Lee Garrison
ARL-IST	SARD-TR	Battle Command Battle Lab (Ft. Leavenworth)
505-678-1225	697-3558	913-684-2366

N. HUMAN-SYSTEMS INTERFACE

IV.N.01. Intelligent User Interfaces. Develop artificial intelligence technologies that enable intelligent interfaces to reduce the complexity and widen the bandwidth of communication between a user and a complex computer application by reasoning about knowledge of user goals and the task domain. By FY95, add the capability to automatically select, arrange, and graphically present information appropriate to achieve the user's goals, including 2-D graphics and complex time and map-based data. Expand this work into tools for visualization, exploration, and analysis of the large quantities of complex information for C2 and logistics. Field evaluate these tools during LAM exercises, the Logistics Anchor Desk (LAD). By FY96, incorporate automatic explanation tools integrating dynamic graphics and natural language generation to explain failures, successes, and alternatives in system reasoning. By FY97, demonstrate mechanisms for constructing, automatically updating, and interactively presenting multimedia staff briefings.

Supports: Logistics Anchor Desk, Total Distribution ATD as part of LAD, LAD field evaluation in LAM exercises, CSS Battle Lab, Battle Command Battle Lab, DSA Battle Lab.

STO Manager:	**TSO:**	**TRADOC POC:**
Carolyn Dunmire	Catherine Kominos	Herbert Russakoff
ARL-HRE	SARD-TR	CSS Battle Lab
410-278-5937	697-3558	804-734-0599

IV.N.03. Human Figure Performance Model (HFPM). Develop interactive, integrated, graphical man-model to interface with computer-aided design (CAD) and engineering processes for automated man-in-the-loop and crew-in-the-loop assessments of advanced concepts early in the material design process. Develop translators between the HFPM (Jack) and several RDEC and industry CAD software packages. Complete software development to add motion (walking), strength, and reach. Complete input of latest anthropometry data, develop intelligent spreadsheet system for handling anthropometric data, and add the capability for surface mapping, simulated uniforms, and basic equipment restrictions by FY96. Demonstrate and distribute Army-wide in FY97.

Supports: Crewman's Associate ATD and Force XXI Land Warrior ATD

STO Manager:	**TSO:**	**TRADOC POC:**
John Lockett	Catherine Kominos	Charles Campbell
ARL-HRE	SARD-TR	MBS BL
410-278-5857	697-3558	502-624-1963

IV.N.04. Performance-based Metrics for the Digitized Battlefield. This STO develops standardized, field-operational measurement scales for use by the Battle Labs, Army Digitization Office, and Army Research and Engineering Centers (RDECs) in defining and evaluating integrated soldier-information system performance on the digitized battlefield. These measurement scales will directly support the U.S. Army's Rolling Baseline assessment of digital information system technology during Advanced Technology Demonstrations, Advanced Warfighting Experiments, and related Force XXI field activities. The resulting metrics will provide both technology developers and field users with a common, standard framework for specifying performance requirements and assessing the contribution of digital information system technology across a variety of battlefield settings (e.g., brigade TOC staff, tank crew, individual dismounted soldier). To achieve this goal, the behavior-based measurement scales will (1) reflect important dimensions of the information processing and decision making tasks performed by soldiers, crews, and staffs; (2) correlate with success in satisfying TRADOC Operational Capability Requirements (OCRs) related to the soldier-information interface; (3) be sensitive to the introduction of new technology, doctrine, procedures, organization, and training; and (4) be observable and measurable in a field setting. Develop and test an initial set of behavioral performance markers addressing tank crew and Command and Control Vehicle (C2V) operator performance as well as digital communications initiatives for dismounted operations in Warrior Focus (November 95). These behavioral performance markers will be refined and further tested during FY96 in Warrior Focus, Army Logistics ACTD, or other major AWE. A draft Army-standard set of soldier-information system performance metrics for common use by ARL will be developed and refined during FY97, and demonstrated in the context of Task Force 97. Standards for Army Materiel Acquisition will be developed in FY98.

Supports: Warrior Focus, Army Logistics ACTD, Task Force 97, ADO, Battle Command Battle Lab, Mounted Battlespace Battle Lab, Dismounted Battlespace Battle Lab.

STO Manager:	**TSO:**	**TRADOC POC:**
Dennis K. Leedom	Catherine Kominos	MAJ Harry Hamilton
ARL-HRE	SARD-TR	BC-BL
410-278-5919	697-3558	

O. MANPOWER, PERSONNEL, AND TRAINING

IV.O.02. Combined Arms Training Strategy for Aviation. By FY97, employing a previously developed methodology, we will demonstrate the effective use of networked simulators and training devices for combat skills sustainment. In addition, a methodology for rapid evaluation and thorough assessment of on-hand and proposed devices for unit training will be demonstrated. Minimum fidelity requirements will be established for critical aircrew skills training and for utilization of and upgrades to existing simulators. In FY97, the aviation combined arms team trainer (AVCATT) functional requirements will be validated.

Supports: U.S. Army Aviation Center (USAAVNC); STRICOM; PM CATT (AVCATT); TSMs for Longbow, Comanche, Kiowa Warrior.

STO Manager:	**TSO:**	**TRADOC POC:**
Charles Gainer	Michelle Sams	COL William Powell
ARI	SARD-TR	USAAVNC
334-255-2834	703-614-7298	334-255-3320

IV.O.05. Human Dimensions of Battle Command. By FY97, provide tools, techniques, and procedures for assessing, training, and maintaining selected knowledge and skills commanders and their staffs will need for successful battle command on future battlefields. In FY95, develop techniques for training tactical pattern recognition and situation assessment. In FY96, develop a model of battle command knowledge and skill requirements. In FY97, provide training guidelines for commanders on how to make effective use of emerging information technologies in battle command, e.g., situation assessment, communication of intent. In FY97, develop innovative techniques for training tactical decision skills and demonstrate enhanced tactical decision-making and battle command skills by commanders and staff in an Army Warfighting Experiment, e.g., Prairie Warrior or other realistic environments.

Supports: CAC-T; Battle Command Battle Lab; Center for Army Lessons Learned; Center for Army Leadership.

STO Manager:	**TSO:**	**TRADOC POC:**
Stanley Halpin	Michelle Sams	LTC Patrick Lamar
ARI	SARD-TR	BC-BL
702-274-8844	703-614-7298	913-684-3323

IV.O.06. Force XXI Training Strategies. By FY01, develop and demonstrate new training and evaluation technologies that prepare operators and commanders to take maximum advantage of evolving digitized C3 systems. This training research will incorporate the use of virtual, constructive, and live simulations to demonstrate and evaluate selected prototype training techniques. By FY98, evaluate prototype staff training packages that use advanced digital technology. By FY99, evaluate training and performance assessment tools developed for the digitized battlefield. The training techniques and strategies will be demonstrated and evaluated in Advanced Warfighting Experiments (AWEs).

Supports: TRADOC, USAARMC&S, MBBL, III Corps.

STO Manager:	**TSO:**	**TRADOC POC:**
Barbara Black	Michelle Sams	MG Maggart
ARI	SARD-TR	Army Armor School
502-624-3450	703-614-7298	502-624-7555

P. MATERIALS, PROCESSES, AND STRUCTURES

IV.P.04. Ultra Light Ballistically Resistant Materials. Demonstrate ultra lightweight ballistically resistant materials which could be incorporated into small arms protective gear having aerial densities of less than 5 pounds per square foot. The understanding of the materials dynamic properties, chemistry, and microstructure and their interrelationships will be advanced and implemented into the development/design of new materials weighing 40 percent less than current materials. Both quantitative and qualitative ballistic performance of candidate armor materials and select combinations will be studied. By FY96, determine the baseline dynamic response of lightweight ceramic and polymeric composite materials. By FY97, correlate the relevant materials dynamic properties and response to improvements in ballistic resistance. By FY98, provide guidelines through modeling and simulation codes for enhancing material performance. By FY99, demonstrate ballistic performance and dynamic response of optimal ultra lightweight armor materials. Analysis and data will be transitioned to the Soldier System Command (NRDEC) for applications into personnel armor for soldier protection.

Supports: Personnel protection for infantry and Special Operations forces, Protect the Force, Force XXI Land Warrior ATD-Follow on Program, Dismounted Battlespace Battle Lab.

STO Manager:	**TSO:**	**TRADOC POC:**
James Mackiewicz	Catherine Kominos	Chris Kearns
ARL-WMR	SARD-TR	DBL
617-923-5066	697-3558	706-545-6391

IV.P.05. Transparent Ceramics for Armor Applications. Develop and demonstrate transparent armor which meet or exceed the ballistic performance of existing glass/polymer, with a 30 percent reduction in weight and thickness, while increasing the in-line transmission in the visible and near IR regions. It will also exhibit superior abrasion resistance, strength, and high temperature properties. By FY97, a ballistic database will be generated for candidate materials for threat levels ranging from fragment threats through 12.7mm Armor Piercing (AP). By FY98, optimized test transparent armor will be developed using the data generated during FY97. By FY99, a prototype component will be designed and fabricated for installation in an existing end item.

Supports: Personnel protection for infantry and Special Operations Forces, Protect the Force, Armored Vehicles, Force XXI Land Warrior Follow-on Program, NRDEC, Soldier System Command, TACOM, and Dual Use (Law Enforcement), Dismounted Battlespace Battlelab.

STO Manager:	**TSO:**	**TRADOC POC:**
Kerry Richards	Catherine Kominos	Chris Kearns
ARL-WMR	SARD-TR	DBL
302-892-6628	697-3558	706-545-6391

IV.P.06p. Advanced Materials for Lightweight Combat System Protection. Develop lightweight armor materials for combat systems protection with the result of 30 percent reduction in weight by the year 2004. Knowledge gained from STO IV.P.04 of dynamic materials properties, microstructural and physical-chemical changes under impact, and penetration mechanics of ultra-lightweight armor materials will be applied to four classes of materials supporting new armor: (1) functional gradient materials, (2) high modulus polymer fibers, (3) improved sintering processed B C/SiC, and (4) ultra-fine grain ceramic matrix composite materials. By FY00, complete feasibility study of fabrication technologies for four classes of materials. By FY01, develop fabrication procedures for four classes of materials. By FY02, initiate fabrication and characterization of selected materials including ballistic performance of the four classes of materials. By FY03, complete characterization of materials and develop guidlines for optimizing fabrication processes. By FY04, scale up of fabrication processes for production and determine optimal applications.

Supports: Protect the Force, Dominate Manuever, Future Armored Combat Vehicles, FMBT.

STO Manager:	**TSO:**	**TRADOC POC:**
Shun-Chin Chou	Catherine Kominos	Charles Campbell
ARL-WMR	SARD-TR	MBS BL
410-278-7283	697-3558	502-624-1963

Q. MEDICAL AND BIOMEDICAL SCIENCE AND TECHNOLOGY

IV.Q.02. Field Wake/Rest Discipline in Sustained and Continuous Operations. The physical and cognitive demands of operational missions interact with limited and fragmented opportunities for rest and sleep. The concept of water discipline emerged from an understanding that there is no alternative to adequate water intake for optimal performance; the same concept holds true for sleep discipline. Systematic sleep and rest, consistent with the demands of the OPTEMPO, must be provided to maintain performance quality and sustainability. This research will develop and demonstrate effective means for counteracting the effects of inadequate restorative sleep and rest on military performance. By FY98, develop and validate animal and human laboratory models and test methods to identify and screen the safety and efficacy of sleep and vigilance enhancing compounds in a military setting. By FY98, incorporate human laboratory database derived models of the effects of sleep deprivation on performance into Louisiana Maneuvers Continuous Operations simulations. By FY99, develop a continuous operations simulation to demonstrate and refine the Sleep-Induction/Rapid Re-Awakening and stimulant components of the Sleep Management System (SMS). By FY99, develop and demonstrate a rapid, reliable, and inexpensive means for assessing a soldier's level of mental fatigue and alertness, transitioning to development, the wrist-worn sleep/activity monitor with integrated microprocessor system.

STO Manager:	**TSO:**	**TRADOC POC:**
Dr. Fred Hegge	MAJ Mark Seymour	LTC Dunham
MRMC	SARD-TM	CSS-BL
301-619-7301	703-695-5615	405-442-5647

IV.Q.03. Performance Limits Models. Warfighting thermal performance status is characterized in this STO using multi-dimensional advances employing USARIEM's state-of-the-art thermal models and mannequin systems which makes available quantitative assessment of heat and vapor transfer properties of clothing and individual protective systems. The information offered by such efforts generate a complete set of tools for implementing physiological thermal predictive control strategies useful over wide thermal and high terrestrial environments. The specific goals are to: (1) biophysically quantify on both healthy and physically stressed soldiers the impact of protective clothing and other systems such as handwear, footwear, and high technology fiber material needed for operations in harsh environments; (2) develop and validate operational and thermoregulatory models to predict performance using integrated schemes employing new concepts and materials such as microclimate cooling, enhanced chemical protective clothing, and cold weather clothing systems; (3) to exploit the broad spatial coverage of weather satellite data resources to provide environmental inputs to thermal strain prediction models and incorporate recent advances in satellite data collection and image processing technologies needed for the Warfighter. By FY96, develop and validate a microclimate cooling model for concept support of the 21st Century Land Warrior, and develop and validate models to predict performance degradation and injury due to cold-air exposure. By FY97, develop a statistical model of rifle marksmanship as affected by environmental (heat and cold) and operational stressors (fatigue and food/water deprivation). By FY 98, complete the integration of real-time satellite-derived weather data into thermal strain decision aids for battlefield commanders.

STO Manager:	**TSO:**	**TRADOC POC:**
Dr. Fred Hegge	MAJ Mark Seymour	LTC Dunham
MRMC	SARD-TM	CSS-BL
301-619-7301	703-695-5615	405-442-

IV.Q.08. Visual Performance. Develop methods, criteria, and predictive models to protect and enhance the visual performance of soldiers using vision enhancement devices and information displays. By FY96, determine criteria for evaluating candidate visual display systems and associated imagery which will optimize compatibility with the human visual system. By FY97, produce a computer model for the prediction of soldier visual performance under varying combat and environmental stressors.

Supports: Model of visual performance utilizing vision enhancement devices under operational conditions; Program Manager Apache, Program Manager Comanche, Aviation Center and School; Conduct Precision Strikes—enhance soldier imaging capabilities without spatial disorientation; Aviation Center and School.

STO Manager:	**TSO:**	**TRADOC POC:**
COL R. K. Gifford	MAJ Mark Seymour	LTC Dunham
MRMC	SARD-TM	CSS-BL
301-619-7301	703-695-5615	405-442-5647

IV.Q.09. Biomechanics for Improved Footwear. By the end of FY97, develop a prototype combat boot embodying materials, design, construction fabrication techniques, and other features to enhance the biomechanical efficiency of the wearer. By the end of FY99, demonstrate a 10 to 15 percent reduction in the probability of occurrence of stress-related, lower extremity disorders among ground troops wearing the new combat boots.

Supports: U.S. Marine Corps, Advanced Development-RJS1/63747/D669-Clothing and Equipment, Engineering Development-RJS1/64713/DL40-Clothing and Equipment.

STO Manager:	**TSO:**	**TRADOC POC:**
Carolyn Bensel	Bill Brower	Chris Kearns
NRDEC	SARD-TT	DBL
508-233-4780	697-8432	706-545-6391

IV.Q.10. Whole-Body Blast Bioeffects. By FY95, develop an injury model to serve as protective criteria for blast overpressure hazards. By FY96, expand the injury model to include gastrointestinal tract and female reproductive tract. By FY97, integrate hearing protection criteria to the health risk model.

Supports: Model to predict injury and establish safe operator exposure limits to blast effects from Army weapons systems; Health Hazards Assessment program (AR 40-10), Armaments Research, Development and Engineering Center; Army Modernization Plan, Medical Annex O—Project, Sustain, and Protect the Force—prevent injury and degradation of soldier performance from blast overpressure.

STO Manager:	**TSO:**	**TRADOC POC:**
Dr. Fred Hegge	MAJ Mark Seymour	LTC Dunham
MRMC	SARD-TM	CSS-BL
301-619-7301	703-695-5615	405-442-5647

IV.Q.11 Helicopter Crewmember Sustainment and Performance. By FY97, reduce performance decrements by 25 percent in aircrews following deployment across time zones and during night operations by demonstrating the efficacy of melatonin in operational units and by developing a software package to optimize crew rest strategies. By FY98, identify countermeasures to optimize aircrew endurance and protection during sustained rotary-wing flight operations including criteria for better helmet design to prevent fatigue from head-supported mass, hearing augmentation to overcome cockpit noise, criteria for the Aircrew Uniform Integrated Battlefield (AUIB) to prevent dehydration and heat stress, and determination of criteria for seats which prevent back pain and are crashworthy in vertical descents. By FY98, complete implementation of findings from the Aviator Epidemiological Data Registry (AEDR) to optimize medical screening and retention criteria for Army aviators. By FY99, reduce low visibility accidents by as much as 50 percent with countermeasures to Army-unique spatial disorientation problems encountered during nighttime and reduced visibility flight.

Supports: Medical countermeasures to aviator fatigue performance degradation; Program Apache, Program Manager Comanche, Program Manager Aviation Life Support Equipment, Aviation Center and School; Conduct Precision Strikes—enhance soldier imaging capabilities without spatial disorientation.

STO Manager:	**TSO:**	**TRADOC POC:**
Dr. Fred Hegge	MAJ Mark Seymour	LTC Dunham
MRMC	SARD-TM	CSS-BL
301-619-7301	695-5615	405-442-5647

IV.Q.12. Warfighter Physiological Status Monitoring. Commanders are concerned with detailed intelligence on enemy forces and are usually well informed of the status of their own materiel; however, they lack tools to access basic information on the physiological readiness of their own soldiers. In the fog of war, it is especially difficult to rapidly assess available human assets. A family of physiological sensors will be developed into the research tool kit needed to gather useful data on soldier status. This data, organized and reduced through a system of knowledge management, will be used to iteratively refine predictive models and to guide the development of a wear-and-forget soldier-acceptable Warfighter Status Monitor (WSM). Information commanders want to have about predicted and current status of soldiers will be provided. The communication and computation platform for the WSM will be the DARPA-developed Personnel Status Monitor (PSM) or its equivalent. All systems will be coordinated with soldier systems command to assure compatability with 21st Century Land Warrior and follow-on programs.

By FY98, a miniaturized accelerometry system will provide a personal assessment of cumulative sleep deficit and predicted level of psychophysiological performance. By FY98, the MERCURY model system of environmental hazards will be complete, predicting soldier performance in specific real-time locations. By FY99, a sensor suite consisting of technologies such as accelerometry, ausculation, spectroscopy, electrical impedance, and force and temperature sensing technologies will be connected through wireless body local area network (LAN) system, with remote passive data interrogation capabilities. By FY01, a knowledge management system will be developed to reduce information obtained through the WSM system and predictive performance and health risk models to provide essential information which commanders want to have. By FY03, enabling technologies will provide additional sensors for special environments, such as bioelectronic toxic hazard sensors, to detect imminent physiological threats in the immediate environment, as well as minute embedded sensors which will bring automation and reliability to physiological sensing.

STO Manager:	**TSO:**	**TRADOC POC:**
Dr. Fred Hegge	MAJ Mark Seymour	Chris Kearns
MRMC	SARD-TM	DBL
301-619-7301	703-695-5615	706-545-6391

IV.Q.13. Prevention of Heat Injuries. Assurance of U.S. Army capability to operate in hot environments lies at the heart of the Force Projection concept now guiding strategic planning. This program establishes the scientific foundation for Army doctrinal development governing operations in thermal extremes and identifies and refines effective strategies to sustain health and performance following rapid deployment to environmentally challenging operational settings. This research will demonstrate the efficacy of strategies to sustain and enhance performance and to prevent and treat thermal illnesses.

By FY98, develop and implement new cellular, organ, and animal models to assess mechanisms of thermal injury. By FY98, determine if anti-lipopolysaccharide is a key protective factor which explains the lower susceptibility of female, compared to male, Marine recruits to exertional heat illness. By FY99, develop acclimatization strategies using heat shock protein-70 as a biomarker of heat tolerance to improve immediate heat tolerance and accelerate heat acclimation. Determine effect of estrogen supplementation on heat acclimatization in servicewomen. By FY00, develop strategies for 21CLW ATD to modify skim blood flow to maximize the effectiveness of microclimate cooling and heating. By FY01, determine the feasibility of immunoprophylaxis in preventing thermal injury.

Supports: Supports medical countermeasures to environmental threats, PM soldier, and AR 40-10. Supports the Army Modernization Plan objectives to Project, Sustain, and Protect the Force—prevent and minimize environmental injury.

STO Manager:	**TSO:**	**TRADOC POC:**
Dr. Fred Hegge	MAJ Mark Seymour	LTC Dunham
MRMC	SARD-TM	CSS-BL
301-619-7301	703-695-5615	405-442-5647

IV.Q.14. Optimization of Physical Performance. This research will lead to the optimization of training programs to reduce injury of physically mismatched individuals to military tasks and to maximize physical readiness through non-materiel ("skin-in") solution. By FY98, establish a database of energy requirements and activity patterns for men and women in a variety of military jobs to predict and plan for voluntary energy requirements. Demonstrate a reduction in training injuries through improved physical training programs during basic training. Develop physical training strategies and alternatives to prevent stress fractures in susceptible individuals. By FY99, establish medical criteria to optimize efficiency and ensure safety of individual soldier equipment (combat boots, body armor, load carriage systems) for use by the equipment developers. Develop state-of-the-art scientifically-based training programs to improve performance of elite units for special occupational requirements, and to increase opportunities of all soldiers in jobs with specific physical standards. By FY00, identify biochemical mechanisms and functional consequences of the effects of sudden increases in physical training volume and prolonged physical exertion (overtraining) for soldiers. Identify high risk for injury groups using existing outcome data. By FY01, develop strategies involving antioxidants, ergogenic aids, and physical training techniques to counter reductions in physical capacity produced by overtraining. By FY02, develop strategies including training and other fitness and nutrition habits to optimize bone mineral accretion in young women to reduce stress fracture and later osteoporosis.

STO Manager:	**TSO:**	**TRADOC POC:**
Dr. Fred Hegge	MAJ Mark Seymour	LTC Dunham
MRMC	SARD-TM	CSS-BL
301-619-7301	703-695-5615	405-442-5647

IV.Q.15 Laser Bioeffects and Treatment. No single factor is more certain to compromise soldier effectiveness than the knowledge of battlefield threats against which there are no proven medical countermeasures. No organ is more vulnerable to the directed energy of laser than the unprotected eye, and blindness, temporary or permanent, can occur in an instant and without warning. Medical research has demonstrated that not all forms of laser energy are equally harmful to the eye; thus, system developers can be guided away from harmful frequency/power mixes by medical exposure standards based on new research, which do not needlessly deny developers options to raise power levels or exploit frequencies which pose less threat. Understanding of the bioeffects must be translated into effective field treatment interventions.

By FY97, demonstrate efficacy of early phase anti-inflammatory therapy in nonhuman primate model for treatment of laser retinal trauma and identify other early phase treatment candidates. By FY97, determine hazards of fast optical switch for tank sights and establish analytical methods for prediction of the degree of ocular protection. By FY97, refine eye tracker model to simulate laser injury and correlate performance with human laser accident case results. By FY98, resolve discrepancies in bioeffects database for subnanosecond exposures and update hazards assessment and exposure limits based on operational performance criteria. By FY98, determine bioeffects of broadband diodes used in advanced military display systems. By FY98, develop high resolution ophthalmoscopic imaging technology for use in telemedical assessment of laser eye injuries, and provide laser injury database for inclusion in smart far-forward medical information systems. By FY98, establish performance-based models characterizing levels of visual impairment pertinent to battlefield laser injury. By FY99, develop and test field therapy kits for laser retinal injury. By FY99, develop in vivo photoreceptor imaging in primate models to enhance assessment of laser retinal injury and repair mechanisms. By FY00, refine operational exposure limits. By FY02, refine methodologies to assess and treat laser retinal injuries. By FY02, convolve high resolution retinal imaging technology with photoreceptor transplant technology to evaluate autologous photoreceptor transplant methodology. By FY02, begin evaluation of electronic retinal implants for treatment of laser scotoma.

STO Manager:	**TSO:**	**TRADOC POC:**
Dr. Fred Hegge	MAJ Mark Seymour	LTC Dunham
MRMC	SARD-TM	CSS-BL
301-619-7301	703-695-5615	405-442-5647

R. SENSORS

IV.R.02. Photonic Signal Processing Technology. By FY96, demonstrate broad bandwidth, wide dynamic range (20-30 dB) two-dimensional (2-D) devices and processors with appropriate algorithms for detection and identification of signals. By FY98, demonstrate a photonic processor with appropriate algorithms for detection and identification of signals. By FY99, demonstrate a 2-D optical processor capable of running real time signal and image processing algorithms on data from imaging sensors such as Synthetic Aperture Radar (SAR) or Electro-optical (EO) images which requires significantly less power than conventional digital processors.

Supports: ATR and SAR applications; Electronic Support Measures testbed.

STO Manager:	**TSO:**	**TRADOC POC:**
Dr. Andree Filipov	Catherine Kominos	Tom Mims
ARL-SED		BC-BL
301-394-2520	697-3558	706-791-2800

IV.R.05. Multi-Sensor Fusion ATR. Develop algorithms that allow multi-sensor fusion of a variety of sensors to include: SAR, MMW/FLIR, LADAR, and acoustic. By FY97, demonstrate multi-sensor fusion algorithms for a MMW, FLIR multi-sensor fusion 10-12 class problem. Address technical issues and assess feasibility for additional sensors to achieve Automatic Target Recognition (ATR).

Supports: Apache-Longbow, Comanche, UGV, Combat ID, Scout, HTI.

STO Manager:	**TSO:**	**TRADOC POC:**
Mark Hamilton	Catherine Kominos	Charles Campbell
ARL-SED	SARD-TR	MBS BL
703-704-1677	697-3558	502-624-1963

IV.R.06. Real Aperture Target Discrimination. Develop innovative technologies to detect, discriminate, and classify stationary targets with a real beam radar. By FY95, complete conversion of primary clutter database to match Longbow resolution. By FY96, complete real beam radar algorithm training in geographically and seasonally diverse environments. By FY98, develop and demonstrate target/clutter discrimination techniques and algorithms that increase probability of target detection in these diverse environments. Provide quantitative assessment using a Longbow equivalent data set as to the improvement of the existing capability. The algorithm suite will be capable of autonomous adaptation to various clutter backgrounds. Performance capabilities will be demonstrated using a Longbow equivalent data set. By FY99, develop more effective classification of tactical vehicles using a twofold approach: (1) Improve underlying fidelity of target signatures using super-resolution techniques and (2) Apply data compression technique such as a wavelet-based approach to vehicle template storage for efficiently cataloging additional signatures.

Supports: Apache-Longbow, Comanche, Mounted Battle Space Battle Lab, Target Acquisition ATD.

STO Manager:	**TSO:**	**TRADOC POC:**
Jeffrey Sichina	Catherine Kominos	Charles Campbell
ARL-SED	SARD-TR	MBS BL
301-394-2530	697-3558	502-624-1963

IV.R.07. Acoustic Tracking and Identification on the Battlefield. Demonstrate the ability to detect, track, and identify targets from their acoustic signatures in the battlefield environment. This program will develop basic tools for acoustic algorithm development and evaluation and demonstrate real time tracking and identification of vehicles. In FY95, a testbed will be delivered to evaluate algorithms and a consolidated database of acoustic signatures will be created. In FY97, a laboratory capability to quickly analyze acoustic data and facilitate generation of acoustic algorithms will be delivered and real time tracking and identification of targets will be demonstrated. In FY98, the real time tracking and identification will be expanded to include a broader base of targets. In FY99, the capability to track large numbers of targets as a group will be demonstrated.

Supports: RFPI—Remote Sentry, Intelligent Minefield, Scout Sensor Suite. DIA—Unattended Measurement And Signature INTelligent (MASINT) sensors.

STO Manager:	**TSO:**	**TRADOC POC:**
John Eicke	Catherine Kominos	Charles Campbell
ARL-SED	SARD-TR	MBS BL
301-394-2620	697-3558	502-624-1963

IV.R.10. Electronic Terrain Board. Develop an electronic capability consisting of interactive 3D (thermal, MMW, radar) models, sensor simulations, and scene generation capability to evaluate ATR and human performance with second generation sensors, multi-sensor, target, and platform motion effects. Thermal models and temperature data will be used to develop "Painting the Night" virtual imagery (Level 2 CIG) for use in Battlefield Distributed Simulation. By FY95, validate 3D thermal models and deliver stealth simulators with a "night" data base of Ft. Hood to Dismounted Battlespace Battle Lab. By FY97, demonstrate the capability to generate a near real-time, multisensor scene rendering.

Supports: Dismounted Battlespace, Mounted Battlespace, Depth and Simultaneous Attack, Battle Command, Early Entry Lethality and Survivability, Combat Service Support, BDS-D, Distributed Interactive Simulation, Horizontal Technology Insertion, Target Acquisition, Hunter Sensor Suite, and Comanche ATR.

STO Manager:	**TSO:**	**TRADOC POC:**
Maxwell Lorenzo	Carolyn Nash	Charles Campbell
CERDEC/NVESD	SARD-TT	MBS BL
703-704-3185	697-8432	502-624-1963

IV.R.11. Hyperspectral Technology. The object is to evaluate tools for hyperspectral data gathering from overhead platforms and provide a capability to exploit that data to rapidly identify targets and militarily significant man-made and natural features to support C2I. By the end of FY96, demonstrate computer-based identification of man-made materials from hyperspectral data and signature data bases. By FY97, demonstrate identification of man-made materials using far infrared spectrum. Determine the utility of an acousto-optic tunable filter to provide data from a elevated platform. Provide this sensor data to sensor developers for their use in determining technologies to be used in future sensors.

Supports: Precision Strike, DMIF, TENCAP, SERDP

STO Manager:	**TSO:**	**TRADOC POC:**
Betty Mandel	Donald Artis	LTC Doug Campbell
TEC	SARD-TR	U.S. Army Engineer School
703-428-68254	(703)697-3558	314-563-4077

SSDC POC : Ben Kerstiens, (205)955-1769, DSN: 645-1769

IV.R.12. Monolithic Integrated Devices for Multidomain Sensors. The Scientific and Technology Objective is to develop an enabling technology for future infrared sensor upgrades beyond 2nd generation FLIR. These upgrades include active/passive interrogation, multispectral detection, and increased local processing in a single FLIR unit. The enabling technology will be demonstrated by the growth of electro-optic devices directly on silicon. The specific objectives are: In FY96, demonstrate a significant reduction in defect density for growth of CdZnTe and GaAs on silicon (to around $10^5/cm^2$) utilizing a recently developed molecular beam epitaxy (MBE) growth technique already demonstrated for CdTe on GaAs. In FY97, demonstrate bulk quality CdZnTe grown on silicon and fabricate test HgCdTe array on silicon in FY98. In FY99, demonstrate high quality electro-optic devices monolithically integrated with silicon electronic devices.

Supports: Future battlespace visualization involving Army thermal imaging systems in tanks, helicopters, missiles, and autonomous scout vehicles, Mounted Battlespace Battle Lab.

STO Manager:	**TSO:**	**TRADOC POC:**
William Clark III	Catherine Kominos	Charles Campbell
ARL-SED	SARD-TR	MBS BL
703-704-2039	697-3558	502-624-1963
DSN:	227-3558	464-1963

IV.R.13. Advanced Focal Plane Array Technology. This STO builds on the Smart FPA STO IV.R.01 to develop and mature components for a more advanced generation of IR imaging sensors which take advantage of advanced large staring focal plane arrays which allow smart temporal and multispectral signal processing. Technology will be developed to provide affordable TV quality imagers in the 3-5mm and 8-12mm bands including practical non-uniformity correction. By FY97, provide an evaluation of the practicality and affordability of large single spectrum staring/scanning arrays along with validated staring array performance models and complete evaluations and trade-offs between the 3-5 and 8-12 micron spectral bands to support design of the Multifunction Staring Sensor Suite. By FY99, demonstrate multispectral sensing and partition smart functions between on- and off-focal plane processing. By FY00, integrate multispectral smart sensing with staring FPAs for enhanced soldier vision. By FY01, demonstrate large focal plane, hyperspectral smart sensing with feedback control from weapon system processor to optimize automated target acquisition. These objectives are obtained by integrating multispectral/hyperspectral FPAs with smart read-out-integrated-circuits (ROICs), innovative micro-optics, and adaptive micro/nano electronics into tactical dewars.

Supports: Mounted Battlespace, Dismounted Battlespace, Depth and Simultaneous Attack, Early Entry Lethality, Battle Command, Force XXI.

STO Manager:	**TSO:**	**TRADOC POC:**
Stuart Horn	Carolyn Nash	Charles Campbell
CERDEC NVESD	SARD-TT	MBS BL
703-704-2025	697-8432	502-624-1963

IV.R.14. Multi-Wavelength Multifunction Laser. Develop and demonstrate high efficiency, compact, laser diode pumped, wavelength diverse laser source in the 0.26 - 5 micron spectral region and system controller software for multi-functional applications. By FY96, develop high (up to 1 Khz) repetition rate laser module with multiple wavelength outputs from 0.26 - 5 microns for countermeasures (near IR, mid IR), obstacle avoidance, biological agent detection, rangefinding, enhanced target recognition, and laser radar for integration with vehicle target acquisition sensors. By FY97, complete software for limited functional applications and integrate laser module with Target Acquisition ATD. By FY99, complete development of multi-application software and demonstrate common approach to multi-function and multi-application laser source.

Supports: Dismounted Battlespace, Mounted Battlespace, Depth and Simultaneous Attack, Battle Command, Early Entry Lethality and Survivability.

STO Manager:	**TSO:**	**TRADOC POC:**
Ward Trussel	Carolyn Nash	Tom Mims
CERDEC/NVESD	SARD-TT	BC-BL
703-704-1355	697-8432	706-791-2800

IV.R.15. Solid State Near IR Sensors. Develop a low cost, lightweight, low light level, exclusively solid state sensor with smart readout chip to provide a digital output and become an integral part of the future Digital Battlefield. This technology will provide affordable, high resolution sensors for reflected light in the 0.4-1.8 micron wavelength region for systems supporting airborne, combat vehicle, and light infantry missions. This sensor technology will be immune to bright light "flash-outs" and require no vacuum tube technology. These sensors will have high resolution and sensitivity to detect sniper fire, detect targets through conventional camouflage, detect laser rangefinders/designators, and detect stressed vegetation. By FY99, develop a low cost solid state near IR camera that demonstrates comparable sensitivity to present I2 tubes and can be transitioned as an HTI for all future vision devices. By FY00, develop a large format near IR solid state focal plane array that can be used for sniper scope applications and pick out targets in camouflage at long ranges. By FY01, demonstrate a near IR sensor for lightweight goggle applications.

Supports: Objective Sniper Weapon, OICW/OCSW Upgrades, Future Multispectral Goggles, Future Driving Devices, Special Operations

STO Manager:	**TSO:**	**TRADOC POC:**
Phil Perconti	Carolyn Nash	Chris Kearns
CERDEC NVESD	SARD-TT	DBL
703-704-1369	697-8432	706-545-6391

IV.R.16. Advanced Signature Management and Deception. Demonstrate technologies that enable development of signature management (SMS) and deception systems which deny acquisition of friendly force assets from threat sensors. Demonstrations will be supported by signature characterization, modeling, and simulation conducted under the Integrated Sensor Modeling and Simulation effort. These SMS/deception systems provide mobile and semi-mobile assets with low cost, low operational burden survivability upgrades addressing detection avoidance in global battlefield conditions. By FY99, develop reactive IR suppressive coatings/appliqués/structures to reduce vehicle and solar loading signatures over an extended period of a diurnal cycle and in varying backgrounds. Complete feasibility study for battlefield deception technologies. By FY00, develop a hybrid SMS to reduce the detection range of tactical, mine warfare, and fire support vehicles by 50 percent and an ULCANS screen that significantly reduces the signature of general purpose platforms in a desert/urban environment. By FY01, demonstrate synergistic coupling of physical and virtual decoys with passive and active signature management to improve survivability of combat and combat support units. By FY02, develop a multispectral SMS and deception system operating in the radar, infrared, and visual spectrums for tactical, mine warfare, fire support, and combat vehicles.

Supports: ULCANS P3I, Multispectral Camouflage System, Light/Medium Tactical Vehicles, LRAS3, Abrams, Bradley, Crusader, Ground-Based Sensor, THAAD, Aviation Systems, BIDS, SICIPS.

STO Manager:	**TSO:**	**TRADOC POC:**
Grayson Walker	Carolyn Nash	Charles Campbell
CERDEC/NVESD	SARD-TT	MBS BL
703-704-2594	697-8432	502-624-1963

IV.R.17. Integrated Sensor Modeling and Simulation. Advance the state-of-the-art in synergistic modeling and prototyping capabilities to permit end-to-end predictive modeling and hardware trade-offs for performance evaluation of new technologies in a virtual environment. Implementation will be supported by development of high resolution, 3-dimensional target, background, and clutter object databases which scale from dismounted infantry to airborne applications. Features will also include realistic portrayal of advanced sensors such as 3rd gen FLIRs, acoustics, and radars; aided, automatic, and fused sensor usage; low observable signature management techniques; and mine targets. Linked or inserted into operational simulations, this technology will allow warfighters to test new capabilities, develop tactics and techniques, evaluate operational effectiveness, plan missions, and train in parallel with the hardware development process. By FY99, develop real-time multi-spectral (0.4 to 14 microns) capability for insertion into wargame simulations. By FY00, develop and integrate SAR and MMW capability for insertion into wargame simulations. By FY01, validate multi-spectral portrayal for search and target acquisition simulations and implementation for driving and pilotage simulations.

Supports: Multifunction Staring Sensor Suite, Masked Targeting, Mine Hunter Killer, Battlefield Visualization ACTD, MOUT ACTD, CATT, COFT, AGTS, FMBT, FIV, FSV.

STO Manager:	**TSO:**	**TRADOC POC:**
Luanne Obert	Carolyn Nash	Charles Campbell
CERDEC/NVESD	SARD-TT	MBS BL
(703) 704-1754	697-8432	502-624-1963

S. GROUND VEHICLES

IV.S.01. Advanced Protection and Protection Design Technology. By FY94, complete and document the Protection Areal density design methodology for hard-faced armors to achieve 25 percent reduction in amount of testing required to define a minimum weight armor design. [TACOM] By FY94, conduct a feasibility demonstration of an armor technology achieving weight savings by using electromagnetic defeat mechanisms. [TACOM funded, ARL (WTD) execution] By FY95, demonstrate an armor for medium weight combat vehicles that defeats the medium caliber KE threat. By FY96, enhance this armor to include CE threats. By FY96, demonstrate an armor to defeat future top attack threats. By FY99, demonstrate armor penetration modeling capability including 3-D effects, material strength, and fracture mechanics that will provide 25 percent reduction in test costs for design of armors against CE jets and heavy metal KE penetrators. [TACOM funded, ARL (WTD) execution, DARPA technology contribution] By FY99, demonstrate a frontal armor system capable of defeating all tank gun launched threats at 65 percent of the weight of current Abrams armor. [TACOM funded, ARL (WTD, MD) technology execution, TACOM integration analysis]

Supports: Crusader, FCS, Abrams and Bradley Upgrades.

STO Manager:	**TSO:**	**TRADOC POC:**
James Thompson	John Appel	Al Winkenhofer
TARDEC	SARD-TT	Armor Center, DFD
810-574-5780	697-8432	(502)624-8064

IV.S.02. North Finding Module. By FY97, demonstrate a compact, self contained, affordable ($5–$10K/unit), azimuth measurement device with an accuracy of 5 to 10 mils and the capability to provide initial measurements within 3 minutes when static or 1 minute when moving. More accurate and timely azimuth data is critical to target handoff accuracy, use of situational awareness data for Combat ID, and full use of GPS data. The North Finding Module will overcome weakness of GPS alone (jamming, occlusion, multipath, etc.) through the use of inertial measurement systems (Interferometric Fiber Optic Gyro, Dynamically Tuned Gyro) and will provide synergy with GPS on the digital battlefield at a low cost-performance ratio. The module could also be used on instrumented ranges such as the National Training Center as a sensor for battle control and scoring.

Supports: Hunter Sensor Suite, Remote Sentry, Precision Guided Mortar Munition, Objective Combat Weapon ATDs; RFPI; PM Combat ID, PM Mortars.

STO Manager:	**TSO:**	**TRADOC POC:**
Jonathan Bornstein	Catherine Kominos	Charles Campbell
ARL-WMR	SARD-TR	MBS BL
410-278-3737	697-3558	502-624-1963

IV.S.03. Advanced Mobility Systems. Demonstrate a new level of cross country mobility with significant improvement over the Abrams/Bradley baseline in the following areas: deployment enhancement by virtue of size and weight (50 percent); increased vehicle survivability by virtue of size, weight, lower heat rejection, and increased dash speed (50 percent); vehicle hull weight and volume reduction (25 percent); increased vehicle range (30 percent); increased design flexibility; increased vehicle burst power when integrated with energy storage (100 percent); quantum improvement in vehicle diagnostics and prognostics resulting from electrical power transfer (100 percent); and improved gun platform stability (30 percent). Critical technical ingredients of this advanced mobility system include: advanced electric drive, advanced suspension system employing adaptive damping and spring rate high wheel travel, and lightweight track. Reliability and Availability will be enhanced over the Bradley/Abrams baseline by virtue of increased use of electronics, smaller size and weight, and increased use of modular components. Selected mobility components will be available for ATD demonstration in 1997. The following new technologies will be demonstrated: advanced motor and generator configurations for electric drive, advanced high power controller packaging, adaptive suspension damping (tracked vehicle), full active suspension, active track retention system, continuous band type track, advance traction control.

Supports: FCS, FSCS, Electric armaments and future electrically-driven vehicles, Crusader, CAV ATD, Abrams and Bradley Upgrades.

STO Manager:	**TSO:**	**TRADOC POC:**
Dan Herrera	John Appel	MAJ Monroe Harden
TARDEC	SARD-TT	Armor Center DFD
(810)574-6411	697-8432	(502)624-4412

IV.S.04. Inertial Reticle Technology. By FY98, demonstrate an inertial reticle fire control system (IRS) that can be used for the control of weapons systems on a variety of platforms: HMMWV, AGS, BFV, helicopters, and unmanned ground vehicles. The primary focus will be the development of a semi-automated weapons station including IRS fire control system and operator control unit integrated with a semiautomatic weapon on a simple pan and tilt platform. This program uses sensor technology to create a virtually stabilized weapon platform that permits automatic tracking of targets, improves weapon control, and reduces crew exposure to hostile environments. Intermediate developmental steps include incorporation of the IRS into a semi-autonomous weapons station on a manned platform during FY96; subsequent integration of target tracking, image stabilization, and target cueing in FY97; culminating in integration and demonstration on a variety of platforms in FY98. Application of the IRS fire control system to direct fire weapons will improve their accuracy when fired on the move to the level of that while stationary. The IRS fire control system will improve Army warfighting capabilities through increased weapons lethality and improved crew survivability.

Supports: ARDEC, TARDEC, CERDEC, Dismounted Battlespace Battle Lab, Mounted Battlespace Battle Lab.

STO Manager:	**TSO:**	**TRADOC POC:**
B. T. Haug	Catherine Kominos	Chris Kearns
ARL-WMR	SARD-TR	DBL
410-278-6518	697-3558	706-545-6391

IV.S.05. Virtual Prototyping Integrated Infrastructure. By FY99, this initiative will develop and demonstrate a synergistic, distributed, complete virtual prototyping infrastructure that can integrate and interface advanced concepts in mobility, survivability, electronics, lethality, command and control, design, and manufacturing into any phase of a system's life cycle. The technology will directly support a system evolution record that will record not only design decisions, but also details on why and how the decisions were made. For efficiency, the infrastructure will be Common Object Request Broker Architecture (CORBA) compliant. Even though future threats will have access to the same technology as U.S. forces, this new capability will ensure Force XXI can maintain a technological advantage on the battlefield by providing the ability to apply new technology in combat systems faster than the threat. In addition, this STO will enable the Army to develop and deploy combat systems faster, with less cost, and more user effectiveness than any existing or future threat. The Virtual Prototyping Infrastructure will be compliant and compatible with Force XXI synthetic theater of war (STOW) requirements.

Milestones include:

- Preliminary design of information kernel and functional interface complete (3Q96).
- Detailed design of information kernel and functional interface completed (3Q97).
- Phase I evaluation completed (reduce development time, cost, and testing by one half over standard development cycle using sample combat concept test cases 3Q98).
- Phase II evaluation completed (reduce time and cost of implementing major structural/electrical design changes/upgrades in an existing combat system by one half over standard reengineering methods, 3Q99).
- System Demonstration Completed (4Q99).

Supports: Programs—FCS, FSCS, Crusader, Abrams and Bradley Upgrades, and Tactical Wheeled Vehicles. Dual Use Potential—Commercial vehicle design and development process.

STO Manager:	**TSO:**	**TRADOC POC:**
Art Adlam	John Appel	Al Winkenhofer
TARDEC	SARD-TT	Armor Center, DFD
(810)574-3803	697-8432	(502)624-8064

IV.S.06. Detection Avoidance for FSCS. By FY00, develop and demonstrate optimized vehicle components which provide reduced signatures with integrated ballistic protection for application to integrate Future Scout and Cavalry System (FSCS) overall survivability. Signature suppression of new ballistic grills and side armor that is FSCS specific will utilize technology from current vehicle and material development programs. These improved components will reduce vehicle signatures while maintaining or enhancing ballistic protection levels. This integrated approach shall also consider the other survivability technologies such as EW and active protection systems. To accomplish the balanced survivability requirement, an initial survivability study will determine the optimized suite for FSCS requirements. Milestones include:

- Initial FSCS balanced study results (3Q97).
- Demonstrate suppressed inlet grills with 50 percent signature reduction goal (4Q96).
- Ballistic and signature optmized warning components (4Q97).
- Demonstration of FSCS side ballistic panels with 50 percent reduction goal (4Q98).
- Optimized side ballistic panel demonstration with 75 percent reduction goal (4Q00).

Supports: FSCS, FCS, Abrams and Bradley upgrades, and Tactical Vehicles.

STO Manager:	**TSO:**	**TRADOC POC:**
David Thomas	John Appel	MAJ Paul Begeman
TARDEC	SARD-TT	Armor Center, DFD
810-574-8911	697-8432	(502)624-8994

IV.S.07. Laser Protection for Ground Vehicle Vision Systems. By mid-FY99, demonstrate retrofittable wide angle optical viewing system design which can incorporate limiting or dispersive materials. These new optical systems could replace the current vision blocks and periscopes found in ground vehicles allowing the soldier to view the battlefield while protected from eye damaging laser energy including frequency agile laser weapons.

Supports: Abrams, Bradley, M113 Upgrades, Crusader, FSCS, FCS.

STO Manager:	**TSO:**	**TRADOC POC:**
Templeton/Pease	John Appel	A. Winkenhofer
TARDEC-NRDEC	SARD-TT	Armor Center, DFD
(810)574-5325	697-8432	(502)624-8064

IV.S.08. Tank Mobility Technology. By FY02, demonstrate critical engine, electric drive, track and suspension technologies to support the mobility field demonstration of the Future Combat System. The electric drive technology is developed through a joint coordinated effort among DARPA, Army, and USMC program offices. Specific products include: generators, storage devices (Flywheels, batteries, capacitors) and power electronics switching devices. All combat electric technologies will be demonstrated by the year 2002 in the lab and on a testbed. The engine development work will focus on high power density, low heat rejection single cylinder diesel engine technology efforts directed toward an extremely compact propulsion system. The track improvement will include advanced track and a track tension system. The advanced track will use nitrile rubber which will increase track pad life to 3,000 miles. Track retention will be actively controlled. Active control enables optimization of vehicle performance by reducing rolling resistance without increasing incidence of track misguide. Reduced rolling resistance requires less horsepower and reduces O&S costs by increasing fuel economy and track bushing life. The suspension technology development will include semiactive/active hydropneumatic and active electric suspension system. These mobility advances will enhance system survivability and operational effectiveness through smaller and lighter systems, improved ride quality, increased agility, improved platform stability, reduced acoustic and IR signatures, and silent operations capability.

By FY98, determine Active Suspension requirements and demonstrate SiC based switches. By FY99, demonstration of PEBB MOS controlled Thyristors. By FY00, identify and demonstrate advanced storage devices. By FY01, demonstrate track tensioner and nitrile track and demonstrate upgraded SiC devices. By FY02: (1) complete single unit active suspension lab testing; (2) demonstrate a single cylinder high power density engine of 1.5 hp/cu.in and specific heat rejection of 18 BTU/hp-min; and (3) formulate FCS engine concepts and engine development approach selection. By FY03, demonstrate all electric Combat Vehicle technology on a testbed.

Supports: Future Combat Systems (FCS), Future Infantry Vehicle. Tank ICT.

STO Manager:	**TSO:**	**TRADOC POC:**
Dan Herrera	John Appel	MAJ Monroe Harden
TARDEC	SARD-TT	Armor Center DFD
(810)574-6411	697-8432	(502)624-4412

T. MANUFACTURING SCIENCE AND TECHNOLOGY

IV.T.05. Simulation of Manufacturing Processes (Virtual Factory). By FY95, develop and demonstrate a prototype modeling and simulation environment (Virtual Factory) for the Resin Transfer Molding (RTM) manufacturing process using high performance computers and distributed interactive simulation between industry, federal labs, and engineering centers. Demonstration will focus on manufacturing composite preforms and insert materials using the RAH-66 Comanche keel beam production as a baseline. By FY97, demonstrate an extended modeling and simulation capability for the manufacturing of thick composite structures in support of the Composite Armored Vehicle ATD hull requirements. Virtual Factory simulation will enable improvements in materials performance and reduced manufacturing costs for dual use military and civilian applications.

Supports: Composite Armor Vehicle ATD, RAH-66 Comanche.

STO Manager:	**TSO:**	**TRADOC POC:**
Walter Roy	Catherine Kominos	Charles Campbell
ARL-WMR	SARD-TR	MBS BL
410-278-0267	697-3558	502-624-1963

IV.T.06. Armament Decision Aids. In FY97, investigate armament decision aids using techniques may include rule-based reasoning, fuzzy logic, artificial neural nets, or a combination of the three, and interface requirements for fire support elements in a maneuver environment. In FY98, conduct object oriented analysis of advanced reasoning and AI techniques implemented in a set of software components for use by fire support elements capable of operating with a maneuver force. In FY99, integrate software components with existing platform vetronics. The components will be designed with the ability to be configured in a distributed (inter-netted) as well as an embedded environment. In FY00, demonstrate software components, reason on digital terrain data with a 50 percent reduction in time required to respond, and fire while operating with a maneuver force as compared to current methods.

Supports: Crusader, Paladin P3I, Mounted Battle Lab

STO Manager:	**TSO:**	**TRADOC POC:**
Victor Yarosh	John Appel	(TBD)
ARDEC	SARD-TT	
201-724-3524	697-8432	

IV.T.07. Battlefield Acoustic Sensors. In FY97, initiate the development of acoustic sensor modeling tools to be used to simulate and predict acoustic sensor performance in various propagation environments, engagement scenarios, and translate user requirements to acoustic sensor design parameters. In FY98, verify performance acoustic sensor model against target acoustic signatures in specific propagation environments, and initiate development of sensor emplacement algorithms based on environmental sensor measurement data. In FY99, develop prototype environmental characterization, propagation prediction, and artificial intelligence rule-based sensor deployment algorithms, and initiate integration of environmental sensors (e.g., temperature and wind) with an acoustic sensor package. In FY00, demonstrate capability of environmental sensors integrated with an acoustic sensor as a decision tool to assist battlefield commanders for optimal deployment of acoustic sensor systems in various propagation conditions and engagement scenarios.

Supports: WAM PIP, IMF, RFPI ACTD, Hunter Sensor ATD, FSCS.

STO Manager:	**TSO:**	**TRADOC POC:**
Jeffrey R. Heberley	John Appel	CPT Scott O'Neil
ARDEC	SARD-TT	Ft. Benning, Dismounted BL
201-724-6255	697-8432	706-545-6382

SCIENCE AND TECHNOLOGHY OBJECTIVES (STOs) FOR CHAPTER VI: INFRASTRUCTURE

C. THE ARMY'S SUPPORTING INFRASTRUCTURE

VI.C.02. Smart Weapon Operability Enhancement. By the end of FY94, develop analytical IR and basic MMW models to simulate the geographical and time/weather driven character of environmental scenes. By the end of FY96, develop validated multi-sensor scene generation capability to allow quantitative consideration of environmental conditions in the design, test, and evaluation of smart weapon and ATR devices. By the end of FY97, extend scene generation capability to encompass RF band weapon systems for global operations.

Supports: Precision Strike, Advanced Land Combat, Synthetic Environments.

STO Manager:	TSO:	TRADOC POC:
Pat Welsh	Donald Artis	Franz Westermeier
CRREL	SARD-TR	USA Engineer School
603-646-4527	(703)697-3558	314-563-7350

VI.C.03. Battlefield Visualization Technologies. By FY97, demonstrate and apply the use of these developments in a virtual reality environment for tactical and training applications. Technology deliverables will allow the soldier to be placed in a "real environment" with replicated actual terrain and climate driven weather, enabling a realistic view with a high level of detail for training and/or mission rehearsal exercises. Intelligence imagery will be used in conjunction with image perspective transformation technology to provide sub-ten meter (current baseline 30 meter) content and position reality.

Supports: Digital Topographic Support System, Army Command and Control Systems, Combined Arms Tactical Trainer, LAM, TDATD.

STO Manager:	TSO:	TRADOC POC:
Thomas Jorgensen	Donald Artis	LTC Doug Campbell
USATEC	SARD-TR	U.S. Army Engineer School
(703)428-6838	(703)697-3558	314-563-4077

VI.C.10. Information Distribution Technology (IDT). By FY95, develop adaptive information distribution techniques (software that maximizes throughput of critical, relevant battlefield information) that allow information exchange to vary automatically in low bandwidth, limited environments (SINCGARS). Provide the first capability to automatically throttle information distribution based on information requirements balanced against network performance. By FY97, provide an IDT capability that responds to complete information exchange failures when information distribution is totally automated. Provide the first capability to automatically respond to intermittent network failures by using computationally intensive techniques for clear network assessment based on passive network monitoring. By FY99, demonstrate scalability of this IDT to large systems of communication nodes (e.g., armored vehicles and aviation assets in a Division) to provide a sound, long-term solution to situational awareness and interoperable C2 on the move.

Supports: Digitization of the Battlefield; CAC2 ATD; BC2 ATD; C2 Situational Awareness; Logistic Information Distribution; Theater Missile Defense; Paramilitary (Police, fire, paramedic); Patient Monitoring; Industrial Distributed Process.

STO Manager:	**TSO:**	**TRADOC POC:**
Sam Chamberlain	Catherine Kominos	Tom Mims
ARL, IST	SARD-TR	BC-BL
410-278-8948	697-3558	706-791-2800

VI.C.16. Soldier System Modeling (SSM). Develop an automated environment to enhance analytic capabilities and promote rigorous Soldier System cost/benefit analyses to quantify and evaluate equipment, operational policy, and training within a system context. By FY95, SSM will integrate models and data into a framework to facilitate multiple analytic functions with completion of the first generation system software for use in 21 CLW analyses. By FY96, provide modeling, simulation, and analysis supporting 21CLW field demonstration to quantify and maximize the viability/capability of proposed systems. By FY97, integrate into the ComputerMan Wound Ballistic Vulnerability Model the methodologies to assess vulnerability across the full range of MOSs. Conduct analyses to define optimal survivability, mobility, and lethality concepts. By FY99, provide a Distributed Interactive Simulation (DIS) compliant methodology to assess the results of the soldier system demonstrations and to provide a basis for future COEAs.

Supports: Force XXI Land Warrior.

STO Manager:	**TSO:**	**TRADOC POC:**
John O'Keefe	Bill Brower	Chris Kearns
NRDEC	SARD-TR	DBL
508-233-4881	697-8432	706-545-6391

VI.C.17. Digital Topographic Data (DTD) Standardization. Provide an effective architecture for assuring that digital topographic data (DTD) can be directly imported and processed by standardized Mapping, Charting, and Geodesy (MC&G) software to increase system interoperability in Army and/or joint operations. Develop written procedures for preparing MC&G software for submission to the Army Reuse Center. In FY97, populate DoD reuse libraries with common MC&G applications which require basic tools. Develop evaluation criteria which can be used to validate the effectiveness of standard DTD software across multiple systems.

Supports: C4I, BDS, CATT, Synthetic Environments

STO Manager:	**TSO:**	**TRADOC POC:**
Richard Joy	Donald Artis	LTC Doug Campbell
TEC	SARD-TR	U.S. Army Engineer School
703-428-6505	(703) 697-3558	314-563-4077

VI.C.19. Individual Combat Simulation in the Synthetic Environment. This program provides and demonstrates technologies for creating multi-sensory, real-time simulation which immerses the individual and allows for interaction in three-dimensional geographical space. A multi-site, distributed laboratory will be established which incorporates concepts and principles consistent with the evolving DoD M&S High Level Architecture (HLA). The cost effectiveness of networked virtual reality devices to immerse the individual into the synthetic environment will be determined. By FY96, the requirements for a mobility platform for an individual combatant simulator will be established, based upon empirical research using the Individual Soldier Mobility Simulator (ISMS). Software to interface the ISMS to synthetic environments will be developed. Studies will be conducted and guidelines will be published for use by metabolic platform developers. By FY97, the program will demonstrate an initial capability to provide individual combatant mobility and interaction in the synthetic environment. By FY98, the program will provide a demonstrated capability to fully immerse the live combatant in the synthetic environment to include control of semi-automated forces through voice and gesture recognition.

Supports: Force XXI Land Warrior Program, STOW, Combined Arms Tactical Trainers (CATT) Program, MOUT ACTD, Small Unit Operations (SUO).

STO Manager:	**TSO:**	**TRADOC POC:**
Gene Wiehagen	Robert Rohde	Diane Schuetze
STRICOM	SARD-TR	Battle Lab Integration and Technology Directorate
407-384-3930	703-6995-1447	804-727-3712

VI.C.20. Computer Generated Forces. Demonstrate intelligent computer generated force simulation technologies for battalion, division, corps, echelon above corps, and joint level forces. Determine the critical behaviors and essential characteristics which must be exhibited for each force level. Define the methodology and computational approach for full level force representation, with the capability to be reconfigurable to varying battlefield behavior. In FY97, improve tools for ModSAF (ground); continue ModSAF/CGF VV&A; and improve behavioral algorithms. In FY98, develop and demonstrate Intelligent Interactive Adversary; deliver improved DI Saf Baseline; deliver ModSAF CGF Voice I/O. In FY99, deliver ModSAF/CGF 3D interface; improve C4 simulation for varying echelons; develop and demonstrate realistic intelligence simulation. FY00 and FY01, improve intelligence models; improve CGF Voice I/O; improve behavioral algorithms.

Supports: ModSAF, PM DIS, PM CATT, Force XXI, STOW, Battlespace Command and Control ATD.

STO Manager:	**TSO:**	**TRADOC POC:**
Gene Wiehagen	Robert Rohde	Diane Schuetze
STRICOM	SARD-TR	Battle Lab Integration and Technology Directorate
407-384-3930	703-695-1447	804-727-3712

VI.C.21. Inter-Vehicle Embedded Simulation Technology (INVEST). By FY00, develop and demonstrate in-vehicle Advanced Distributed Simulation (ADS) capability employing common reusable simulation components, interfaces, tutoring systems, take home packages, and scenarios. This effort will determine the specific Embedded Training (ET) architecture and common hardware and software components required for individuals and crews to maintain system proficiency while in-vehicle and on-station. It will enable units to conduct collective training, exercises, or mission rehearsals autonomously or when networked with other "live" or "virtual" simulations. The effort will also assess which tasks and skills are appropriate and affordable candidates for embedding and how this capability may augment the simulations systems in the existing training device simulation/simulator (TDSS) hierarchy. A standard ET simulation architecture using common components will permit development of a consistent synthetic battlefield representation for use in all ET systems and improve interoperability and affordability among future systems.

By FY97, establish ET test bed which uses existing virtual simulations and live systems (BFV) to prototype and assess ET architecture and common components. With TRADOC, initiate studies and analysis to determine hierarchy of embedded training capability. With TARDEC, assess databus loading, timing, sizing, RAM, and related impacts of ET to Intra-Vehicle Electronics Suite. Initiate experiments and assess approaches to enable "direct-fire" or "line-of-sight" interactions between live and virtual systems. Assess commercial image generator technology to determine feasibility of displaying virtual targets on vehicle systems. With CECOM, continue development of live to virtual linkage of C4I systems. By 98, develop and prototype ET modular hardware and software common components. Prototype Virtual-Live interactive system. Link STRICOM ET Test bed with TACOM VETRONICS Systems Integration Laboratory (VSIL) and CECOM Digital Integrated Lab (DIL). By FY99, tailor and integrate standard ET common components to Future Scout and Cavalry System (FSCS) ATD program. With TRADOC, initiate development of prototype training scenarios and data bases. By FY00, support TARDEC with in-vehicle DIS experiments using Intra-Vehicle Electronics Suite.

Supports: Future Scout and Cavalry System (FSCS), Future Combat System (FSC), M1A2 and M2A3 Upgrades, CRUSADER, Digitization of the Battlefield, TASK Force XXT, Open Systems Task Force, and Army Technical Architecture.

STO Manager:	**TSO:**	**TRADOC POC:**
Gene Wiehagen	Robert Rohde	MAJ Sean Mahan
STRICOM	SARD-TR	BCTD
407-384-3930	697-8432	913-684-7838
970-3930	227-8432	552-7838

Annex B

ADVANCED TECHNOLOGY DEMONSTRATIONS (ATDs)

CONTENTS
CURRENT ATDs

FY 95 Starts

FY 96 Starts

FY 97 Starts

FY 98 Starts

CURRENT ARMY ACTDs

Approved ACTDs

CURRENT ATDs

ROTORCRAFT PILOT'S ASSOCIATE ATD
STO #III.D.1

Objective:

Develop a cooperative interdependent man/machine system that uses and understands the volume and quality of internal and external information available to achieve maximum effectiveness and survivability for our combat helicopter forces.

- Revolutionary MEP technologies
- High speed data fusion processing
- Cognitive decision aiding expert systems

Justification:

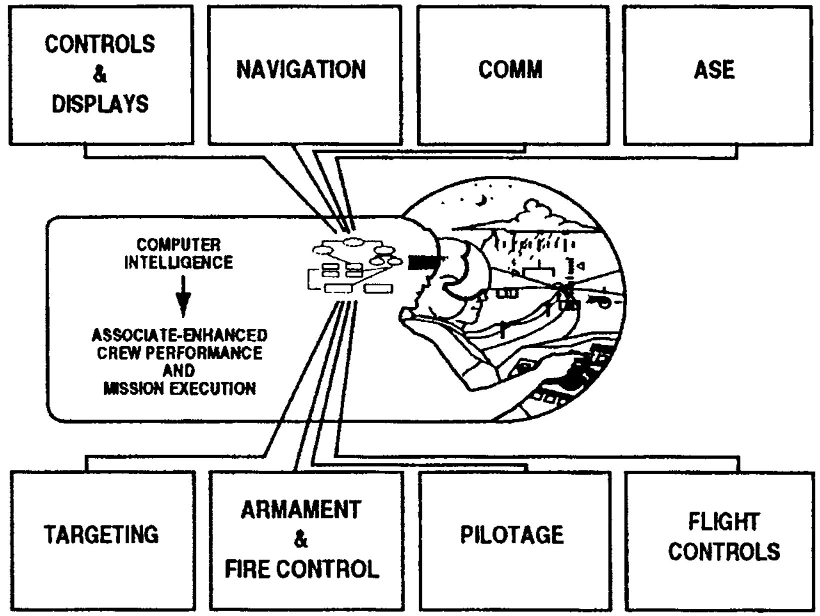
- Reduction in mission losses 30–60%
- Increase in targets destroyed 50–150%
- Reduction in mission timelines 20–30%

Battlelab:

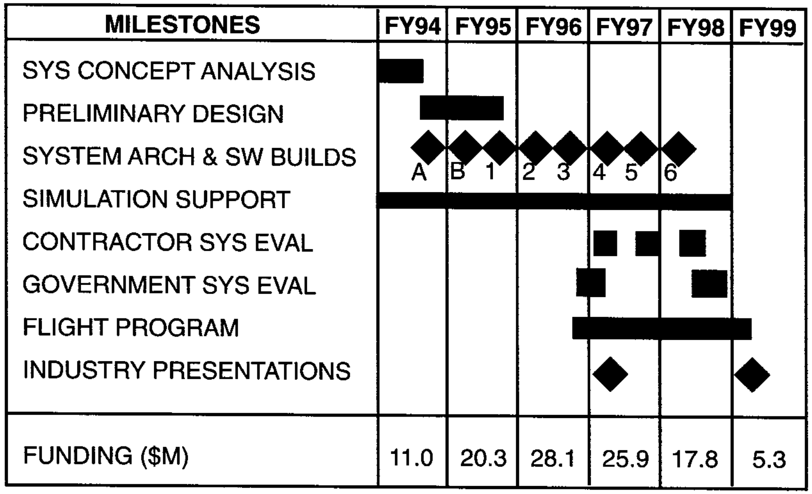
- Mounted Battlespace

PEO:

- Aviation



Schedule and Funding:



Approach:

Structure an iterative development process which gathers knowledge, uses rapid prototyping to develop CDAS software, uses simulation to evaluate the system performance, and uses the knowledge from the evaluation to feed the next iteration.

FY94-96:

- Design and develop CDA and integrate software
- Conduct initial combined arms simulation in DIS

FY97–98:

- Complete CDA development and integration
- Conduct virtual and constructive simulation and flight test evaluations

FY99:

- Complete data analysis and report

Applications:

RAH-66 Comanche, AH-64 Apache Improvements, OH-58D AHIP, SOA, A2C2S, AMPS, Improved Cargo Helicopter (ICH)

ROTORCRAFT PILOT'S ASSOCIATE ATD EXIT CRITERIA

OPERATIONAL CAPABILITY	RAH-66 COMANCHE BASELINE	END ATD	
		MINIMUM (%)	GOAL (%)
SYSTEM LEVEL:			
• Reduction in Mission Losses	1	30	60
• Increased Targets Destroyed	1	50	150
• Reduction in Mission Timelines	1	20	30
SUBSYSTEM LEVEL:			
• *Decrease in Time Exposed to Threat*	1	15	30
• Reduction in Blue Losses During Engagement	1	30	80
• Improvement in Onboard Sensors	1	50	100
• Increased INTEL Information for Threat Location	1	50	100
• Improvement in Target Acquisition	1	30	100
• Improvement in Missile/Gun Capability	1	30	50
• Improvement in Loss Exchange Ratio	1	30	100
• Reduction in Mission Replanning Time	1	20	50
• Decreased Flight Time to Accomplish Mission	1	12	30
• Improvement in Obstacle/Terrain Detection	1	70	90

BATTLEFIELD COMBAT IDENTIFICATION (BCID) ATD
STO #III.#.07

Objective: Improve Combat Effectiveness and Substantially Reduce Fratricide

- Demonstrate a Fully Digitized SA/Target ID Capability at Platform Level Within a Digitized Task Force (Enhanced BCIS)
- Demonstrate Multiple System Concepts for Rotary Wing and Fixed Wing to Ground Combat ID
- Establish Technical Baseline for Joint Service ACTD for Integrated Ground-to-Ground and Air-to-Ground Combat ID
- Demonstrate Lightweight, Vehicle Interoperable Combat ID Concepts for Dismounted Soldier Application Including Functional Integration Into Land Warrior System
- Demonstrate Advanced Concepts for a Fully Digitized Friend and Foe, Target ID/Target Acquisition/SA Capability

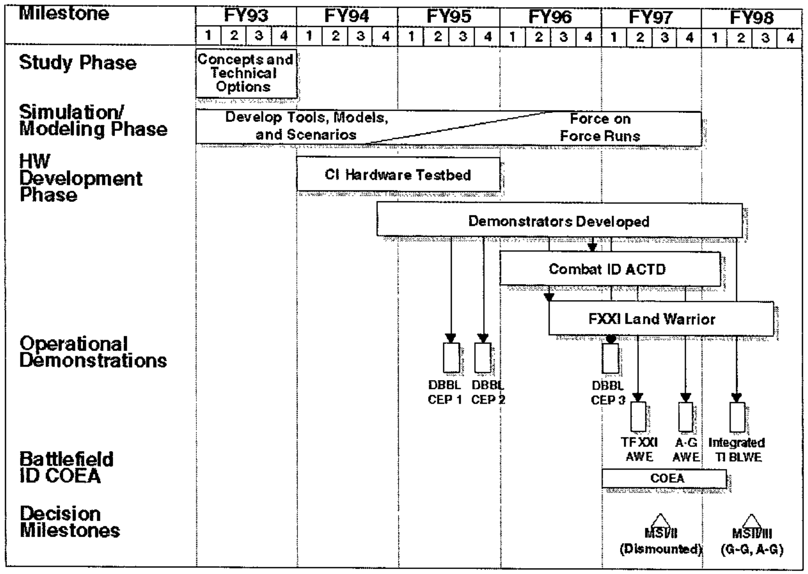
Justification:

- Battlefield Combat ID ORD
- Draft ORD for Dismounted Soldier Combat ID System

Proponents:
MBBL, DBBL

Acquisition:
PEO IEW (PMCI)

Schedule and Funding:



Approach:

Ground-to-Ground	Dismounted Soldier
• Enhanced BCIS • SA Through Sight • DDL(+) • Laser/RF	• Interoperable Laser/RF • Functional Integration Into Land Warrior Suite
Air-to-Ground	**Modeling and Simulation**
• BCIS Pod • SINCGARS SIP(+) • Enhanced FAC • MK XII/GPS	• G-G, A-G, and Dismounted Soldier

Applications:

- All U.S., NATO and Potential Coalition Combat, Combat Support, and Combat Service Support Systems

BATTLEFIELD COMBAT IDENTIFICATION (BCID) ATD EXIT CRITERIA

OPERATIONAL CAPABILITY	CURRENT BASELINE	ATD MINIMUM	ATD GOAL	ACHIEVEMENTS TO DATE
Target Identification (Friend)				
Ground-to-Ground	Combat ID Panels (Limited by Weather and Man-in-Loop Performance)	Improved BCIS	Improved BCIS	Improved BCIS
P_{ID}		98%	99%	98%
ID Range		5.5 km	5.5 km	>5.5 km
ID Time		<1 sec	<1 sec	<1 sec
Rotary Wing-to-Ground	(No Cooperative ID Capability)			SINCGARS SIP(+)
P_{ID}		90%	99%	> 90%
ID Range		8 km	8 km	> 12 km
ID Time		<4 sec	<1 sec	2.3 sec
Fixed Wing-to-Ground	(No Cooperative Capability)			
P_{ID}		TBD (ACTD)	TBD (ACTD)	Enhanced FAC
ID Range		TBD (ACTD)	TBD (ACTD)	Concept
ID Time		TBD (ACTD)	TBD (ACTD)	Demonstrated
Dismounted Soldier	Visual and Budd Lights (Limited by Weather and Man-in-Loop Performance)			Laser/RF
P_{ID}		95%	99%	93%@1km
ID Range		>1.5 km	>2 km	2.4 km Max
ID Time		<1 sec	<1 sec	<1 sec
Weight		<4 lb	<2 lb	4 lb
Target Identification (Foe & Neutral) Ground-to-Ground	1st Gen FLIR (Manual Operation)	Leverage Non-Cooperative Sensors - 2nd Gen FLIR - IDS - PLAID	Leverage Non-Cooperative Sensors - 2nd Gen FLIR - IDS - PLAID	BCIS/IDS Virtual Simulation in Process
Situational Awareness Ground-to-Ground				
Position Accuracy	~500 Meters	100 Meters	50 Meters	BCIS DDL (12 sec GPS Position Updates Demonstrated)

INTELLIGENT MINEFIELD (IMF) ATD
STO #III.M.7

Objective:

To integrate new mine systems and new technologies into an optimized, logistically efficient, autonomous anti-armor barrier and demonstrate:

- Long range single point control and relay of target data in support of RFPI
- Minefield enhanced performance
- Planning and decision aids
- Provide acoustic sensor for RFPI ACTD

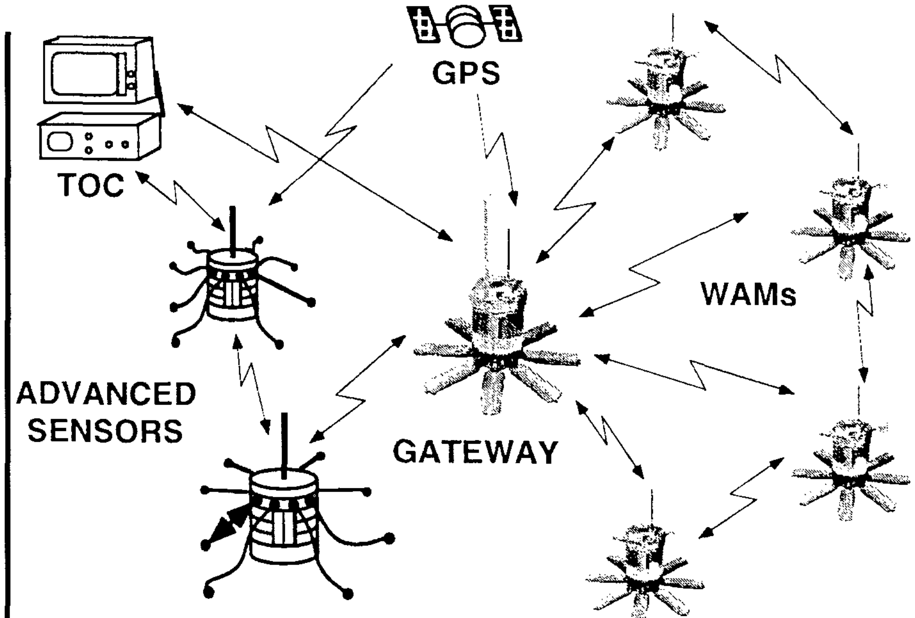
Justification:

- Demo 50 to 100% increase in minefield effectiveness
  - Reduces logistic burden of transportation and delivery
- Demo utility of remote control and observation
  - Increase targeting information resources
  - Provides maneuver freedom
  - Eliminates overwatch force
- Enhanced targeting/situational awareness through acoustics

Battlelab and PM Interest:

- Early Entry Lethality & Survivability (High)
- Mounted Battlespace (High)
- Dismounted Battlespace (High)
- Depth and Simultaneous Attack (High)
- MNS approved at DCSOPS
- DEM/VAL and EMD funds identified

MILESTONE	FY94	FY95	FY96	FY97	FY98	FY99	FY00	FY01
ATD (6.2 and 6.3)	2.3	3.2	5.4					
RFPI Spt (6.3)				2.2				
DEM/VAL (6.4)					4.1	4.6	4.6	



Approach:

- User involvement in concept development and evaluation through use of common simulation tools
- Use technology common to current mines and commo systems
- Use open architecture testbeds to evaluate HDW concepts with other virtual elements
- Field demos with user participation will validate full system effectiveness
- Development of DIS compatible simulator

Applications:

- Wide Area Munition (WAM)
- Future mine and demolition systems
- Countermobility Remote Control System (CIRCE)
- Targeting for NLOS systems
- Battlefield digitization

INTELLIGENT MINEFIELD (IMF) ATD EXIT CRITERIA

OPERATIONAL CAPABILITY	CURRENT BASELINE (WAM)	MINIMUM	GOAL	PROJECTED EMD REQUIREMENT
GATEWAY CONTROLLER				
Minefield Performance	Classified	+50%	+100%	+70% - 100%
Number of Systems	N/A	1	4	3
Range of Control Station	N/A	10 km	30 km	20-30 km
CONTROL STATION				
Number of Minefields	N/A	2	6	3-6
MCS/ATCCS Links	N/A	Yes	Yes	Yes
OVERWATCH SENSOR				
Range	0.6 - 0.8 km	2-3 km	3-5 km	3-5 km
Targets	2	7	15+	8-15

HUNTER SENSOR SUITE ATD
STO #III.H.02

Objective:

- Demonstrate a Lightweight, Deployable and Survivable Hunter Vehicle With Advanced Long Range Sensor Suite to Provide Rapid, Multiple Target Acquisition and Enhanced Target Hand-off for RFPI NLOS Killers.

Justification:

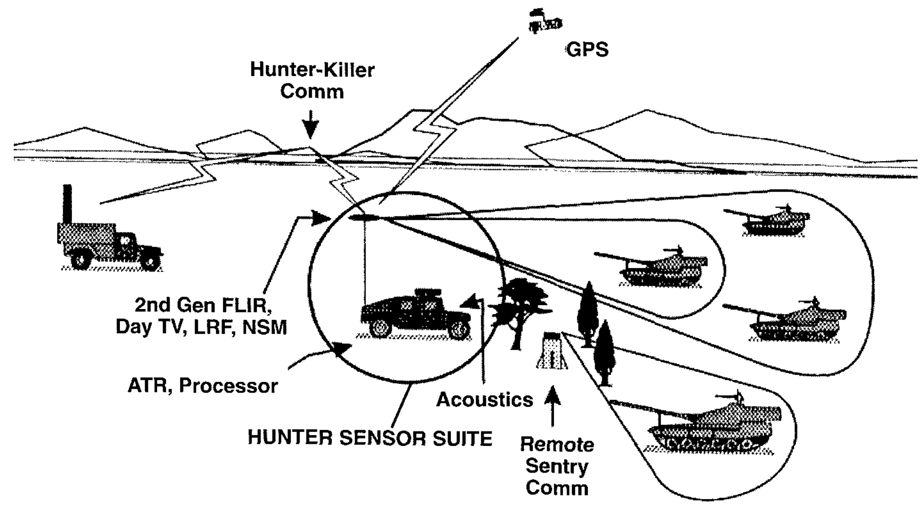
- Improves Survivability
  - Low Observable Platform and Sensor Payload
  - Long Range Target Acquisition and See-First/Shoot-First Capability
- Improves Lethality
  - Precision Targeting for Indirect Fire Weapons
  - Aided Target Recognition and Prioritization
  - Facilitates Battle Damage Assessment

Battle Lab:

- Dismounted Battlespace

PEO:

- IEW (Sensors) (PM NV/RSTAEO)
- GC&SS (Integration)



Schedule and Funding:

MILESTONES	FY93	FY94	FY95	FY96	FY97	FY98
Modeling and Simulation						
Mast Study						
AWEs						
RFPI Early Version Demo						
Sensors Development						
Demo Sensors						
Algorithm Mod/Processor Integ						
Image Comp/Transfer Impl						
RFPI Integration						
Final Report						
User Training						
RFPI ACTD						
Funding		4.4	10.1	12.6	11.4	0

Approach:

- On a Low Observable Platform, Integrate 2nd Generation Thermal Imaging, Acoustics Cueing Sensor, Day TV, and Eyesafe Laser Rangefinder Technology, Coupled with Modular ATR Algorithms & High Density Processor to Produce a Long Range Hunter Sensor System in an Operational Configuration
- Combine High Accuracy Position/Location Sensors, Image Compression Techniques, and Secure Communications to Hand-off Precision Targeting Information
- Utilize VPS to Evaluate Hunter Concepts and Man-Machine Interface Functionality
- Demonstrate System as Part of the RFPI ACTD
- Incorporate IPPD Approach to Address Producibility and Affordability Risks and Use Statistical Metrics to Estimate and Manage ATD Sigma

Applications:

- RFPI ACTD
- Tech Transfer to LRAS3 & Future Scout & Combat Vehicles

HUNTER SENSOR SUITE ATD EXIT CRITERIA

OPERATIONAL CAPABILITY	CURRENT CAPABILITY	ATD		TENTATIVE REQUIREMENT E&MD
		MINIMUM	GOAL	
• Long Range, 24 Hour Target Acquisition, Surveillance & BDA	• AN/TAS-6 w/2X Lens	• 2nd Generation Sensor Suite	• 2nd Generation Sensor Suite	• Enhanced 2nd Gen Sensor Suite
- Recognition Range [Pr, 70%] * (Normalized)	1X	1.3X	1.7X	1.7X
• Target Recognition	• Manual	• Aided Target Recognition	• Aided Target Recognition	• Aided Target Recognition
- False Alarm Rate [Pd, __%] * [Pr, __%] *	N/A	1X /deg^2	0.5X /deg^2	0.5X/deg^2
- Time To Detect	100 sec	20 sec	15 sec	15 sec
• Receive & Transmit Targeting Information (Voice/Data/Imagery)	• None	• Data Compression Receipt & Transfer	• Data Compression Receipt & Transfer	• Data Compression Receipt & Transfer
- Transmission Time	N/A	< 15 sec	< 10 sec	< 10 sec
• Precision Target Location	• Estimated Range	• Positioning Sensors	• Positioning Sensors	• Positioning Sensors
- Accuracy	400 - 600 m	50 m	30 m	30 m

** Target, background and atmospheric assumptions are specified in Technical SOW*

COMPOSITE ARMORED VEHICLE (CAV) ATD
STO #III.G.01

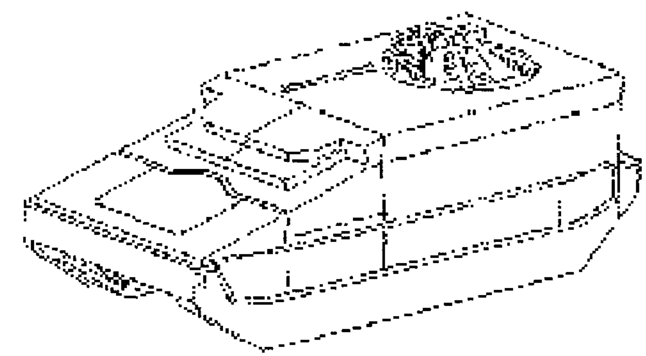
Objective:
- Demonstrate technical feasibility, operational potential, and cost effectiveness of composite materials for combat vehicle structures
  - Validate design, models, and simulations
  - Define composite materials, design baselines, and guidelines for future lightweight combat systems

Justification:
- Strategic deployability is driven by vehicle size and weight
  - Minimum 33% structure and armor weight reduction
- Demonstrates composite materials applicability to ground combat vehicles
- Demonstrates *integration of structure, armor, and signature materials*

Battlelab Support:	**Battlelab Experiment:**	**PEO:**
Dismounted Battlespace	Mounted Battlespace	GC&SS
Mounted Battlespace		

Schedule and Funding:

MILESTONE	FY94	FY95	FY96	FY97	FY98
Preliminary Detailed Design and Analysis		PRELIMINARY DESIGN REVIEW			
Detailed Design Analysis			CRITICAL DESIGN REVIEW		
Fabrication/Assembly					
System Performance Demonstrration/Validation					
Model Development	MODELING AND SIMULATION				
Experiments and Validation					
Develop Virtual Prototyping					
Funding ($M)	16.8	29.4	10.8	13.5	1.5



LIGHTWEIGHT STRUCTURE/ARMOR
ENHANCED SURVIVABILITY
STRATEGIC DEPLOYABILITY
IMPROVED PRODUCIBILITY

Approach:
- Analyze and optimize composite structure designs by modeling and simulation
- Conduct ballistic and structural testing on components and coupons
  - Validate material design limits
- Fabricate a demonstrator and structural test hull
- Demonstrate performance
  - Measure 105mm gun firing loads on hull structure
  - 6K mile endurance test with 25mm cannon
  - Deployment demonstration
  - Repair demonstration
- Validate models/simulations
- Transition design tools and documentation
- Demo chassis available for follow-on user experiments

Applications:
- Future Scout Vehicles
  - Scout Vehicle
  - Light Infantry Fighting Vehicle
  - Light Self-Propelled Howitzer
  - Crusader
- Preplanned Product Improvements (components)

COMPOSITE ARMORED VEHICLE (CAV) ATD EXIT CRITERIA

OPERATIONAL CAPABILITY	CURRENT CAPABILITY	END ATD		TENTATIVE REQUIREMENT E&MD
		MINIMUM	MAXIMUM	
Lightweight	Monolithic Aluminium (22-ton weight class)	33% Weight Savings (Structure/Armor)	>33% Weight Savings (Structure/Armor)	≥33% Weight Savings (Structure/Armor)
Deployable	C130/C141 Transportable	C130/C141 Transportability	C130/C141 Transportability	C130/C141 Transportability
Survivable	Camouflage	Classified	Classified	Classified
Affordability	Metal Structure/Armor (MSA) Cost	1.4 MSA Cost	1.0 MSA Cost	1.0 MSA Cost

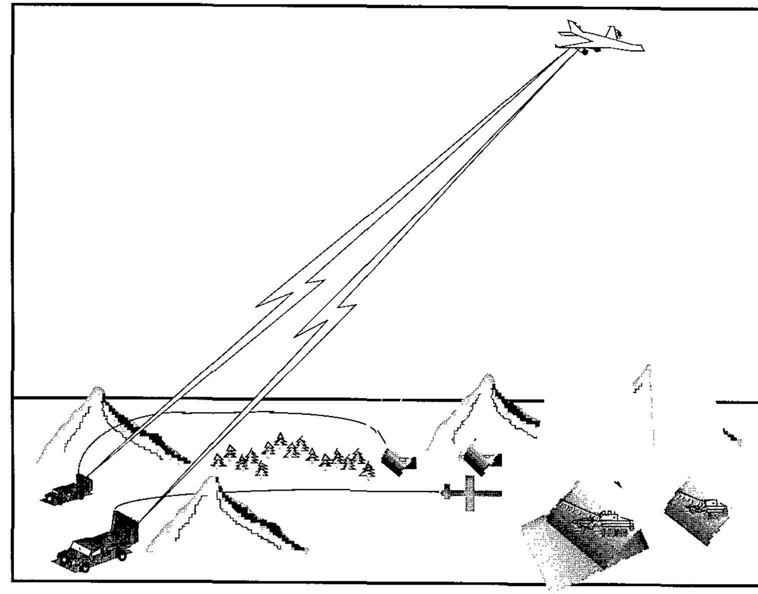
ENHANCED FIBER-OPTIC GUIDED MISSILE (FOGM) ATD
STO #III.H.03

Objective:
- Demonstrate EFOGM Multi-Purpose, Precision Kill
  - Day/Night/Adverse Weather
  - Extend Maneuver Commander Battlespace
- Engage and Defeat
  - Armored Combat Vehicles
  - Hovering or Moving Rotary-Wing Aircraft
  - Other High Value Ground Targets

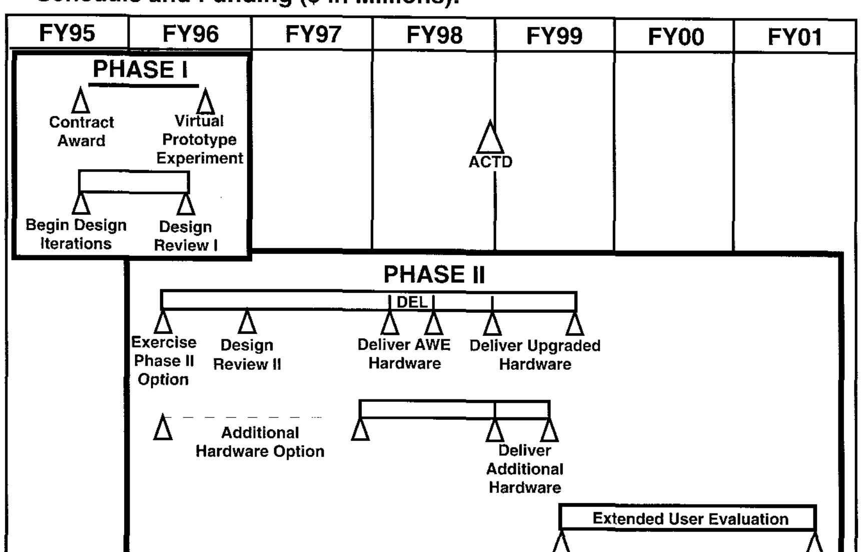
Description:
- Day/Night Adverse Weather Capability
- 15 km Range
- Non-Ballistic Trajectory
- Positive Visual ID Eliminates IFF Casualty Risks
- GPS/Inertial Navigation
- C4I Compatible
- Embedded Training
- Gunner in the Loop

Battlelabs:
- Dismounted Battlespace Battlelab
- Early Entry Lethality and Survivability Battlelab

PEO:
- Tactical Missiles



Schedule and Funding ($ in Millions):



FY95	FY96	FY97	FY98	FY99	FY00	FY01
30.5	60.2	37.7	57.9	36.7	15.0	3.8

Approach:
- Contract Awarded 16 May 95
- Basic Contract for Virtual Prototype
- Phased Options
  - Prototype Hardware/Software
  - Demonstrations Support
  - User Test Support
- Integrated Product Development (IPD)
- No Planned Production

Applications:
- RFPI Demo in FY98
- Extended User Evaluation (FY99–FY01)

ENHANCED FIBER-OPTIC GUIDED MISSILE (FOGM) ATD PHASE I EXIT CRITERIA

EXIT CRITERIA / SIMULATION TYPE	STATIONARY SIMULATOR	MOBILE SIMULATOR	SURROGATE MISSILE	6-DOF	BEWSS
PROJECT AND SUSTAIN FORCE					
SYSTEM MISSILE LOAD		X			
SYSTEM MISSILE RELOAD:					
BENIGN CONDITIONS		X			
NIGHT, ADVERSE WEATHER		X			
SYSTEM RESPONSE TIME-LAUNCH:					
LAUNCH WITHIN 0.5 MINUTES	X	X		X	X
CAPABLE OF TWO MISSILES IN FLIGHT	X	X		X	X
PROTECT THE FORCE					
MISSION PLANNING AID	X	X			
POSITIVE IDENTIFICATION (RECOGNITION)	X	X	X (Tower)		
WIN INFORMATION WAR					
MISSILE SEEKER IMAGERY EXPLOITATION:					
RECORD SEEKER VIDEO		(X)	X (Tower)		
PLT OBSERVE PLATOON VIDEO	X				
PLT TRANSMIT VIDEO TO OTHER FUs	X				
AUTOMATICALLY RECEIVE TARGET INFO FROM C2	X	X			X
CONDUCT PRECISION STRIKE					
GUNNER CONTROL OF IN-FLIGHT MISSILES:					
IN-FLIGHT CORRECTIONS TO FIRST / SECOND MISSILES	X	X	(X)		X
MANUAL SWITCH TO SECOND MISSILE	X	X			
RECEIVE / PROVIDE UPDATED TARGET INFO	X	X			X
DOMINATE THE MANEUVER BATTLE					
ENGAGE TARGETS NOT IN LINE OF SIGHT	X	X	(X)		X

(X) Not Completed

TOTAL DISTRIBUTION ATD
STO #III.O.11

Objectives:
- Provide commanders/logisticians at strategic, operational, and tactical levels enhanced capabilities to plan, analyze, mobilize, deploy, sustain, and reconstitute materiel, personnel, and forces in combat or crisis response situations.
- Reduce logistics timelines and support costs.

Justification:
- Inadequate automation for logistics task organization, logistics communications, source data, and processing of extensive, separated sources.
- Inadequate logistics relational data bases and documentation.
- Inability to accurately track assets in transit or in place.

Battle lab:
- Combat Service Support

PEO / PM :
- CSSCS
- AGCCS

Schedule and Funding:

MILESTONES	94	95	96	97	98	99
INTEGRATION						
• ASSET VISIBILITY TASKS						
• INFRASTRUCTURE ASSESSMENT						
• DISPLAY & VISUALIZATION						
• SIMULATION TASKS						
• DIL / COE EVALUATION						
• PEO / PM TRANSITION						
• JL ACTD SUPPORT						
EXECUTION						
• STACCS INTERFACE						
• AGCCS INTERFACE						
• CSSCS INTERFACE						
• AWE SUPPORT						
PW / MSF						
JWID						
• JOINT ENDEAVOR						
FUNDING	4.4	10.1	9.4	9.6		

Approach:
- Integrate existing legacy and emerging logistics C2 systems, data bases, and stamis.
- Provide seamless connectivity between sources and users of logistics information.
- Common Operating Environment (COE)/ Army technical architecture compliance.
- Validate concepts and capabilities through the CECOM Digital Integration Laboratory (DILI), AWEs, and real world exercises.
- Provide initial products on a stand-alone workstation, then as a client server architecture, and finally as software modules for host system installation.
- Transition ATD products to PEO/PM managed systems for further development or host platform installation.

Applications:
- Joint Logistics Advanced Concept Technology Demonstration (JL ACTD)
- PM, Combat Service Support Control System (CSSCS)
- PM, Army Global Command and Control System (AGCCS) logistics functionality
- U.S. Army Total Asset Visibility (TAV)

TOTAL DISTRIBUTION ATD EXIT CRITERIA

OPERATIONAL REQUIREMENT	CURRENT CAPABILITY	ATD GOAL	PROTOTYPE THRESHOLD GOAL
Planning/ Execution	Demonstrate semi-automated alert and correlation of logistically related problems/ need for a single unit.	Accomplish semi-automated alert and correlation of logistically related problems/ need for several units.	Demonstrate semi-automated alert and correlation of logistically related problems/ need for any mission.
	Demonstrate automated interface to distributed logistics databases in transportation, in-transit visibility, demand and asset history, ownership (by unit) and location during mobilization, deployment, and sustainment for a single unit.	Demonstrate automated interface to distributed logistics databases in transportation, in-transit visibility, demand and asset history, ownership (by unit) and location during mobilization, deployment, and sustainment for several units.	Demonstrate automated interface to distributed logistics databases in transportation, in-transit visibility, demand and asset history, ownership (by unit) and location during mobilization, deployment, and sustainment for any unit.
	Display on standard digital maps real time locations of in-transit and stationary assets from existing databases worldwide for multiple units.	Display on standard digital maps real time locations of in-transit and stationary assets from existing databases, Automated Identification Tags, and Command and Control systems worldwide for a unit.	Display on standard digital maps real time locations of in-transit and stationary assets from existing databases, Automated Identification Tags, and Command and Control systems for any unit.
	Display logistics, transportation, and engineering infrastructure and terrain assessments for specific areas on standard military mapping systems.	Display logistics, transportation, and engineering infrastructure and terrain assessments for specific areas on standard military mapping systems in 2D/ 3D.	Display logistics, transportation, and engineering infrastructure and terrain assessments for any area on standard military mapping systems in 2D/3D.
	Demonstrate convoy/ route planning capability with route deconfliction that will identify problems and provide alternative Main Supply Routes (MSRs).	Demonstrate convoy/ route planning capability with route deconfliction that will identify problems and provide alternative Main Supply Routes (MSRs).	Demonstrate convoy/ route planning capability with route deconfliction that will identify problems and provide alternative Main Supply Routes (MSRs).
Communications	Demonstrate the ability to link logistics planners, share information, and perform distributed collaborative planning through dedicated communications assets.	Provide the ability to link logistics planners, share information, and perform distributed collaborative planning through standard communications architecture assets.	Demonstrate the ability to link logistics planners, share information, and perform distributed collaborative planning through standard communications architecture assets.
Decision Support	Demonstrate the capability to plan in less than one hour, mobilization, deployment, and sustainment of a single unit to one theater for classes I, III, and V.	Accomplish the capability to plan in less than 30 minutes, mobilization, deployment, and sustainment of a single unit to one theater for classes I, III, V, and IX.	Demonstrate the capability to plan in less than 10 minutes, mobilization, deployment, and sustainment of a single unit to one theater for all classes of supply .
	Simultaneous display of logistics planning, execution, and replanning information at strategic, operational, and tactical levels and provide a single COA analysis in <30 minutes.	Concurrent display of logistics planning, execution, and replanning information at strategic, operational, and tactical levels and provide multiple COA analysis.	Simultaneous display of logistics planning, execution, provide multiple COA analysis , and replanning information at strategic, operational, and tactical levels in <10 minutes.
	Compare planned consumption data to actual consumption and adjust planning factors for classes I, III, and V.	Compare planned consumption data to actual consumption and adjust planning factors for classes I, III, V and IX.	Compare planned consumption data to actual consumption and adjust planning factors for all classes of supply.
Training	Integrates intelligent knowledge based planning systems with Combat Service Support Command and Control systems.	Provide linkage of Combat Service Support Command & Control real time data with an operator training system, mission rehearsal simulation driver.	Integrate intelligent knowledge based planning systems with Joint Combat Service Support Command and Control systems.

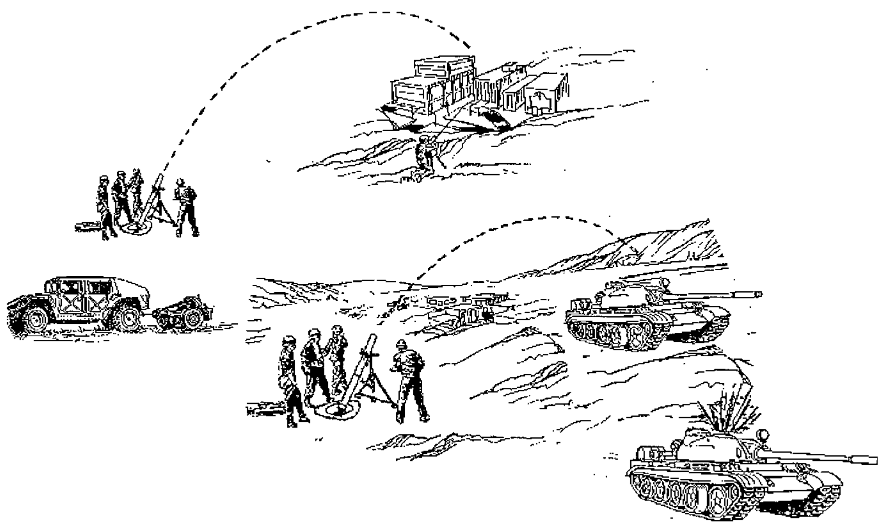
PRECISION GUIDED MORTAR MUNITION ATD
STO #III.H.4

Objective:
- Demonstrate precision guided mortar concept utilizing advanced seeker and guidance technology
- Demonstrate integrated man portable fire control
- Common seeker for 120/105 application

Justification:
- Expands capability of mortars (12 km)
- Increased PH and PK
- Point target capability at long ranges
- Reduced fratricide through man-in-the-loop
- Rapid, accurate fire missions (2.5 minutes, 2 mils)

PM:
PM-Mortars

Battle Lab:
DBBL, EELSBL



Schedule and Funding:

MILESTONES	FY93	FY94	FY95	FY96	FY97	FY98	FY99
FCT	━	━					
EXP DEV	━	━					
MORTAR ATD		━	━	━	━		
ADV CONCEPT						━	━
($M)							
63004/D43A		2.4	5.6	9.4	7.0	4.2	3.9
62624/AH18	0.2	0.3					
0605130D (FCT)	3.0	0.4					

Approach:
- Conducted foreign comparative testing (FY94/95)
- Evaluated U.S. technology (FY94/95)
- Selected technical approach (FY95)
- Complete Captive Flight testing (FY95)
- Conduct ACTD CFT (FY97)
- Manportable fire control (FY98)
- 120mm PGMM ATD all-up-round firing (FY99)

Applications:
- Integral part of Rapid Force Projection Initiative (RFPI)
- Top attack surgical kill capability for U.S. infantry

PRECISION GUIDED MORTAR MUNITION ATD EXIT CRITERIA

	BASELINE	THRESHOLD	GOAL
120mm Range (km)	7.2	12.0	15.0
120mm Targets	N/A	High Value Targets	High Value Targets
120mm Weight (lbs)	50.0	40.0	35.0
FC Time to Fire (min)	4.0	2.5	0.5
FC Accuracy (mil)	5.0	2.0	1.0
FC Weight (lbs)	N/A	30.0	15.0

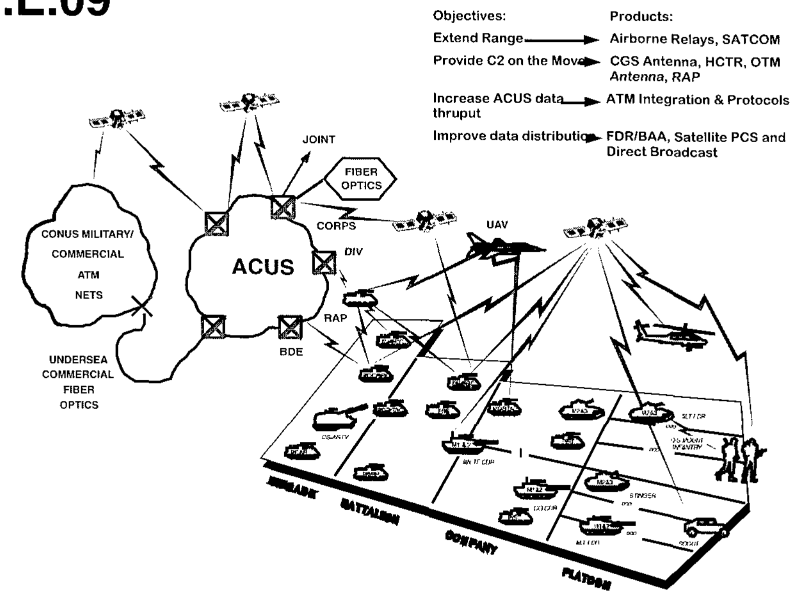
DIGITAL BATTLEFIELD COMMUNICATIONS (DBC) ATD
TACTICAL COMMUNICATIONS FOR THE WARRIOR
STO III.E.09

Objective:
- Demonstrate a secure, robust, seamless, digital, multimedia information transport capability for the Army tactical user that is compliant with and exploits emerging commercial standards and the DISN architecture.

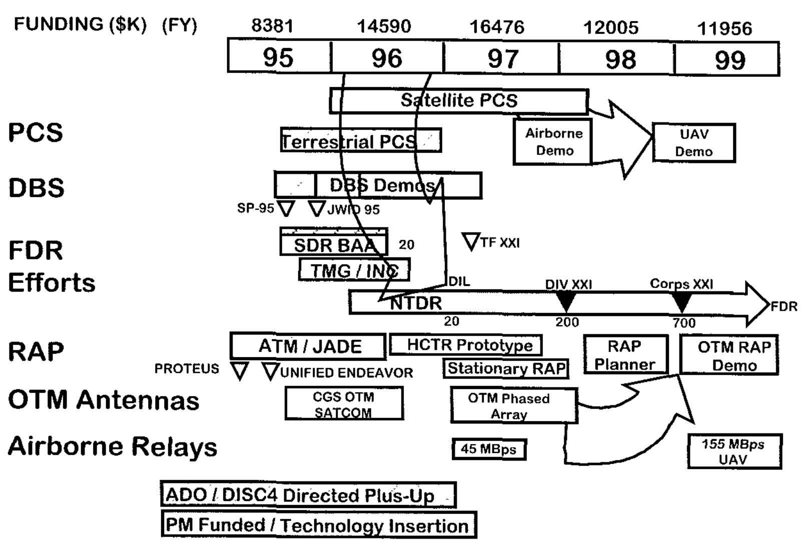
Justification:
- Satisfies "information pull" required by the warfighter of the next decade.
- Resolves current communication deficiencies of limited bandwidths, mobility, range, and interoperability.
- Provides access whenever and wherever needed to large volumes of imagery, intelligence, and logistics data necessary to support split-based operations.

Battle Lab:
- Battle Command

PEO:
- C3S



DBC / BITS Product Evolution



Approach:
- Develop and integrate a series of technologies to support the digitized battlefield
  - Wideband Mobile Digital Radios
  - Wideband OTM High Capacity Trunk Radios (HCTR)
  - Mobile Communications (CNR, SATCOM)
  - Airborne Relays (UAV)
  - New Services (DBS, SAT PCS, PCS)
- Allow evolutionary growth from today's systems to support interface to commercial ATM infrastructure/global comm/DISN
- Establish joint test bed experiments with BCBL(G) and other Service labs
  - Support ADO Campaign Plan by injecting technology into TF, Div, Corps XXI
  - Incremental product insertion into Battle Labs/AWEs
- Modeling and Simulation to define and evaluate alternative concepts
- Utilize CAC2 and BC2 as feeder applications

Applications:
- Force XXI Bits
- Army communications at all echelons

DIGITAL BATTLEFIELD COMMUNICATIONS ATD EXIT CRITERIA

TECHNOLOGY	CURRENT CAPABILITY	MINIMUM EXIT CRITERIA	GOAL EXIT CRITERIA
RAP Phased Array Antenna	S/C-Band, low data rate, static operation, one transmit beam, three receive beams, half duplex	X-Band, static, triple beam full duplex operation @ 45MBps with airborne relay and fixed sites	X-Band, On-The-Move (OTM), triple beam full duplex operation @ 45MBps with airborne relay and fixed sites
Airborne Relay	UHF SATCOM surrogate satellite	DS-3 (45MBps total transponder bandwidth) radio/antenna system payload for UAV serving static users (e.g., RAP)	DS-3 (45MBps total transponder bandwidth) radio/antenna system payload for UAV serving OTM users (e.g., RAP)
RAP	None	Integration of existing mobile radio communications and full duplex link (High Capacity Trunk Radio) to wide area ATM network via airborne relay at halt operation; minimum set up/initialization; multiple HCTR links	OTM integration of existing mobile radio communications using MBMMRs and full duplex link (High Capacity Trunk Radio) to wide area ATM network via airborne relay; OTM operation; multiple 45MBps links
ATM Access	None	Demo operational network with 6 ATM enabled ACUS nodes; use permanent virtual circuits for ATM switching; transmit MSE voice integrated with multimedia over ATM; operate ATM with channel BER of 10--4	Demo operational network with 8 ATM enabled ACUS nodes; use switched virtual circuits, transparent call establishment (10 calls simultaneously established); demo 10 on demand 4-way VTCs; use adaptive FEC with varying BERs in external FEC unit
PCS	MSRT/radio access unit in MSE	Integration of commercial PCS (IS-95) cellular capability into MSE Standalone operation (place calls within a cell without the MSE backbone present) Man portable user terminal less than 2 pounds Tactical base station supports 30 simultaneous calls with tactical antenna heights Calls into/across MSE	Type 1 security integrated into user terminal Demonstrate hand-off and roaming between base stations Calls into/across MSE
Direct Broadcast	None	Demo Multiple Channel Broadcast (push) of secured/unsecured digital data up to 23 MBps including video, MCS & ASAS, and JSTARS to multiple receive sites with VCR size receive sets and 1.2 m quick deployable antennas Demo in-theater user reachback (pull) via Surrogate Digital Radio and Trojan spirit to uplink info source	Same as minimum with the ultimate goal of evolving into an element of the Warrior Multicast Service, providing the Warfighter with worldwide information and multimedia exchange while on the move

This page intentionally left blank

ADDITIONAL DBC PRODUCTS

TECHNOLOGY	CURRENT CAPABILITY	MINIMUM EXIT CRITERIA	GOAL EXIT CRITERIA
High Capacity Trunk Radio	None	DS-3 (Fixed bandwidth of 45 MBps) operation transferring full duplex ATM data cells in a stationary mode of operation External Forward Error Correction (FEC)	DS-3 (Fixed bandwidth of 45MBps) operation transferring full duplex ATM data cells while operating on-the-move (one end stationary) External Forward Error Correction (FEC)
HCTR (–)	2 MBps MSE line-of-sight links AN/GRC-226 @ 40 Km	10 MBps replacement for MSE AN/GRC-226 line-of-sight links @ 40 km	10 MBps replacement for MSE AN/GRC-226 line-of-sight links @ 40Km
Wideband HF Radio	Narrowband HF, 2400 Baud data rate No access to Tactical Internet	Narrowband HF @ 4800 Bps Tactical Internet Access COTS Wideband HF	Wideband HF @ 19200 Bps Tactical Internet Access
Surrogate Digital Radio	EPLRS 56 Kbps of network throughput Dynamic Multihop Relay Tactical Internet	Data hauler for Tactical Internet ABCS traffic 180 Kbps throughput per net Dynamic Internet routing Dynamic multihop relay	Same as minimum with the ultimate goal of providing a seamless network with connectivity transparent to the user

TARGET ACQUISITION ATD
STO #III.G.08

Objective

- Demonstrate automated wide area search, acquisition, identification, and prioritization with automated cueing/tracking/hand-off at extended ranges to allow reduced crew workload/timelines in support of lethal, deployable combat vehicles with fewer crew members

Justification

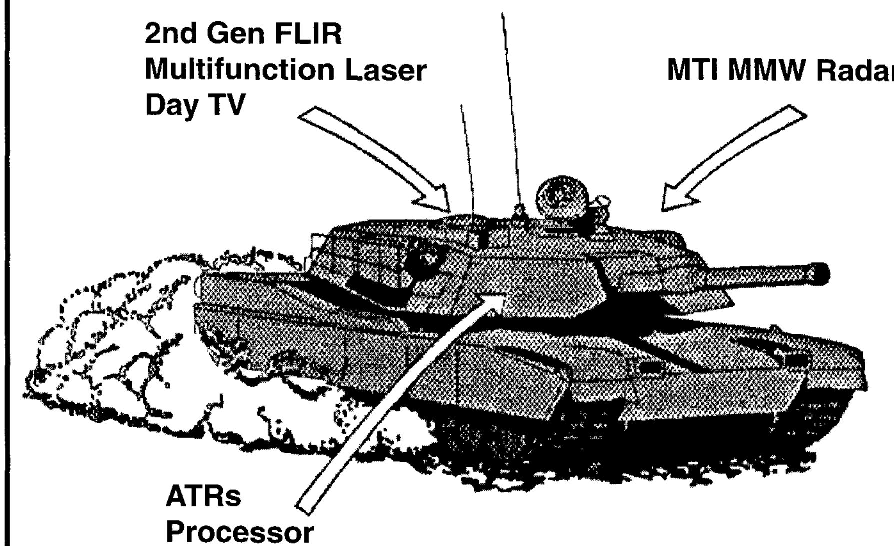
- Addresses key user requirements for future combat vehicles and combat vehicles upgrades
  - lethality (rapid detection & long range ID) - degraded condition fire control
  - deployability - lighter vehicle, reduced crew
  - survivability - see first, shoot first

Battlelab:

- Mounted Battlespace

PEO:

- IEW (Sensors) (PM NVEO)
- GC&SS (Integration)



Schedule and Funding:

MILESTONE	FY96	FY97	FY98	FY99
Milestones	▲ AWARD			
Multifunction Laser	FAB / INTEGR.	△ MFLS CEP		
MTI Millimeter Wave Radar	INTEGR. & TEST △ STAND ALONE DEMO			
ATD Hardware Evolution	ANALYSIS / DESIGN	GPS INTEG.	△ GPS/RADAR DEMO; CITY INTEGRATION △ CITY DEMO	
ATR Software Evolution	ANALYSIS / COMANCHE VER.	△ TARGET FINDER DEMO; ATD VERSION	ATD VERSION	
Abrams SEP Milestones	M1A2 PRODUCTION	M1A2 PRODUCTION	M1A2 PRODUCTION	/ M1A2 SEP
FSV Milestones			FSV ATD	FSV ATD
TA ATD Funding	$6225	$8254	$1924	

Approach:

- The target acquisition ATD MTI radar and the gimbal scan second generation FLIR will perform target detection, then hand-off target positions to the FLIR sensor/ multifunction laser sensor (future STI radar sensor) for aided target identification
- Integrate a multi-function laser, second generation FLIR sensor suite, and a high density processor coupled with modified ATR algorithms as a 'b" kit into a surrogate for operational demonstration.
- Provide MTI MMW radar (STI growth potential) for target acquisition, tracking, and cueing enhancement in degraded conditions
- Integrate with CAC2 network through Crewman's Associate ATD for improved situational awareness
- Incorporate IPPD approach to address producibility and affordability risks and use statistical metrics to estimate and manage ATD sigma
- Employ FLIR/laser sensor fusion, design for growth to full sensor fusion (STI radar)
- Technology feed to the MWBL sponsored ACT II LATARS program

Applications:

- Potential upgrades (Abrams, Bradley, LRAS3)
- Tech transfer to FSV / FIV

TARGET ACQUISITION ATD EXIT CRITERIA

OPERATIONAL CAPABILITY	GEN II FLIR (BASELINE - NO AUTOMATION)	END ATD SENSOR SUITE	
		MINIMUM	GOAL
Target Detection			
Moving/Stat	1.0 good weather 0.5 bad weather	1.2 good 0.6 bad	1.5 good 1.2 bad
Hull Down	0.6 good 0.4 bad	0.6 good 0.4 bad	0.7 good 0.5 bad
Identify Target			
Moving/Stat	0.5 good 0.3 bad	0.8 good 0.6 bad	1.0 good 0.7 bad
Hull Down	0.3 good 0.2 bad	0.7good 0.5 bad	0.9 good 0.6 bad
Time to Detect	90 sec	15-20 sec	10-15 sec
False Alarm Rate	N/A	1.0 X / deg^2 *	0.16 X / deg^2 *

NOTE: All range criteria are normalized.

* Indicates MSAT-AIR ATD based values.

HIT AVOIDANCE ATD
STO #III.G.06

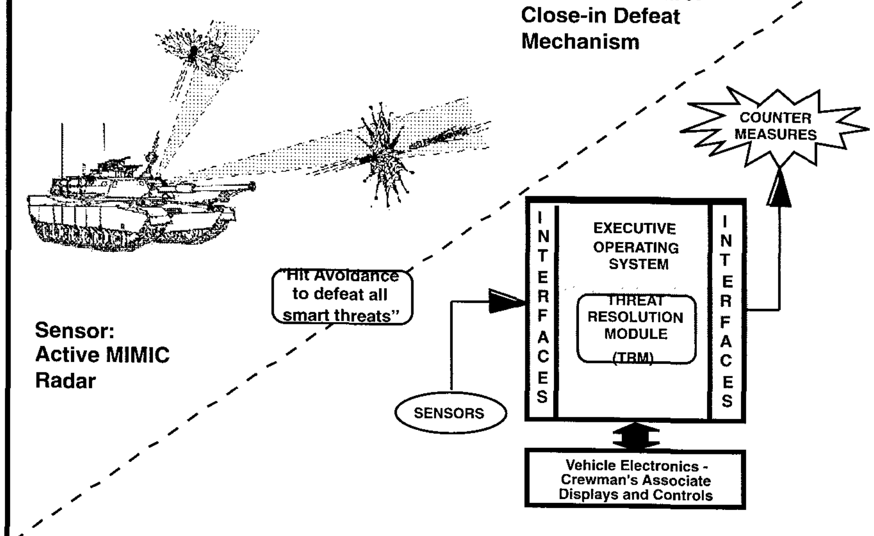
Objective:
- Demonstrate a Commander's Decision Aid in a Systems Integration Laboratory (SIL).
- Demonstrate low-cost active protection in a field demonstration.
- Provide a system engineering simulation through integration of threat sensor, countermeasure, and ancillary support models.
- Transition Commander's Decision Aid to PEO-ASM.
- Identify affordable force protection technologies through continued Guardian analysis.
- Demonstrate ability to tailor sensor-countermeasure suite to meet existing battlefield requirements.

Justification:
- Crew survivability against smart threats.
- Operational advantages:
  - provides capability to control tempo of battle and maintain the initiative
  - increased situation awareness.

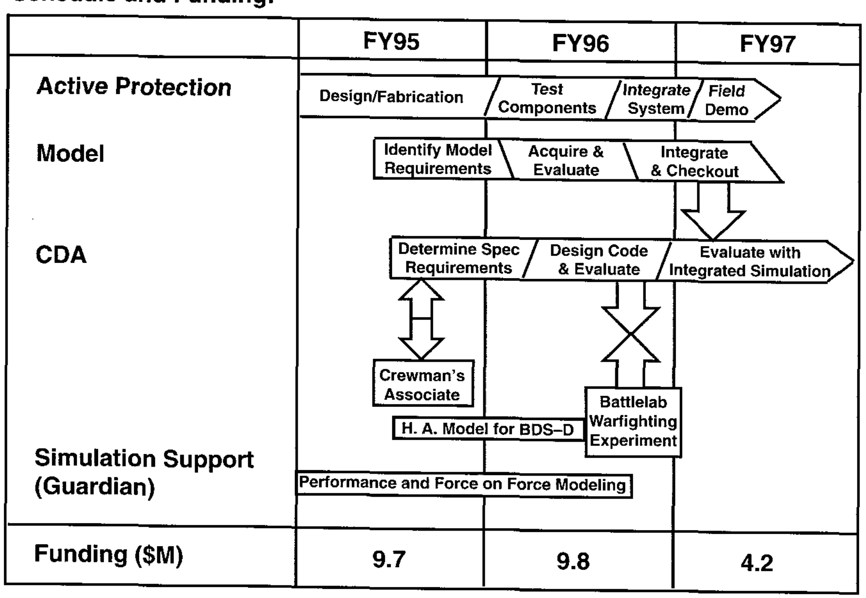
Battle Lab:
- Mounted Battlespace

PEO:
- ASM

Near Term Active Protection



Schedule and Funding:



Approach:
- Integrate a MIMIC radar with a close-in defeat CM and demonstrate a stand alone low-cost active protection system in the field.
- Identify and verify applicable models and integrate within a computer software infrastructure.
- Develop Commander's Decision Aid that correlates, identifies, and prioritizes the threat and recommends optimal countermeasure.
- Control and display requirements developed in conjunction with Crewman's Associate ATD design requirements.
- Sensor and CM integration requirements developed in conjunction with ESGV.
- Determine user requirements through BLW Experiment.
- Assess affordability through CASTFOREM modeling.
- Leverage existing programs from ARPA, CECOM, AVSCOM, ERDEC, ARL, PMs, and Air Force.

Applications:
- Emerging systems (AGS, Crusader, Breacher, Future Combat System, Future Scout Vehicle).
- Survivability Upgrades (Abrams, Bradley, M113).
- Tactical vehicles.

HIT AVOIDANCE ATD EXIT CRITERIA

ACTIVE PROTECTION	
• ATGM DEFEAT	80%
• THREAT PENETRATION (90% PROBABILITY)	<1.5" RHA
• AFFORDABILITY	<$300K
SIMULATION	
• HIT AVOIDANCE SYSTEM COMPONENT MODELS CORRELATE TO FIELD DATA	90%
COMMANDER'S DECISION AID	
• THREAT RESOLUTION VERIFICATION—Kinematic/Track Fusion, Threat Attribute Fusion	90%
• EFFECTIVE COUNTERMEASURE RESPONSE—Prioritize CM, Timing	95%
• TOTAL PROCESSING TIME	1.0 SECONDS

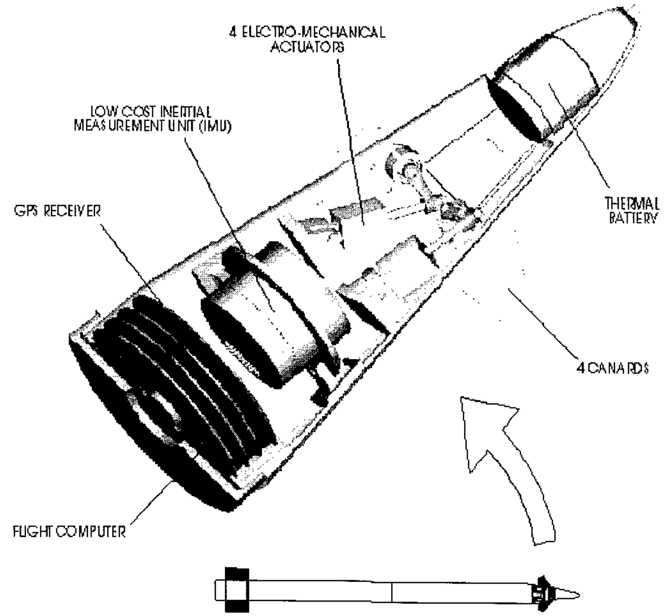
GUIDED MLRS ATD
STO #III.N.11

Objective:
- Demonstrate 2-3 mil delivery accuracy using inertial guidance and a 10-meter CEP delivery accuracy using GPS-aided inertial guidance.
- Demonstrate a guidance and control package with a projected cost of less than $14,000.

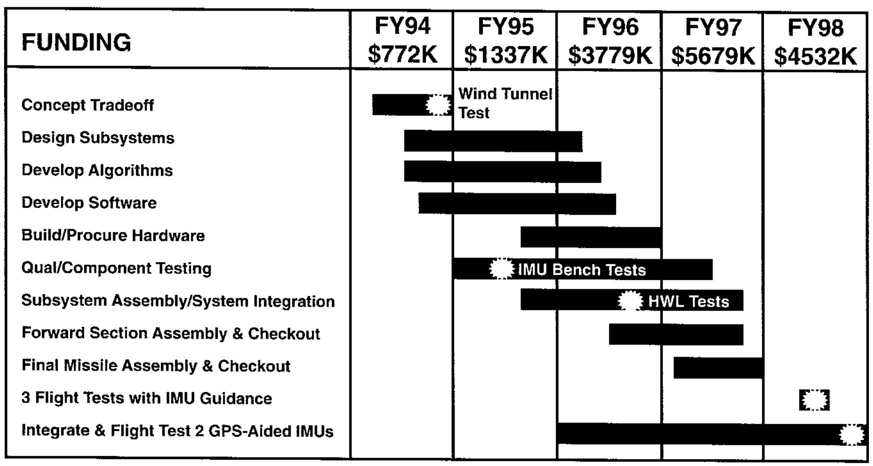
Justification:
- The extended range MLRS rocket is in development.
- Improvements in delivery accuracy will reduce:
  - the number of rockets required to defeat the target by as much as sixfold at maximum ranges
  - the required number of launchers per fire mission
  - the logistics burden
  - fire mission duration, and
  - collateral damage/fratricide.

TRADOC Interface:
- TRADOC System Manager for Rockets and Missiles, Depth and Simultaneous Attack Battle Lab

PEO Interface:
- MLRS Project Office



Schedule and Funding:



Approach:
- Integrate a guidance and control package into the nose of the current extended range rocket.
- Design a package which is independent of rocket payload.
- Demonstrate a package based on a low-cost inertial measurement unit and canards as Phase I.
- Integrate GPS into the guidance and control package as Phase II.

Applications:
- Rapid Force Projection Initiative (RFPI)
- M270 and High Mobility Artillery Rocket System (HIMARS) launchers
- MLRS rocket with bomblet, precision guided submunitions, mines, or earth penetrator/unitary warheads.
- JPSD Precision/Rapid Counter MRL ACTD.

GUIDED MLRS ATD EXIT CRITERIA

	CURRENT BASELINE	ATD THRESHOLD	ATD GOAL
Additional Production Cost	$0 per rocket	$30,000 per rocket	$14,000 per rocket
Delivery Accuracy (using pure inertial)	Confidential	4-mil CEP	2-mil CEP
Delivery Accuracy (using GPS-aided inertial)	Confidential	30m CEP	10m CEP
Shelf Life (years)	15	15	15
Maintenance	None	None	None
Reliability	0.97	0.70	0.91

OBJECTIVE INDIVIDUAL COMBAT WEAPON ATD

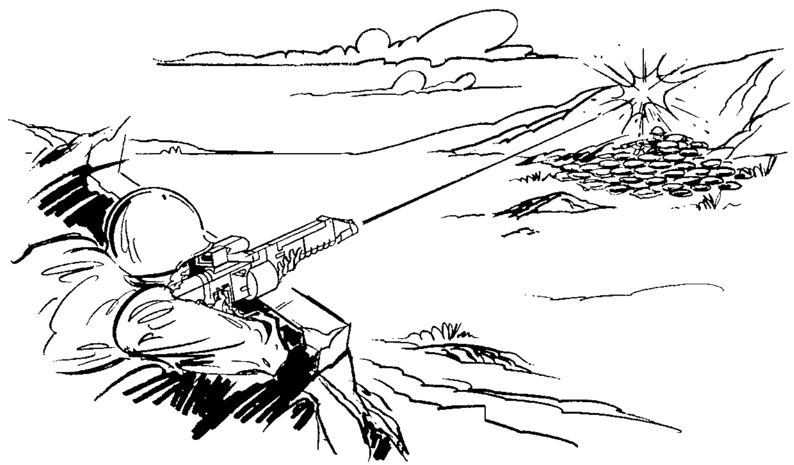
Objective:

Demonstrate OICW Operational Utility, Versatility, Technological Maturity and Lethality Through Scenario Driven Troop Testing, Simulation, and Land Warrior Soldier System Interfacing.

Justification:

- Improve Hit Probability 300%: >0.5 to 500m
- Decisively Violent & Suppressive Target Effects
- Ability to Defeat Defilade Targets; Increased Effective Range
- Army & Joint Service Small Arms Master Plans - Potential Replacement for M16A2 Rifle Family and M203 Grenade Launcher
- OCRs - DBS01A/02A/03/14/16/24
- STO III.I.1/ATD - Joint Service Program

Battlelab: DBS **PM:** PMSA Linkage



Schedule and Funding:

FY	94	95	96	97	98	99	00	01
Transition to 6.3								
Trade-Off Determination								
Industry Solicitation								
Contract Award								
Concept Design								
Prototype Dev & Build								
Prototype Demonstration								
OICW Adv Tech Demo								
Prepare for Milestone Dec								
Transition to 6.5								
Land Warrior Interfacing								
($K) PE/Proj: 62623A/AH21		2431	370					
PE/Proj: 63607A/D627	1895	4041	3450	3500	3352	3010		
6.2/6.3 Cong Plus-Up		1786						
USMC			500	1100	1200	600		
SARD			(1000)	(3500)	(2000)	(1000)		
JSSAP				(1000)				

Approach:

Technology/System Performance Trade-Offs

Simulation: CASTFOREM; IUSS

Design and Demonstrate Integrated OICW Systems:

- Air Bursting Warheads/More Powerful Explosives
- Modular Optoelectronic Fire Control
- Composite Weapon Components
- Dynamic Damping Techniques
- All Environment Operation

Build Systems for Scenario Driven Operational Tests

Provide Systems for Dismounted Battlelab Experiment

Interface With MOUT ACTD

Applications:

Objective Family of Small Arms (OFSA)

Compatible With Future Soldier's Helmet and Computer

Transitions to PMSA

OBJECTIVE INDIVIDUAL COMBAT WEAPON ATD EXIT CRITERIA

Exit Criteria Metric	M16/ M203/TWS	OICW Threshold	Contractor	
			Threshold	Goal
Probability of Incapacitation	15%	50% @ 300M	50-70% @ 300M	40-50% @500M
Transmit TOF Signal To Fuze	N/A	Single Shot	Single Shot	Semi-Auto
System Weight:				
Empty:	>15 lb	16	< 11-14	<12
Loaded:	>16.5 lb	19	< 13-17	
System Cost	$25+K	$15.0 K	<$9-13.0 K	
Ammunition Cost	$14 (M433)	$30	<19-$25	

VEHICULAR MOUNTED MINE DETECTOR
STO #III.N.08

Objective:

- To Evaluate and Demonstrate the Capability to Detect Metallic and Non-Metallic Anti-tank Mines On/Off Roads at Moderate Speeds

Justification:

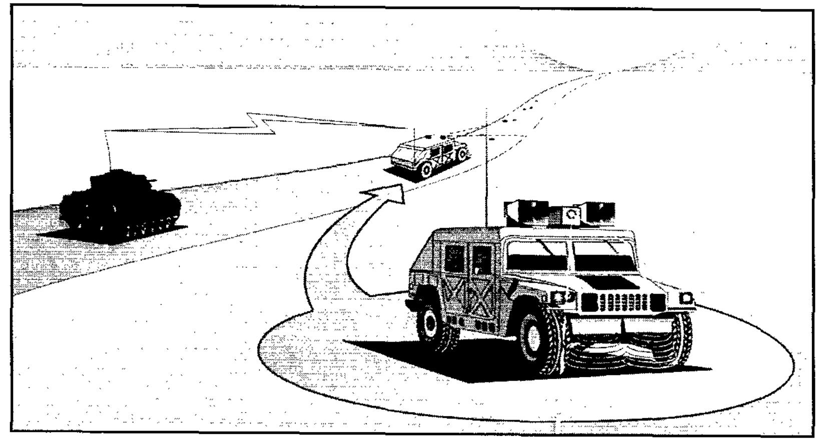
- To Maintain LOC/MSR Free of Mines
- To Improve Survivability by Avoiding Main Source of Vehicular Losses in Most Conflicts (Including OOTW)

Battle Lab:

- Mounted Battlespace
- Dismounted Battlespace
- Early Entry Lethality & Survivability

PEO:

- ASM (PM-MCD)



Schedule and Funding:

MILESTONES	FY94	FY95	FY96	FY97	FY98
6.2 Exploratory Development					
Sensor Testbed Fabrication					
Sensor Arid Field Testing					
Sensor Temperate Field Testing					
Data Analysis/ATD Sys. Spec.					
ATD System Contract Award					
Systems Fabrication					
Arid Field Demos					
Temperate Field Demo					
Transition/Milestone II (EMD)					
Funding 63606/(D608)		5.6	4.5	8.3	3.0

Approach:

- Demonstrator Development
  - Develop Two Multi-sensor Suite Approaches
  - Electromagnetic Induction
  - Down & Forward Looking Ground Penetrating Radars
  - Forward Looking IR
  - Sensor Fusion/ATR
- ATD Phase
  - Test in Arid & Temperate Realistic Terrains & Clutter
  - Test in Operational Scenarios
  - Test Best Sensors or Combinations

Applications:

- Joint Countermine ACTD
- Countermine Lightfighter Battle Lab Experiments

VEHICULAR MOUNTED MINE DETECTOR EXIT CRITERIA

OPERATIONAL CHARACTERISTICS	OFF ROAD (Dense, Scatterable Minefield) Minimum (Goal)	ON ROAD (Dense, Scatterable Minefield) Minimum (Goal)
Detection Speed (km/H)	2 (3)	3.6 (5)
Probability of Detection (%)		
AT Surface	92 (98)	95 (99)
AT Buried	90 (95)	92 (95)
Maximum False Alarm Rate (per meter of forward progress)	0.25 (0.15)	0.06 (0.04)
System Power Requirement (kw)	5 (3.5)	5 (3.5)
Per Unit Production Cost ($K)	250	250

NOTE: AT (Antitank) Mines to Include Metallic and Nonmetallic.

DIRECT FIRE LETHALITY ATD
STO #III.G.10

Objective:

- Provide advanced frontal and top attack armor defeat capability against 2005 ERA protected threats at extended ranges.
- Provide dramatic increase in system accuracy [P(h)] at 3km under moving conditions.

Justification:

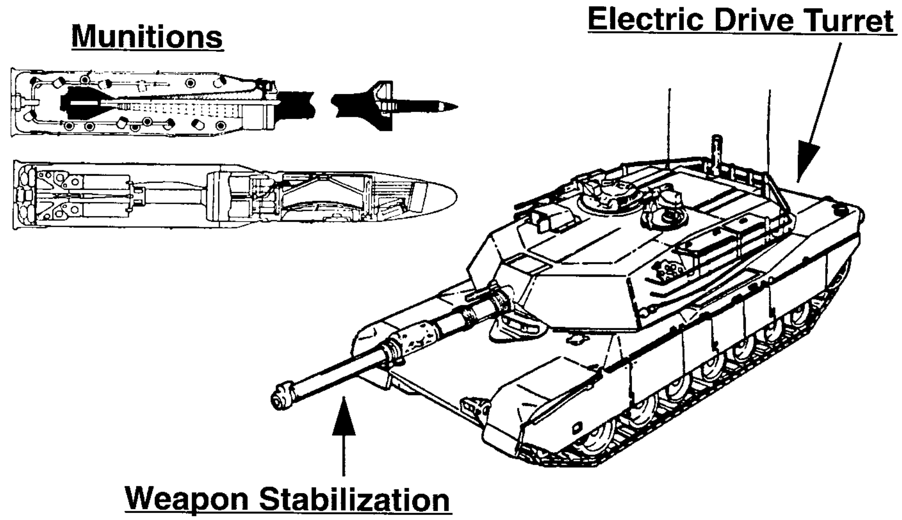
- 2005 ERA projected threat protection levels
- User desire to expand lethal battlespace
- Large system errors degradation of P(h) at extended ranges.
- Crew safety and health issues regarding hydraulics

Battlelab:

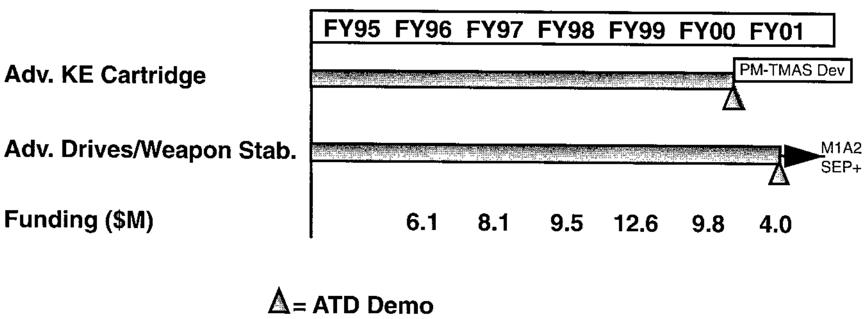
- MBS

PEO:

- GC&SS



Schedule and Funding:



Approach:

- Integrate KE precursor and advanced propellant to efficiently defeat ERA protection.
- Demo dual-liner STAFF warhead formation and defeat capability of ultra-long EFP.
- Integrate and demo on M1A1 smart barrel actuators, distributed direct (gearless) drive, and modern digital servo control technologies.
- Conduct integrated performance demonstration via simulation and modeling.

Application:

- Future Combat Vehicle
  - M1A2 SEP+, FCS, FSV, FFV
- Future Aviation Platforms
  - Apache Upgrade/Comanche
- Preplanned Product Improvements

DIRECT FIRE LETHALITY ATD EXIT CRITERIA

OPERATIONAL CAPABILITY	BASELINE	THRESHOLD	GOAL
ADVANCED KE CARTRIDGE			
Armor Penetration (against ERA III protected 2001-3 threat)	M829A2/M256	>=40% @ 3 km	>=50% @ 3 km
System Accuracy	M829A1/M256	>=20% # 3 km	>=30% # 3 km
Affordability	M829A2 Defeat @ 3 km and UPC		>=M829A2 Defeat / M829A2 UPC
STAFF ENHANCEMENTS			
Armor Penetration (against ERA II Top Attack Protection)	XM943/M256	>=33%	>=50%
Effective Range	XM943/M256	>=1 km	>=1.5 km
ADVANCED DRIVES AND WEAPON STABILIZATION			
Probability of Hit (Moving vs Stationary)	M1A1	>=200% @ 3 km	>=300% @ 3 km

INTEGRATED BIODETECTION ATD
STO #III.K.03

Objectives:

- Demonstrate the ability of state-of-the-art biological agent detection and identification technologies to provide pre-exposure warning of biological agent attacks.
- Demonstrate an enhanced identification device with improved sensitivity, selectivity, and extended range of threat agents for the Joint Biological Point Detection System (JBPDS).
- Demonstrate a real-time remote biological aerosol detection system for early warning of an immediate hazard to high value battlefield assets.

Justification:

- Provides increased decision cycle for commanders.
- Enhances overall force mobility and survivability.
- Critical for early masking, "all clear" signal, and early treatment.

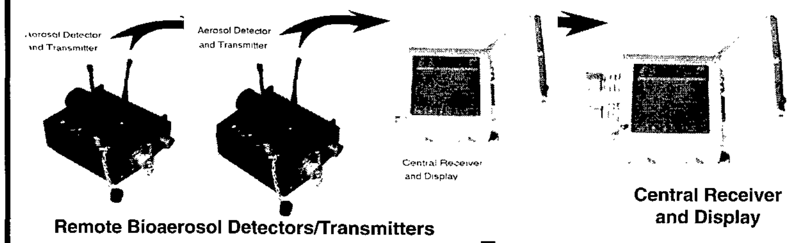
Battlelab:

- Dismounted Battlespace

PEO:

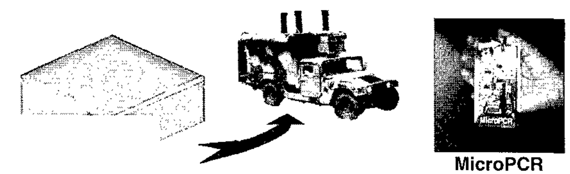
- JPO-Bio Defense

Biological Aerosol Warning System



Automated DNA Diagnostic

Aerosol Sampler
●
DNA Extraction & Processing
●
PCR Amplification
●
Detection & Identification



Schedule and Funding:

MILESTONES		FY96	FY97	FY98	FY99
6.2 Supporting Technologies		■	■	■	
Fab/demo Automatic DNA Diagnostic		■	■	■	
Pathogen Testing				■	■
Fab/demo Bioaerosol Warning System		■	■		
Integration			■	■	
BLWE Planning		■	■	■	■
BLWE					■
Funding ($K)	63384/DE83	3717			
	63384/CB3		6558	7134	5830

Approach:

- Develop and demonstrate Automatic DNA Diagnostics using evolving gene probe technology to uniquely identify threats.
- Develop and demonstrate real-time detection and early warning/alert of immediate bio-hazard using existing military communications system.
- Conduct battlefield simulation and agent simulant outdoor field trials to assess effectiveness of technologies.
- Conduct developer/user field demo to simulate and validate operation under CB mission conditions.

Applications:

- BIDS P3I
- Airbase/Port ACTD
- JBPDS
- Remote Early Warning System

INTEGRATED BIODETECTION ATD EXIT CRITERIA

OPERATIONAL CAPABILITY	CURRENT CAPABILITY	DEVELOPMENTAL (FY98)	END ATD GOALS (FY99)
POINT BIOSENSORS			
Bacteria Identification	2-Agents *(1)*	5-Agents *(2)*	All Threats
Automated Virus ID	None	None	All Threats
Identification Sensitivity	25 ACPLA	15 ACPLA	1 ACPLA
Selectivity	Antibody-Based	Antibody-Based	DNA-Based
Identification Times	30 Minutes	20 Minutes	20 Minutes
Operator Interface	Manual	Semi-Automatic	Automatic
Logistics Burden	Multiple Reagents	Multiple Reagents	Single-Step Assays
Reagent Storage	Basic	Basic	Hot, Basic, Cold
PRE-EXPOSURE WARNING			
Detection of Missile, Bomblet, Covert Release Over Corps Area	Low Probability	Same	High Probability
Upwind Alert to Attacked Area	Post-Exposure Warning	Same	Pre-Exposure Warning
Aerosol Type	Generic (aerosol)	Same	Specific (bioaerosol)
Threat Source	Line Source	Same	Line, Point Sources
Platform	Helicopter	Same	Ground Unit
Battlefield Integration	Voice Transmission	Digitized Transmission	Digitized Transmission

(1) Plus two toxins *(2)* Plus three toxins ACPLA = Agent containing particles per liter of air

MULTISPECTRAL COUNTERMEASURES
STO #III.D.13

Objective:

- Demonstrate an All Laser Solution That Will Be Capable Of Countering Both Present And Future Multi-Color Imaging Focal Plane Array And Non-Imaging Missile SAMs and ATGMs.

Justification:

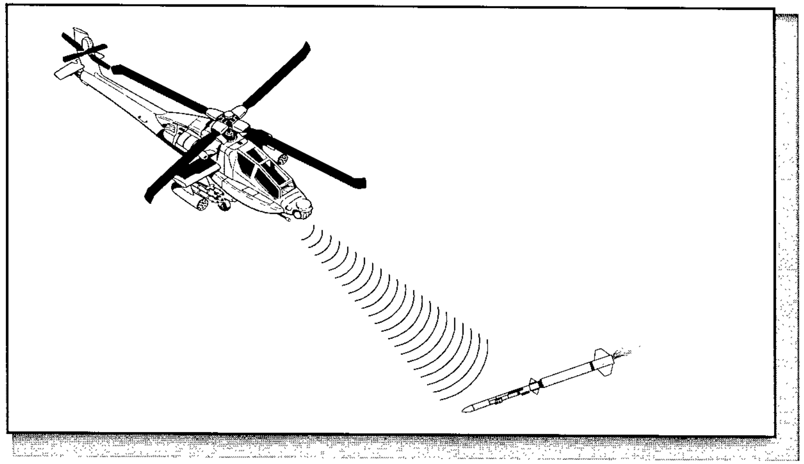
- Enhanced Survivability of Deep Attack Systems
- Improve Mounted Forces Mobility
- Identify and Engage Deep Targets with Early Entry Forces

Battle Lab:

- Mounted Battle Lab

PEO:

- Aviation



Schedule and Funding:

MILESTONES	FY96	FY97	FY98	FY99
Supporting Joint ECM Effects SIM/Tests				
Evaluate/Test Laser Sources				
Laser Modifications				
Fiber Optic Coupling				
Jamming Algorithms				
Integrate with ATIRCM				
Live Fire Tests				
Funding: 63270/DK16 Total: $16.2M		3.9	5.3	7.0

Approach:

- Utilize ATIRCM/Tri-Service Common Missile Warning System (CMWS) Sensors and Processor as Core System Hardware
- Leverage Tri-Service Development and Testing of Laser, Microhead and ECM Waveforms
- Upgrade Jamming Capability With Multi-Line Laser
- Conduct Live Fire Cable Car Test Versus Imaging SAMs and ATGMs
- Transition to Survivable Armed Reconnaissance on the Digital Battlefield ACTD and Integrated Situational Awareness and Countermeasures Tech Demo

Applications:

- Tri-Service ATIRCM/CMWS Improvements
- All Army/Navy/Air Force/SOCOM/VIP Aircraft
- Hit Avoidance/ATGM Defense System (ADS)

MULTISPECTRAL COUNTERMEASURES ATD EXIT CRITERIA

- **Proposed Exit Criteria**

OPERATIONAL CAPABILITY	BASELINE ATIRCM	ATD MINIMUM	ATD GOALS
Effectiveness	Lamp/Laser	All Laser	All Laser
Non-Imaging	90%	95%	99%
Imaging	NA	90%	95%
Jam/Signal Ratio	500 / 1	2000 / 1	3000 / 1
System Weight (w/o A-Kit)	125 lb	100 lb	90 lb
Power Consumption	2.4 kW	1.2 kW	1.0 kW
Jam Head Size	13.5"h X 8.0"dia	5.0"h X 3.5"dia	4.5"h X 3.0"dia

- **Transition**
  - ATIRCM/CMWS
  - Ground Vehicle ATGM Defense System (ADS)
- **Modernization / JWS&T Plan / DTAP Objectives Supported**
  - Weapons DTAP - DTO WE.03
  - JWS&T Plan - Electronic Warfare DTO H.02
  - Protect the Force

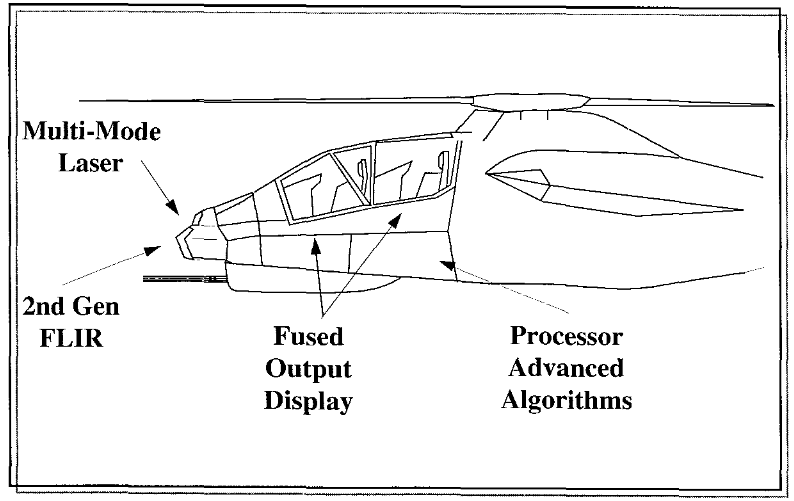
AIR/LAND ENHANCED RECONNAISSANCE AND TARGETING ATD
STO #III.D.14

Objective:
- Demonstrate On-The-Move Wide Area Search, Target Detection, and Identification in an Automated FLIR/Laser Target Acquisition Suite

Justification:
- MTD03 – Target Acquisition
- DSA09 – Real-Time Location and Identification of Targets
- EEL01 – Stop Modernized Threat Forces
- BC01 – Sensors

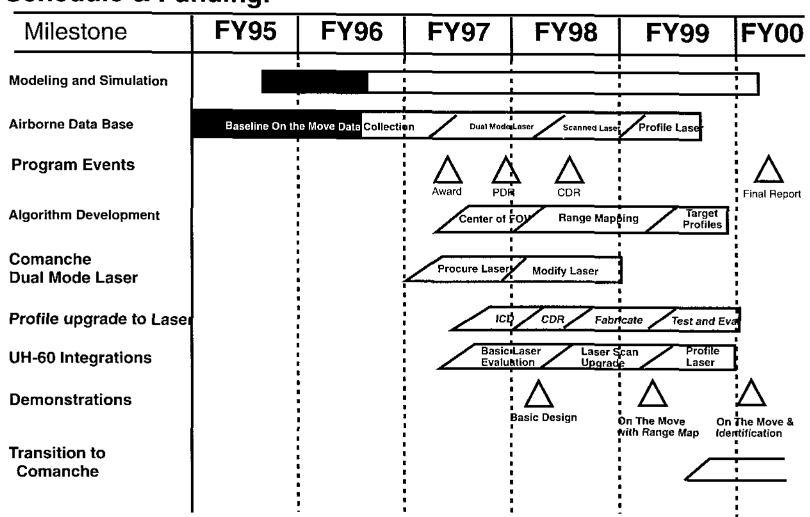
Battlelab:
- Mounted Battlelab
- D&SA Battlelab

PEO:
- Aviation



alert/v4/ 4/10/96

Schedule & Funding:



Funding: 63710/DK86 1.3 6.0 5.8 2.3
63238/D177 2.09

Approach:
- Demonstrate Advanced Targeting for Rotary Wing Strike Aircraft as part of the Armed Reconnaissance on the Digital Battlefield ACTD
  - 2nd Gen FLIR/Multi-Function Laser Sensor Suite
  - EO MTI/USAF Algorithms
  - Laser Target Profile
  - Neural Net Processing
  - Data/Image Compression and Transmission of Target Reports and Imagery

Applications:
- RAH-66 Comanche
- AH-64D Apache

AIR/LAND ENHANCED RECONNAISSANCE AND TARGETING ATD
EXIT CRITERIA
Normalized to current field performance

OPERATIONAL CAPABILITY	BASELINE FLIR PERFORMANCE	EXIT CRITERIA	* GOAL EXIT CRITERIA
On The Move Detection	1x Pd	1.35x Pd	1.6x Pd
On The Move Recognition	1x% Pr	1.2x% Pr	1.4x% Pr
On The Move Identification	N/A	1.1x% Pi	1.35x% Pi
False Alarms with Clutter Levels	1y/Km^2 - Low N/A - High	0.1y/Km^2 - Low 0.2y/Km^2 - High	0.01y/Km^2 - Low 0.05y/Km^2 - High
Acquisition Range	1z- 2z Km	2z-3z Km	3z - 4z Km
Forward Velocity and Scan Size	k Knots d Degrees	k Knots 5d Degrees	k Knots 7d Degrees

Performance is for 2.3 x 2.3 Meter Target with 0.6 degree C temperature contrast at the sensor.

* Goal is to achieve static performance or better while on-the-move.

BATTLESPACE COMMAND AND CONTROL ATD
STO #III.E.06

Objective:

The objective of the BC2-ATD is to demonstrate, through modeling, simulation, and experimentation with the user, the critical solutions leading to a demonstrable Command and Control (C2) and Battlefield Visualization (BV) prototype providing software tools supporting Consistent Battlespace Understanding; *Forecasting, Planning, and Resource Allocation; and* Integrated Force Management for Commander and Staff. These capabilities will be integrated into the C4I Systems Architecture, at Battalion through Division. Interoperability with Corps/Joint/Allied assets is a goal. The ATD will also *explore the insertion of developed C2/BV software into Corps and Echelons* above Corps. The scope and architecture boundary of BC2-ATD are illustrated in the graphic.

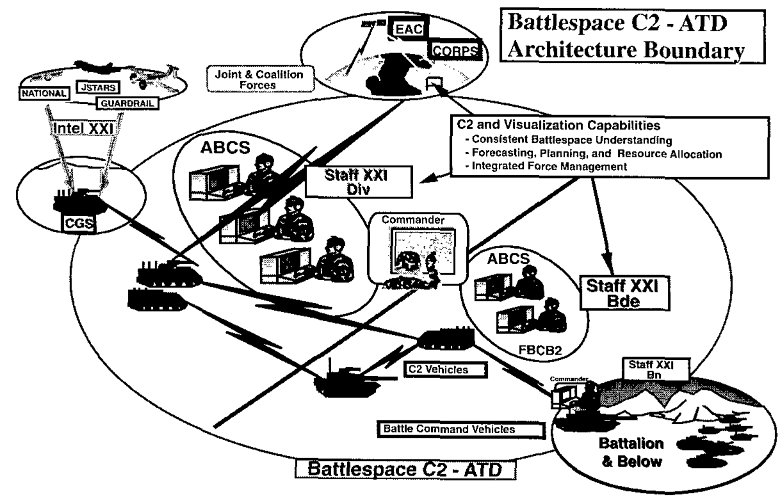
C2/BV prototypes, concepts, and architecture will support the following: Prairie Warrior (98,99,00), BCV/C2V BLWEs, Rapid Battlefield Visualization-ACTD, Battlefield Awareness Data Dissemination-ACTD.

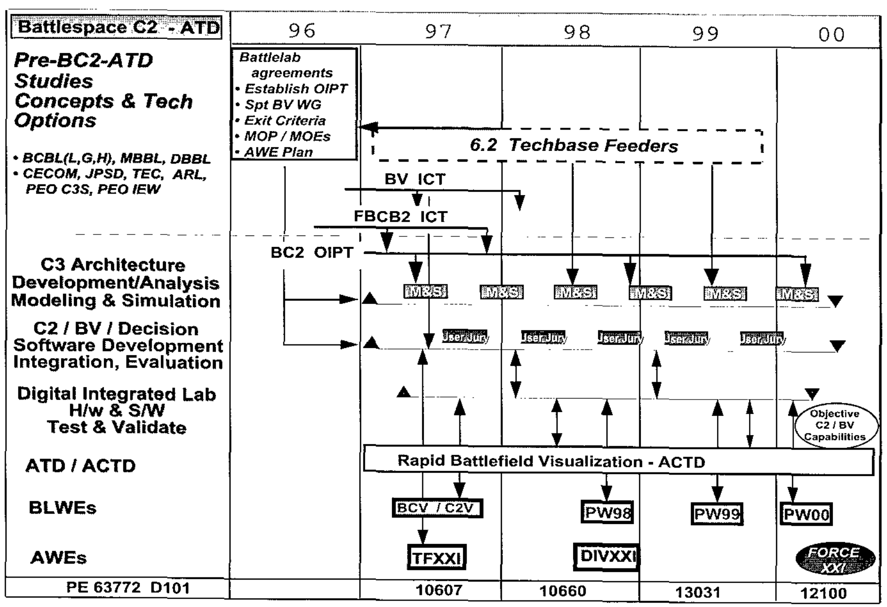
Battle Labs:

BCBL–(L,G,H), MBBL, DBBL

PEO:

C3S





Approach:

BC2-ATD uses a systems engineering approach that includes:

- Identify C2/BV requirements (User lead)
- Develop/evolve software prototype solutions and architecture definition
- Examine and analyze prototypes, products, architectures, and alternative solutions through use of enhanced Modeling and Simulation Tools
- Evaluate products (BLWEs, User Jury, etc.)
- Demonstrate solution sets at selected AWEs
- Hand-off incremental product modules to PEOs and ACTDs.

Operational Payoff for Commander and Staff:

- Consistent battlespace understanding
- More thorough/swifter sharing of tactical information
- Proactive means for collaborative planning, COA, forecasting

Applications:

Battlefield Digitization, Battlefield Visualization, Force XXI, Staff XXI, Intel XXI, BCV/C2V

BATTLESPACE COMMAND AND CONTROL ATD EXIT CRITERIA

CRITERIA	BASELINE	MINIMUM	GOAL
• REDUCE REACTION / DECISION TIME *[Deliberate]**	BDE = 12/24 Hrs DIV = 24/36 Hrs	Factor of 2	Factor of 4
• REDUCE MISSION TO ORDER PREPARATION TIMES *[Deliberate]**	BDE = 12/24 Hrs DIV = 24/36 Hrs	Factor of 2	Factor of 4
• INCREASE THE NUMBER OF COMBAT OPTIONS EVALUATED *[per unit time]**		Factor of 1.5	Factor of 2

* *Dependent on: Echelon being evaluated (BN, BDE, or DIV) & SCENARIO (dictates where in Tactical Decision Making Continuum - DELIBERATE, COMBAT, or QUICK)*

MINE HUNTER KILLER ATD
STO III.N.09

Objective:

- Develop an Integrated System Concept for Autonomous Detection and Destruction of Mines at Maneuver Speeds

Justification:

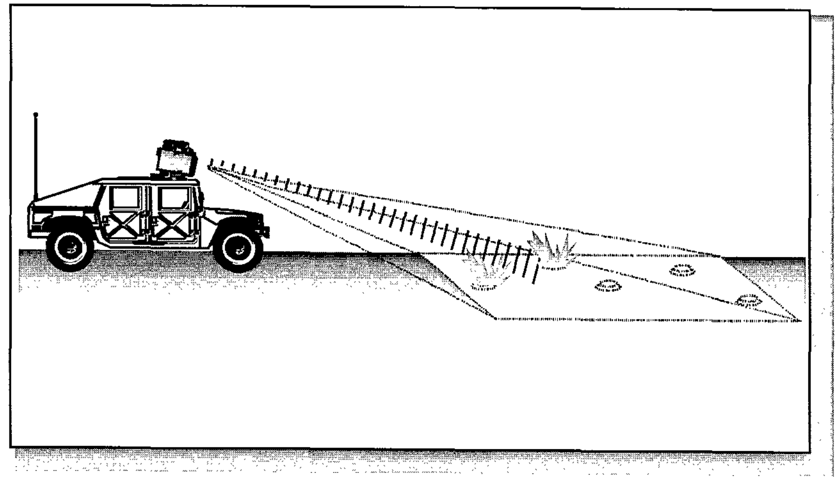
- MTD03 Mounted Forces Mobility
- DBS22 Rapid Breaching of Obstacles
- EEL07 Remote Early Entry Forces
- CSS17 Logistics Mobility
- DSA05 Enhanced Survivability of Deep Attack Systems

Battle Lab:

- Mounted Battle Lab

PEO:

- ASM



Schedule and Funding:

MILESTONES	FY96	FY97	FY98	FY99	FY00
6.2					
Modeling and Analysis					
Vehicle Mounted Mine Detector					
Detection Technology Enhancements					
Explosive Neutralization					
6.3					
Hunter-Killer Integration					
Demo					
Funding					
AH20/AH94	3.7	4.0	5.5	4.8	
D608			7.6	9.1	9.5

Approach:

- Combine mine detection and neutralization technologies into an integrated autonomous system capable of detecting, locating, and destroying mine targets
- Leverage mine detection technologies from vehicle mounted mine detection program

Applications:

- Mine, UXO, and route clearing
- Battlefield mine/UXO clearing
- Stability in support operations

MINE HUNTER KILLER ATD EXIT CRITERIA

- Proposed Exit Criteria

OPERATIONAL CAPABILITY	BASELINE VMMD	ATD MINIMUM	ATD GOALS
Mine Detection (Types)	All	All	All
Breaching Speed	3 Mph	5 Mph	20 Mph
Neutralization Range	None	50 Meters	75 Meters
Probability of Detection	85%	90%	98%
False Alarm Rate (per meter forward advance)	0.25	0.06	0.04

- Transition
  - Mine Hunter Killer / Breacher P3I
- Modernization / JWS&T Plan / DTAP Objectives Supported
  - Weapons DTAP- DTO WE.02
  - JWS&T Plan - Countermine DTO G.01
  - Protect the Force
  - Dominate Maneuver

MULTIFUNCTION STARING SENSOR SUITE ATD
STO # III.H.N.01

Objective:

- Demonstrate a compact, affordable, multifunction - mortar/sniper location, low signature vehicle detection, non cooperative target ID, air defense - staring sensor suite for ground vehicles

Justification:

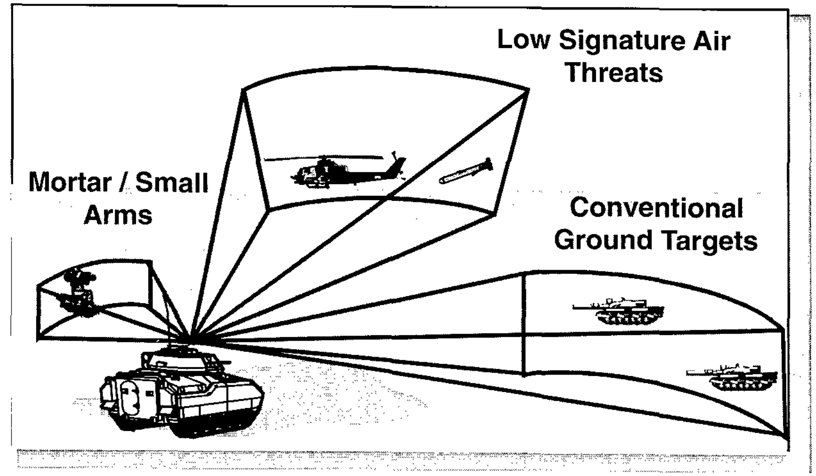
- MTD02 Improved capability to acquire low signature ground and air targets
- DBS14 Extend range of target acquisition to include mortar/sniper weapons location
- EEL05 Improved capability to acquire and ID conventional and low signature targets

Battlelab:

- Mounted Warfighting
- Dismounted Battlespace

PEO:

- IEW-PMNV/RSTA
- ASM-FSV



Schedule and Funding:

MILESTONES	FY97	FY98	FY99	FY00	FY01
Technical Risk Reduction					
Modular Backplane					
Staring FLIR					
Laser/Acoustics					
Sensor Integration					
Demonstration					
Funding:					
DK70 - $35.2M		6.3	9.7	9.6	9.6

Approach:

- Confirm sensitivity/resolution goals with early field tests
- Develop modular sensor backplane to accommodate multiple sensor interfaces
- Demonstrate reconfigurable sensor with ATR in an operational environment
  - Medium Format Staring FLIR operating in NIR/MWIR or LWIR spectrums
  - Multifunction laser
  - Acoustic cueing sensors

Application:

- Bradley Stinger Fighting Vehicle-Enhanced
- Future Scout Vehicle
- Future Infantry Vehicle
- Advanced Amphibious Assault Vehicle

MULTIFUNCTION STARING SENSOR SUITE ATD EXIT CRITERIA

OPERATIONAL CAPABILITY	BASELINE HTI FLIR	ATD MINIMUM	ATD GOAL	REMARKS
Target Detection (Pd = 0.70)				
UAV	1.0	1.0	1.1	LWIR
Helo	1.0	1.0	1.1	LWIR
Mortar Projectile	N/A	5.4 Km - NFOV	6.0 Km - NFOV	MWIR
Sniper Fire (AK-47)	N/A	0.4 Km - NFOV	0.5 Km - NFOV	MWIR
Ground Target ID (Pid = 0.70)				
FLIR only	1.0	1.1	1.3	LWIR
FLIR + Laser	1.0	1.0	1.3	LWIR
Configurability	N/A	3-5 or 8-12	Vis-5 and 8-12	
Temporal/Hyperspectral	N/A	Yes	Yes	
Panorama	N/A	No	Yes	

- Transition
  - SV / FMBT / FIV
  - Bradley Stinger Fighting Vehicle - Enhanced
- Modernization / JWS&T Plan / DTAP Objectives Supported
  - JWS&T Plan - Precision Force
  - JWS&T Plan - MOUT
  - Dominate Maneuver
  - Protect the Force

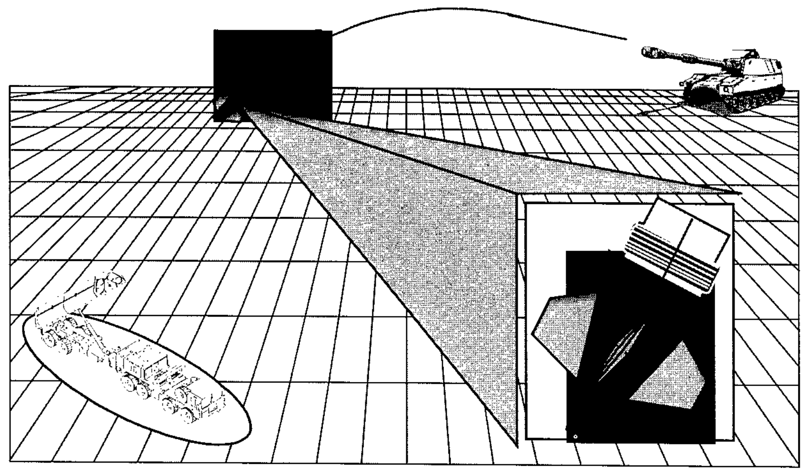
INDIRECT PRECISION FIRE ATD
STO #III.N.18

Objective:
- Demonstrate low cost miniaturized (standard fuze volume; $9in^3$) GPS/INS guided modules to improve the effectiveness of all current and future artillery projectiles for all platforms, enabling first round fire for effect.

Justification:
- 155mm extended ranges lack a cost-effective accuracy solution
- Ft. Sill - accuracy improvement analysis - FY93
- TRADOC PAM 525-5

Battle Lab:
- D&SA

Program Manager:
- PM SADARM



Schedule and Funding:

MILESTONES	FY97	FY98	FY99	FY00	FY01
Auto-Registration Demo Transition Navy Technology Define Army Requirements Miniaturize IMU Design Communication Link Design Integrated Fuzing Capability Integ. & Test GPS Receiver / Fuze Subsystem Integration & Test System Integration Conduct ATD					
FUNDING: **Total $29.6**	5.7	7.5	7.2	6.8	1.9

Approach:
- Autoregistration demonstration
- Conduct effectiveness study of a precision munition with guide to submunition footprint or point target capability.
  - Mid-Flight range and deflection corrections
  - Sensor / communication links
- Leverage Navy's $27M tech devel investment
- Define optimum tech development strategy
- Develop Integrated Fuzing Capability
- Miniaturize subsystems (GPS, IMU, fuze, control)
- Conduct operational demo

Applications:
- Existing and future 155mm munitions / platforms

INDIRECT PRECISION FIRE ATD EXIT CRITERIA

	Current Baseline	Minimum	Goal
Delivery Accuracy @ 35km	318 m CEP	50 m CEP	10 m CEP
Size	N/A	9 in^3	9 in^3
Cost Per Unit	N/A	$3000	$1500
Perform in Jamming Environment	N/A	Resistant	Resistant
Additional Gun-Line Procedures	Current ARTEP STD	+15 Seconds	None

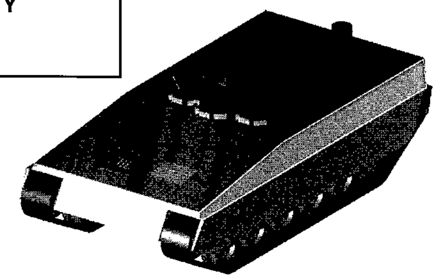
FUTURE SCOUT AND CAVALRY SYSTEM (FSCS) ATD

Objective:
- Demonstrate technical feasibility, operational potential of a Scout by integrating Scout specific technologies with advanced vehicle technologies. (Integrates efforts from STO III.G.11 and STO TAR-02).

Justification:
- FSCS Integrated Concept Team (ICT) findings.
- FSCS validated Mission Need Statement (MNS).
- FSCS Draft Operational Requirements Document (ORD).
- Existing platforms not designed for recon missions.

User Support:	**Battlelab Experiment:**	**PEO:**
Armor Center DFD	Mounted Maneuver	GC&SS
Mounted Maneuver Battlelab		

- **IMPROVED TARGET ACQUISITION**
- **OPEN SYSTEMS ELECTRONIC ARCHITECTURE**
- **ADVANCED CREW STATION**
- **INTEGRATED SURVIVABILITY**
- **ENHANCED MOBILITY**
- **LIGHTWEIGHT STRUCTURE/ARMOR**
- **STRATEGIC DEPLOYABILITY**
- **LETHALITY**
- **SYSTEMS INTEGRATION**



Schedule and Funding:

MILESTONE (FY)	97	98	99	00	01	02
DEVELOP MOBILITY COMPONENTS AND CREW STATION DESIGN						
DEMONSTRATE MOBILITY COMPONENTS & CREW STATION SIMULATOR						
DEVELOP FSCS VIRTUAL PROTOTYPE & DEMO FSCS IN VIRTUAL ENVIRONMENT						
COMPETITIVELY AWARD THE ATD						
DEMONSTRATE SCOUT MOBILITY & SURVIVABILITY TECHNOLOGIES IN BLWE						
DEVELOP PRELIMINARY DESIGNS						
INITIATE SYSTEMS INTEGRATION LAB						
DEVELOP DETAILED DESIGN						
DESIGN, FABRICATE & INTEGRATE DEMONSTRATOR						
DEMONSTRATE/EVALUATE SCOUT TECHNOLOGIES AND TACTICS IN BLWE						
FUNDING ($M):	1.7	3.1	20.4	34.3	37.9	6.0

Approach:
- Use virtual prototyping to evaluate many different configurations to determine the optimal combination of survivability, mobility, target acquisition, lethality, and deployability technologies such as:
  - Scout Sensor Suite
  - Advanced command and control
  - Advanced crew station
  - Advanced survivability systems
  - Electric drive, lightweight track, and semi-active suspension
  - Advanced lightweight structural materials and armors
  - Medium caliber weapon/surrogate
- Demonstrate Scout Vehicle hardware and software soldier machine interface in distributive interactive simulation (DIS) environment
- Demonstrate hardware/software in system integration lab (sil)
- Finalize Scout design and build demo vehicle platform
- Provide demo vehicle platform to user for mobility and survivability evaluation (BLWE) and Scout tactics development (BLWE)
- Leverage DARPA's hybrid electric power program

Applications:
- Transition to EMD for FSCS
- Potential joint vehicle development with Marine Corps
- Potential joint vehicle development with United Kingdom

FUTURE SCOUT AND CAVALRY SYSTEM (FSCS) ATD EXIT CRITERIA

ENHANCEMENT	BASELINE	END ATD MINIMUM	END ATD GOAL
1. Decrease vehicle signature (visual, thermal, radar, acoustic)	M3A3*	y%**	z%**
2. Target detection rate	M3A3*	500%	600%
3. Target identification range	M3A3*	0%	30%
4. Cross-country speed	M3A3*	25%	30%
5. Reduce time required to create and send a Spot Report	M3A3*	25%	35%
6. Improve operations on the move	M3A3*	30%	40%
7. Transportability	M3A3*	C-17	C-130

** Waiting production decision.* *** Classified.*

This page intentionally left blank

ATDs in ACTDs

PRECISION RAPID COUNTERFIRE—MRL

- ENHANCED EFOGM ATD
- MULTI-PLATFORM LAUNCHER ATD

JOINT COUNTERMINE ACTD

- VEHICLE MOUNTED MINE DETECTOR ATD
- OFF-ROAD SMART MINE CLEARANCE ATD

JOINT COMBAT IDENTIFICATION ACTD

- BATTLEFIELD COMBAT ID ATD

RAPID FORCE PROJECTION INITIATIVE ACTD

- ENHANCED EFOGM ATD
- HUNTER SENSOR SUITE ATD
- INTELLIGENT MINEFIELD ATD
- REMOTE SENTRY ATD

JPSD PRECISION/RAPID COUNTER–MRL ACTD

Objective:

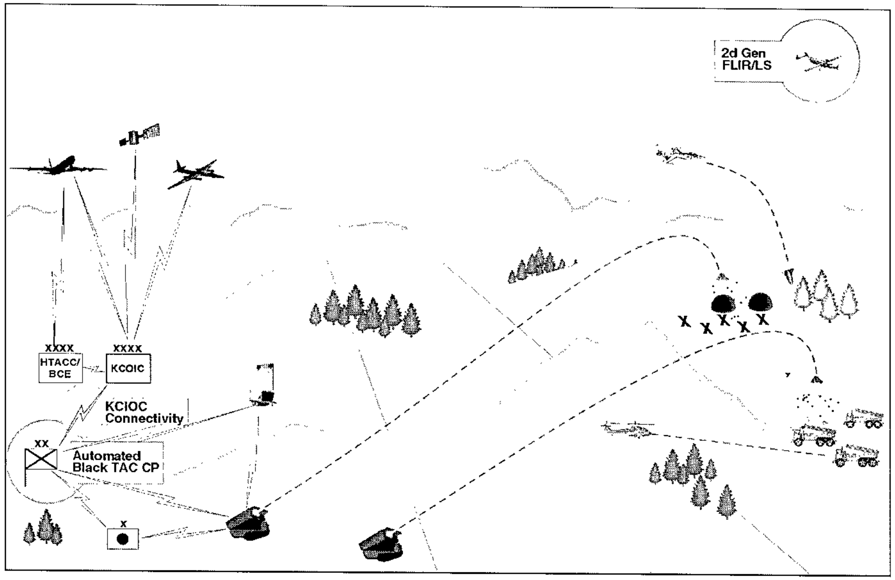
- Demonstrate an improved capability, through current emerging and advanced technology, to defeat a 240 MRL attack against South Korea during H to H plus 48 hours.
- Provide leave behind capabilities.

Justification:

- CINC identified requirements to neutralize attack (DSABL).

Battlelab:

- Depth & Simultaneous Attack (DSABL).



Schedule and Funding:

MILESTONE	FY95 2Q	FY95 3Q	FY95 3Q (2)	FY95 4Q	FY96 1Q	FY96 2Q	FY96 3Q	FY96 4Q	FY97 1Q	FY97 2Q	FY97 3Q	FY97 4Q	FY98 1Q	FY98 2Q	FY98 3Q	FY98 4Q
INTEL/SETUP FOR CONUS DEMO			■	■												
CONUS DEMO INSTALL/ REHEARSE				■												
KOREA DEMO					■	■	■	■								
KOREAN DEMO								■								
RESIDUAL CAPABILITY/ SUSTAIN									■	■	■	■	■	■	■	■

	FY95	FY96	FY97	FY98
FUNDING ($M)				
ARMY	31.2	15.8		
OSD	5.7	5.7	16.6	13.3
TOTAL ($M)	36.9	21.5	16.6	13.3

Approach:

- Employ surveillance strategy to cue new target acquisition capabilities. Automate and integrate targeting and fire direction process to destroy high value targets in open and deny access to protected positions.
- Conduct CONUS demonstration in FY95 and Korean demo in FY96 employing both live and simulated systems as required.
- Analyze data at JPSD Integration and Evaluation Center, publish after action reports lessons learned, and distribute to combat and materiel developers.
- Provide residual capability for comms to Combined Ops Intel Center (COIC), Automated DEEP Ops Coordination Cell.

Applications:

- Deep Strike with Smart Weapons; C3I; UAV.

JPSD PRECISION/RAPID COUNTER–MRL ACTD EXIT CRITERIA

THIS ACTD FOCUSES ON THE DETERMINATION OF A MORE EFFICIENT SENSOR-TO-SHOOTER PROCESS TO REDUCE TIMELINES AGAINST A FLEETING TIME-CRITICAL TARGET, THE 240MM MRL. THE OVERALL OBJECTIVE IS TO MAINTAIN FRIENDLY FORCE TIMELINES WHICH ARE WITHIN THE ENEMY'S TIMELINES AND TO CONTROL THE TEMPO OF OPERATIONS. NUMBER OF MINUTES FOR DECISION CRITERIA 1 AND 2, AND A PERCENTAGE FOR DECISION CRITERIA 3 ARE CLASSIFIED AND HAVE BEEN LEFT BLANK. THEY ARE CONTAINED IN JPSD'S PRECISION/RAPID COUNTER MRL ACTD MANAGEMENT PLAN.

- DEMONSTRATE THE CAPABILITY TO PUT AN MLRS SEEDED MINEFIELD IN PLACE AND OPERATIONAL WITHIN H-HOUR PLUS ___ MINUTES.
- DEMONSTRATE THE CAPABILITY TO EXTEND THE 240MM MRL TIMELINE TO ___ MINUTES.
- DEMONSTRATE THE ABILITY OF ALTERNATIVE SYSTEMS TO RENDER ___ PERCENT OF TARGETED LAUNCHERS COMBAT INEFFECTIVE.

JOINT COUNTERMINE ACTD

Objective:

- Demonstrate seamless transition of countermine capabilities from sea to land operations.

Major Challenge:

- Integration of Army/Navy/Marine Corps developmental systems with fielded hardware to produce new countermine operations.

Approach:

- Conduct two major demonstrations.

Milestones:

ACTD MANAGEMENT PLAN APPROVED.................................. 3QFY95
JCOS PROGRAM.. 2QFY95
C4I EXECUTION PLAN COMPLETE.. 4QFY96
CONDUCT DEMONSTRATION I.. 3QFY97
CONDUCT DEMONSTRATION II... 4QFY98
COMPLETE ANALYSIS OF DEMONSTRATION EVENTS........ 3QFY99
FOLLOW-ON SUPPORT AND EVALUATION........................... FY99-FY00

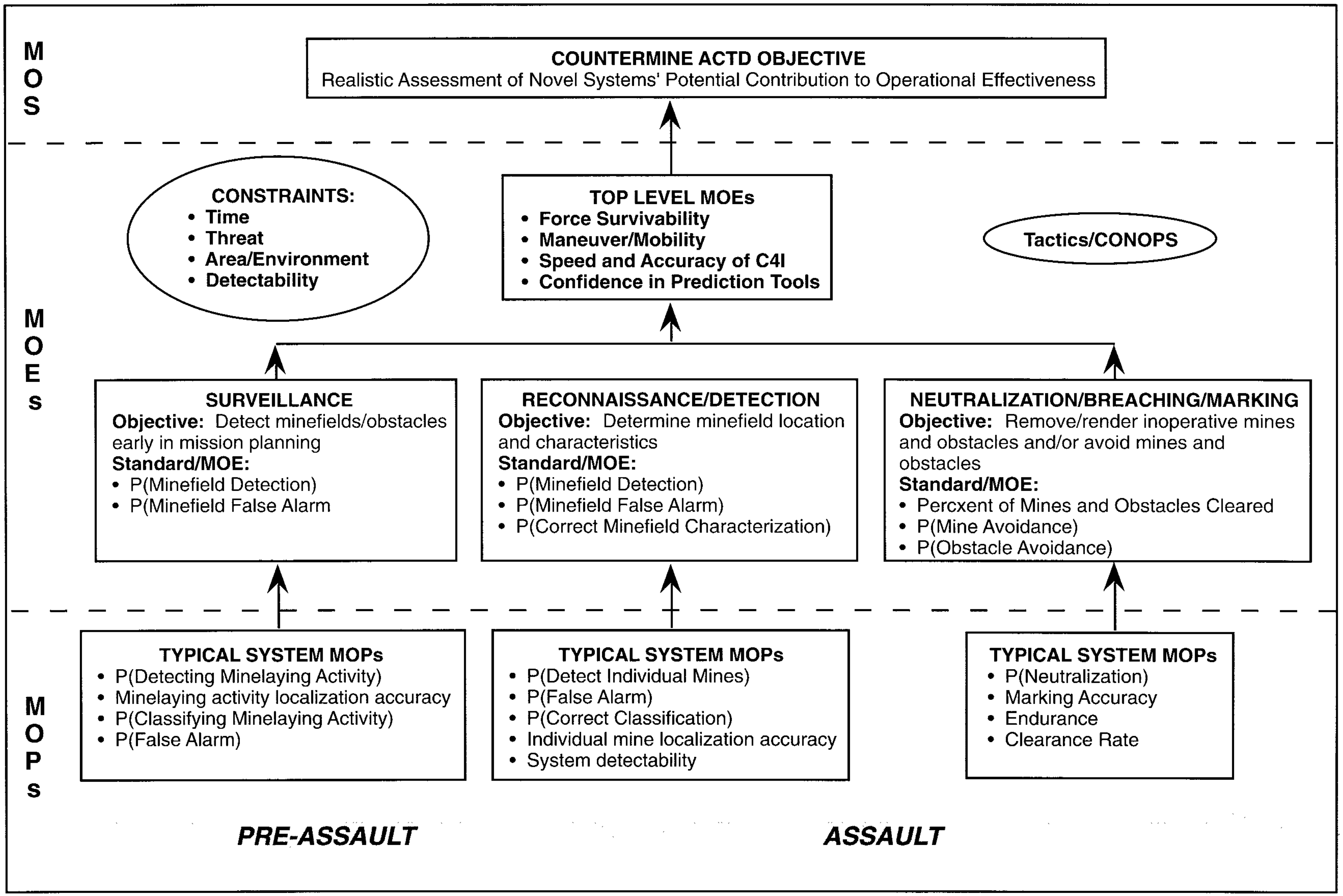
Funding:

SOURCE	FY95	FY96	FY97	FY98	FY99	FY00	TOTALS
OSD CM ACTD FUNDING							
ARMY	7.5	7.4	7.6	5.7	2.2	1.4	31.8
NAVY	5.6	6.8	8.1	10.1	3.9	1.5	37.8
SUBTASK	13.1	14.2	15.7	15.8	6.1	2.9	69.6

Accomplishments:

- Joint Project Office established.
- CINC USACOM signed on as "operational user".
- Prepared Management Plan.
- Initiated Joint Countermine Operational Simulation (JCOS) and Joint CRI Effort.

COUNTERMINE ACTD OPERATIONAL OBJECTIVES AND MEASURES



JOINT COMBAT IDENTIFICATION ACTD

Objective: Increase Combat Effectiveness and Reduce Fratricide

Demonstrate a joint, integrated air-to-ground and ground-to-ground combat identification capability

- Quantify the contributions of select identification technologies to reduce fratricide and increase combat effectiveness.
- Support a Cost and Operational Effectiveness Analysis (COEA) through assessment of Measures of Performance (MOPs) and Measures of Effectiveness (MOEs) from both exercises and simulations.

Refine inter/intra-Service tactics, techniques, and procedures.

Leverage the investment in the digitized battlefield initiative to explore synergism between SA and TI.

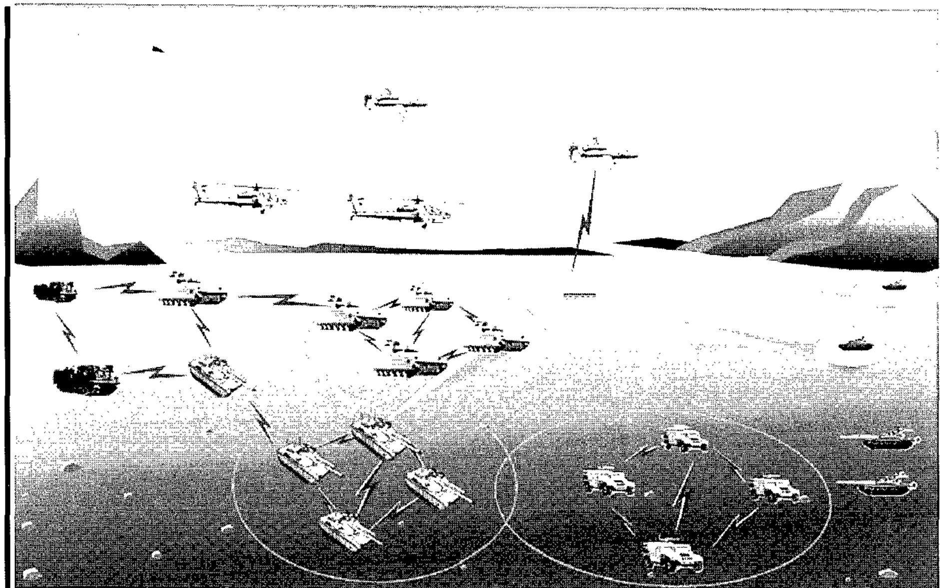
Provide a "leave behind" capability for an operational force.

Justification:

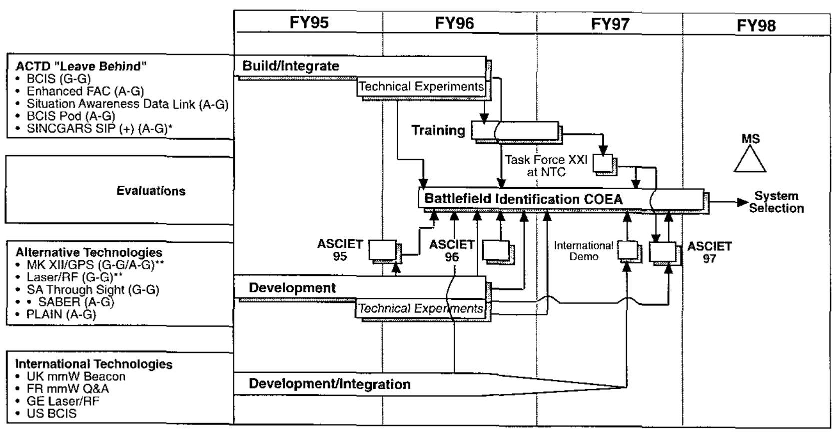
- JROC MNS, 26 Mar 92

Sponsor:

- CINC, Atlantic Command



Schedule and Funding:



FY96–FY98:

Target ID

- Performance
- Interoperability
- Added Ground Platforms
- Air Platform
- Allied Interoperability

Situational Awareness

- Digital Data Link
- Data Correlation
- Heads Up Display
- Display on *Commander's Tactical Terminal*

JOINT COMBAT IDENTIFICATION ACTD EXIT CRITERIA

OPERATIONAL CAPABILITY	BASELINE	IMPROVEMENT	ACTD GOAL
Target Identification	G-G	A-G Q & A	A-G Q & A
• Cooperative (Friends)	BCIS Q & A		
• Non-cooperative (Foe and Neutrals)	2nd Gen FLIR	FW A-G	FW A-G
– ID Time	Several Seconds	90% <2.3 Secs A-G	90% <1 Sec All
– PID	~80%	90% <1.0 Sec G-G	
• Range	Limited by Resolution and Weather	1.0 X Weapon EFF Range	1.5 Weapon EFF Range
Platform Extension	Ground Vehicles	Rotary Wing, Fixed Wing Aircraft, FAC	Rotary Wing, Fixed Wing Aircraft, FAC
Situational Awareness	Manual	Integrated	Automated, Integrated
Joint Interoperability	None	Yes	Yes
Allied Interoperability	None	No	Yes
Loss Exchange Ratio	Measured at ASCIET 96		2X ASCIET 96
Fratricide	Measured at ASCIET 96		0.5X ASCIET 96

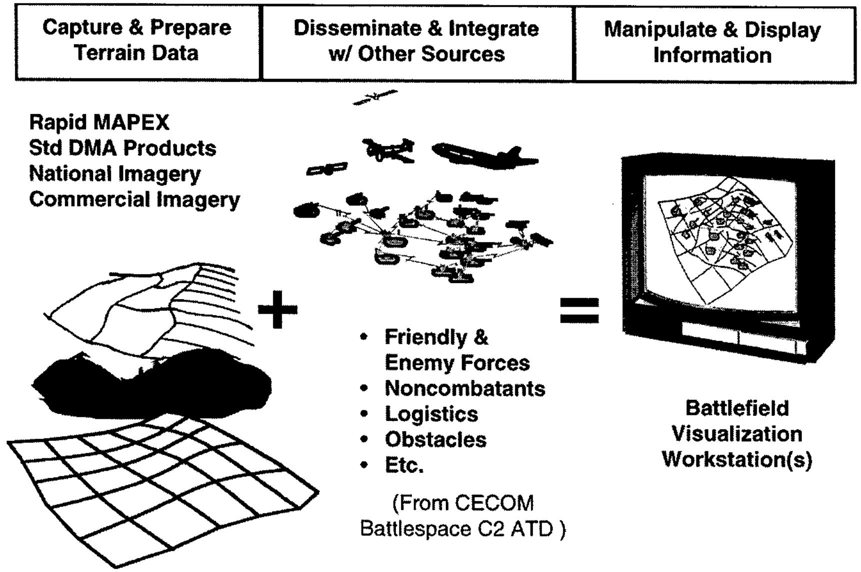
RAPID BATTLEFIELD VISUALIZATION ATD (PROPOSED ACTD)

Objective:

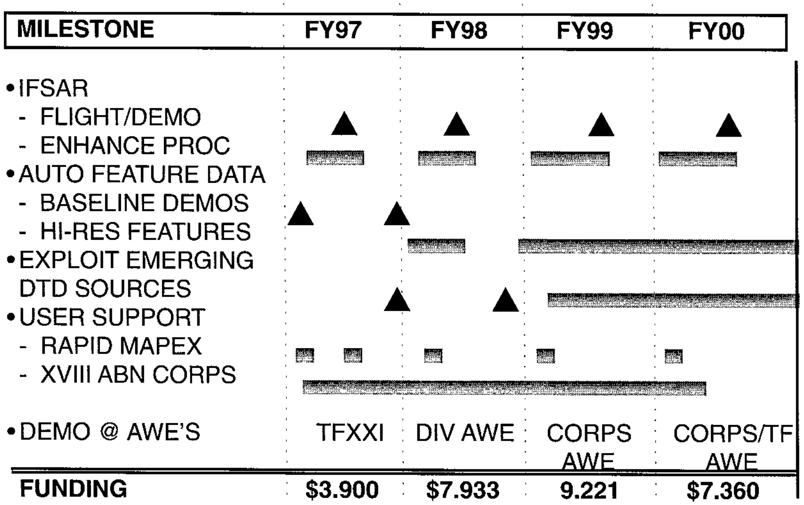
- Integrate technologies for rapid, high resolution digital terrain data (DTD) generation, dissemination, and display/utilization
- Demonstrate DTD merged with INTEL data as foundation for battlefield visualization

Justification:

- Emerging capabilities must be integrated to ensure availability of critical terrain data to warfighter
- Army does not have high resolution digital terrain data needed for mission planning and execution worldwide
- Capability to integrate terrain data with INTEL and situational awareness data is limited



Schedule and Funding:



Approach:

- Demonstrate rapid generation of digital topographic data (DTD) to support force projection timelines (early entry)
- Integrate DTD with intelligence and situational awareness data from BC2 ATD
- Use existing and emerging wideband electronic communications to disseminate data to users
- Demonstrate/integrate IFSAR capabilities to produce high resolution elevation data
- Integrate semi-automated feature extraction capabilities to provide rapid feature data for contingency operations

Applications:

ABCS, TEM, DTSS, ASAS-RWS, CGS, BVIZ-ACTD, BADD-ACTD, BC2-ATD

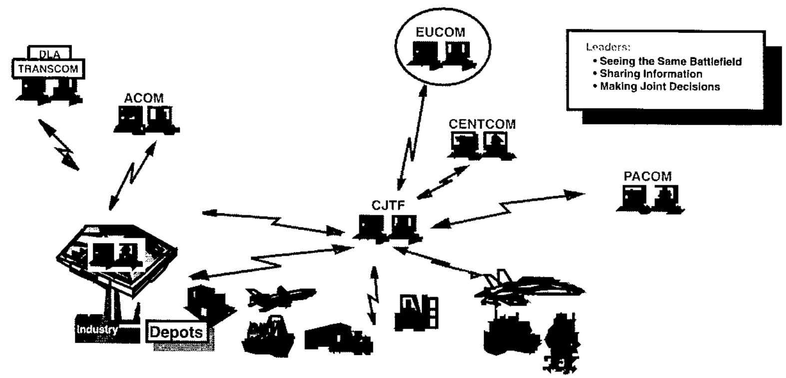
RAPID BATTLEFIELD VISUALIZATION ATD (PROPOSED ACTD) DECISION CRITERIA

OPERATIONAL CAPABILITY	BASELINE	MINIMUM	GOAL
• Collection Management	• Decentralized, Manual	• Semi-automated Process	• Integrated and Automated Process
• Elevation Data Generation	• DMA, Carto Source, DTED Level I (100m) and II (30m)	• Image or IFSAR Source, Multi-Res, Level III (10m)	• Mil Platform IFSAR or Image Source, Tailored Res, Level V (1m)
• Feature Data Generation	• DMA, Cart Source, ITD, Labor Intensive	• Image Source, Semi-automated, Limited Feature Content	• Any Source, Semi-automated, ITD-Like Feature Content
• Spatial Data Management	• No Current Capability for Multi-Res, Multi-Scale	• Hierarchical Database for Finite Set of Resolutions and Scales	• Flexible Hierarchical Database for Multi-Res, Multi-Scales
• Data Transform for C2 and Mission Planning Systems	• Manual, One-at-a-Time for Non-DMA Compliant Systems	• Automated for One BV System	• Automated for Suite of BV Systems
• Data Dissemination	• Mag Tape or CD-ROM	• Near-Real-Time Electronic, COTS	• Near-Real-Time Electronic, Military
• Data Display/Use	• 2-D Capability, Limited 3-D	• 3-D Mission Planning on COTS Portable Workstation	• BV Capability on Multi-Platforms, Multi-APPS

JOINT LOGISTICS ACTD

Objective: To provide CINCs and CJTFs with the capability to plan and execute more responsive and efficient logistics support.

- Network of workstations connecting operational planners and logisticians across Services and echelons.
- Advanced data distribution and visualization techniques to provide a common, relevant picture.
- Integration of existing logistics models with knowledge-based tools to provide decision support.
- GCCS compliant.



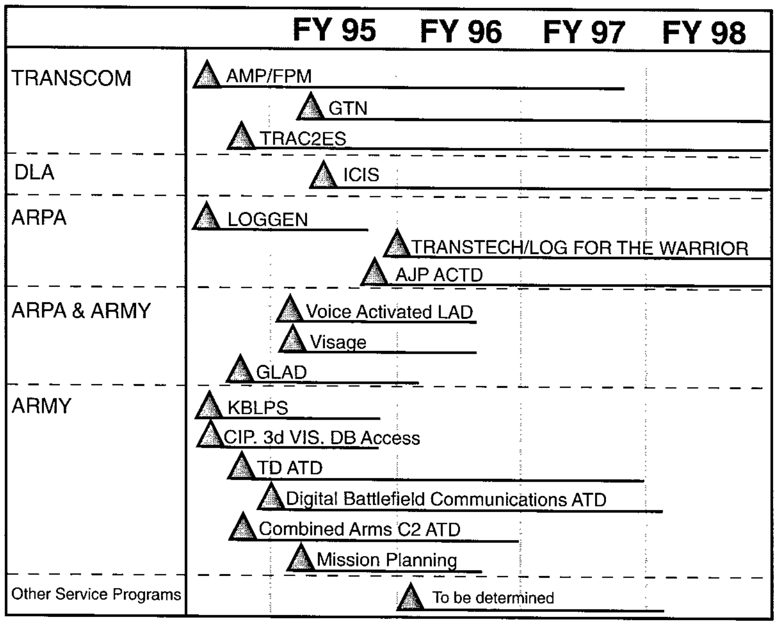
Justification:

- Limited end-to-end sustainment C2.
- Decision support tool stovepiped.
- Lack of collaborative planning capability.

Battlelab:

- CSS Battle Lab.

Schedule:



Approach:

- Apply mature DoD and commercial technology to critical logistics problems.
- Provide significant improvement in mission capability through enhanced logistics situational awareness and predictive model/ simulation tools.
- Provide capability to rapidly plan and execute more responsive and efficient logistics support.

JOINT LOGISTICS EXIT CRITERIA

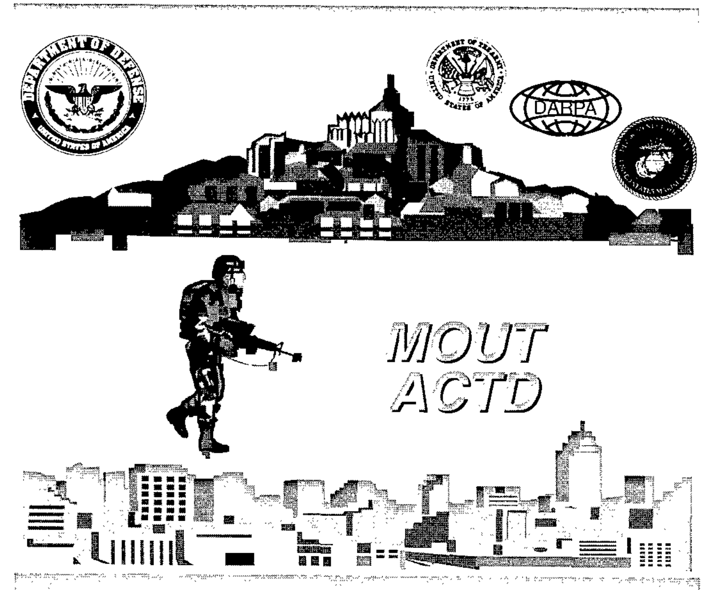
The primary evaluation metric relates to the demonstrated ability to handle user needs in diverse program-mission areas. User criteria will reflect compliance with the strategic and tactical objectives of the particular program mission area.

- Automated access to relevant joint data, including forces, logistics, and infrastructure.
- Interfaces with joint planning tools developed by the Advanced Joint Planning ACTD.
- Advanced visualization tools for logistics data that will provide a common, relevant logistics picture with a single interface usable by all Services.
- Planning tools to allow dynamic resource allocation across Services.
- Joint course of action generation, analysis, and comparison of logistics plans.
- Greater detail and accuracy in communicating logistics mission orders and requirements.
- Execution monitoring tools linked to the logistics plan.
- Enabling technologies to facilitate interpersonal communications.
- Demonstrate utility over garrison, tactical, and commercial communications.
- Reduced administrative requirements for communications engineering.

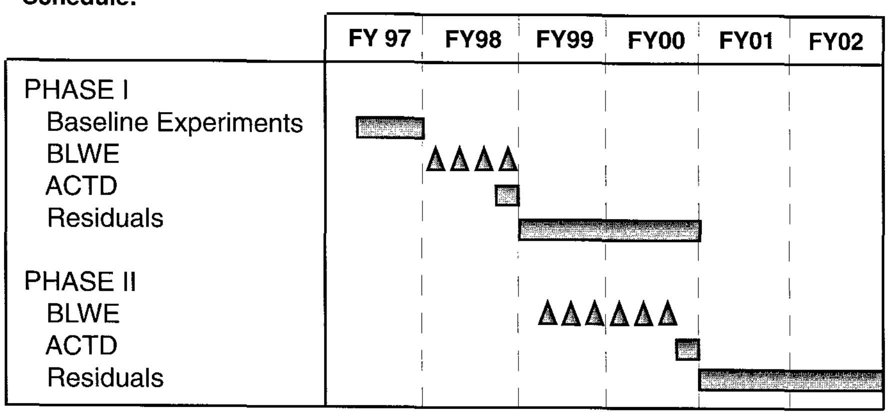
MILITARY OPERATIONS IN URBAN TERRAIN ACTD

Objective:

- Identify, integrate, and demonstrate a system of existing and emerging technologies to provide improved Command, Control, Communications, and *Intelligence* (C4I), *Engagement, and* Force Protection to warfighters operating in the restrictive urban environment.
- C4I systems integration and interoperability will increase situational awareness by 50% through use of advanced sensors and a nonhierarchical adaptive network system, providing the ability to conduct multimedia communications through buildings and other non-line-of-sight obstacles.
- MOUT Engagement will demonstrate both lethal and less-than-lethal technologies, using improved systems of fire control, ammunition, and fusing technologies to augment the joint service lethal and nonlethal weapons in engagements against hard and soft targets.
- MOUT Force Protection will be improved 20% though integration and demonstration of new ballistic protection, countersurveillance, combat identification, counter-sniper, and individual medical technologies.



Schedule:



FUNDING:

	FY 97	FY98	FY99	FY00	FY01	FY02
MOUT ACTD ($Mill) (*PE 0603001A/D393*)	0.0	20.3	21.2	21.0	2.0	2.0

Approach:

- *Identify existing and emerging* C4I, *Engagement, and Force Protection* technologies. Exploit NDI, COTS, and GOTS items, as well as mature R&D efforts, many already being developed and demonstrated by other funded TDs and ATDs.
- Provide the environment and integrate technologies and components into a system of systems, designed for operation in the restrictive urban environment.
- Use modeling and simulation to quantify systems integration to increase combat performance, operational impact, and tactical employment.
- Phase I will complete instrumentation, baseline experiments, and experiments with mature and existing technologies. Phase II will complete experimentation with upgraded h/w and s/w comprised of emerging technologies. Residuals include a company-level set of successfully demonstrated equipment.

MILITARY OPERATIONS IN URBAN TERRAIN EXIT CRITERIA (CONCEPTUAL)

Description	Measures of Success	
GIVEN: (a) AN ENEMY FORCE OF APPROXIMATELY COMPANY STRENGTH ENTRENCHED IN AN URBAN AREA WITH ORGANIC MORTAR, FIELD ARTILLERY, AIR DEFENSE, AND SNIPER SUPPORT, INTERMIXED WITH A NEUTRAL, UNKNOWN, OR HOSTILE CIVILIAN POPULACE, AND A NEUTRAL TO UNSYMPATHETIC WORLD PRESS CORPS, AND (b) A U.S. BATTALION-SIZED TASK FORCE ACTING AS THE VANGUARD FOR A LARGER FORCE (BRIGADE SIZE OR LARGER) AND EQUIPPED WITH A VARIETY OF MOUT-SPECIFIC TECHNOLOGIES, ATTACKING TO SEIZE AN URBAN AREA IN SUPPORT OF A LARGER OPERATION TO SEIZE A PORT CITY. THEN:	PERCENT IMPROVEMENT OVER BASE CASE (AS DEFINED BY THE DSB 1994 SUMMER STUDY ON MILITARY OPERATIONS IN BUILT-UP AREAS)	
	Minimum	**Goal**
A. INCREASE SITUATIONAL AWARENESS OF THE SIZE AND LOCATION OF THE THREAT APPLYING INTEGRATED SENSOR ORIENTATION AND SENSOR INTERCONNECTIVITY ACROSS THE BATTLEFIELD TO ACCURATELY IDENTIFY FRIENDLY, ENEMY, AND NEUTRAL PERSONNEL ON THE "BATTLEFIELD"	50% IMPROVEMENT	100% IMPROVEMENT
B. DEFEAT ENEMY FORCES IN SECTOR WITHOUT SUSTAINING CIVILIAN CASUALTIES	X%*	X%*
C. COMMUNICATE EFFECTIVELY WITHIN THE URBAN AREA	X%*	X%*
D. INCREASE THE SURVIVABILITY OF THE BATTALION TASK FORCE.	20%	45%

*TO BE DETERMINED FOLLOWING CASTFOREM RUNS.

Annex C

INTERACTION WITH TRADOC

TABLE OF CONTENTS

INTERACTION WITH TRADOC

A. INTRODUCTION

Battle Labs were created in response to the factors and implications of a changing world, strategy, budgetary reality, and a need for a new way of doing business. Battle Labs have quickly demonstrated their value as places where new concepts and technologies can be investigated for their implications on the battlefield, in the areas where warfighting appears to be changing most dramatically.

Following are overviews of Battle Lab concepts and their corresponding Operational Capabilities Requirements. Purpose of these overviews is provide insights on the battlefield dynamic each Battle Lab is charged to investigate, that Battle Labs' vision of future warfighting, and their perspective on operational capabilities required to fulfill the vision.

The process of developing Operational Capability Requirements (OCRs) is as follows:

a. Operational Capability Requirements are statements of capabilities required for the Army to fulfill the vision articulated within the Army Modernization Objectives. TRADOC Pamphlet 525-5 and the Battle Lab Concepts.

b. One set of OCRs are written for each Battle Lab and encompass the battlefield dynamic for which the Battle Lab is responsible. Scope of the Battle Lab's OCRs include the horizontal capabilities required of the force as well as relevant branch contributions to these capabilities. OCRs state required and desired capabilities across the full dimension of operations.

c. OCRs are a set of brief statements which break out required capabilities into discrete subsets, the aggregate of which, if fully attained, permits the Army to fulfill the National Military Strategy of winning quickly and decisively, while minimizing casualties.

d. OCRs are derived within the framework of historical lessons learned from operational experiences as well as the opportunities provided from technology exploitation.

e. OCRs are to encompass needs of the force stated within CINC's Integrated Priority List (IPL); however, given the lack of singular, analytically defined threat, OCRs are to also include a vision of desired capabilities emanating from technology opportunity.

f. Objective of the OCRs are to focus the Army S&T community towards capabilities which will provide technological superiority over any potential adversary. Technological superiority is required despite the potential that adversaries may have access to some state-of-the-art, high technology capabilities available in the world market.

g. Applications:

(1) Operational Capability Requirements are used within the Army Science and Technology Master Plan (ASTMP) process to provide a warfighting focus to technology base funding.

(2) OCRs articulate required and desired capabilities to the materiel developer community internal and external to the Army.

(3) OCRs are employed in Battle Lab S&T Reviews as the yardstick for assessing the warfighting merits of individual science and technology efforts and the total Army S&T program in aggregate.

(4) Perceptions of shortfalls derived from Battle Lab S&T Reviews should generate dialogue with the materiel developers to confirm or resolve the perceptions. Confirmed shortfalls should be considered in budgetary, planning, and programming reviews by the material developer. Shortfalls which exceed Army resource capabilities can be identified to industry to permit discretionary industry investments in needed areas.

(5) OCRs are employed in the Army Science and Technology Objectives (STO) process as the yardstick of warfighting merit. Candidate efforts selected as Army STOs within this process are published in the Army Science and Technology Master Plan as the most important S&T objectives for the Army R&D community. Army STOs receive senior Army leadership oversight and have priority for resourcing.

B. EARLY ENTRY SURVIVABILITY AND LETHALITY CONCEPT OVERVIEW

1. Characteristics of Early Entry

a. Early entry forces, the Army's "first to fight" forces, must be lethal, survivable, and deployable. Early entry operations will require deployment and employment of tailored armored, light, and special operations forces which can deploy rapidly, enter into the operational area, secure the lodgment, and have immediate decisive effect, or create conditions for the arrival of follow on forces which conduct decisive operations.

b. Operations of the early entry forces are intrinsically joint operations. Army forces must be able to use and integrate national intelligence systems linked to joint command, control, and communication systems. Joint force capabilities may be required to initially compensate for ground combat power shortfalls.

c. Combined and coalition operations with allies of friendly nations are the expected norm. U.S. early entry forces must be interoperable with these forces. Combined or coalition interoperability should retain the strengths and minimize the weaknesses of all combined or coalition members.

d. Interagency operations may require support from the Army's early entry forces. Army forces may operate under civilian control and authority in achieving objectives associated with the economic, political, and informational elements of national power.

e. Logistical support for the early entry forces will probably be bare based and may lack required infrastructure. Ports, roads, rails, water, and power grids may be nonfunctional or nonexistent.

Early entry is highly situational dependent and may occur across the continuum of military operations. Early entry can be categorized into three types. Unopposed entry when no combat is taking place, such as deterrent presence, disaster relief or humanitarian assistance. Unopposed entry under combat conditions where combat is underway, or imminent, but where the ports and airfields are under friendly control. In this case, early entry forces may be required to control terrain and prevent the enemy from seizing ports of debarkation. Forcible entry aimed at immediate decisive effect or to secure a lodgment for the subsequent arrival of larger forces that conduct decisive operations.

Five phases of force projection are predeployment activities, mobilization, deployment, entry and decisive operations.

a. Predeployment Activities: Commanders conduct mission analysis and preparations of the force. Must determine command structure, correct mix, and sequence of forces to deploy. Timely theater specific intelligence as well as predictive data on operations and logistics must be immediately available.

b. Mobilization: Active Army forces will comprise the preponderance of the early entry force; however, Mission, Enemy, Troops, Terrain, and Time (METT-T) factors are unique in every operation and may require mobilization of Reserve Component forces for unique situations or capabilities.

c. Deployment: Commanders tailor the early entry force sequence of deployment based upon factors of METT-T, available strategic lift, and the capabilities of joint, combined, and host nation forces. Continuous and rapid build up of friendly combat power is critical to early entry operations. Objective is to achieve overwhelming superiority and to set the preconditions necessary to win decisively. Early entry forces require enroute communications for mission refinement, change, and continuous intelligence update. Interconnection into the command, control, and communications of joint, coalition, and host forces must be quick and certain.

d. Entry: Early entry forces require the capabilities to seize, control, and hold lodgment areas in conditions including forcible entry. Entry forces may initially be outnumbered. To the extent possible, must establish the conditions for decisive operations. Must achieve air superiority around airfields and port. As the operation progresses early entry forces must introduce and integrate systems to kill deep. Early entry forces must also be capable of protecting themselves from enemy small arms, mines, direct fire, biological/chemical attack, artillery, tactical ballistic missiles, air attack, terrorism, a potentially unfriendly populace, and friendly fire.

e. Decisive Operations: Early entry force may be required to accomplish decisive operations immediately via a coup de main. In such cases, early entry forces seek to rapidly collapse the enemy's center of gravity (national command and control, vital infrastructure, forces' C^3I, and/or main combat capabilities).

2. Early Entry, Lethality, and Survivability Operational Capability Requirements

EEL01: Precision Line of Sight Munitions and Weapon Systems. Required capability to employ line of sight precision munitions and weapons systems (lethal/non-lethal) from ground, air, sea, and special operations platforms that minimize collateral damage and human risk during military operations.

EEL02: Drop Zone Assembly. Required capability to assemble forces on the drop zone, quickly link personnel with combat/combat support equipment, and reduce employment exposure time during forced entry/initial entry operations.

EEL03: Suppressive Fire. Require capability to employ effective suppressive fires (including smoke) from ground, air, sea, and special operations platforms during military operations.

EEL04: Precision Non-Line of Sight: Munitions and Weapon Systems. Required capability to employ non-line of sight precision munitions from organic ground, air, sea, and special operations platforms to counter threat fires during military operations.

EEL05: Identify Targets. Required capability to employ advanced target detection systems (including airborne and space-based warning systems) to rapidly acquire, identify, and transmit real time targeting data to multiple receivers.

EEL06: Non-lethal Munitions. Required capability to employ non-lethal munitions and methods in support of military operations to minimize collateral damage and casualties.

EEL07: Remote Early Entry Forces. Required capability to remove the soldier from the initial entry battlefield through the employment of remote sensor suites that provide commanders with security reconnaissance, surveillance, target acquisition-designation (RSTA-D), chemical and biological detection, and mine-countermine capabilities.

EEL08: Soldier/Equipment Protection. Required capability to rapidly install highly deployable soldier/equipment protection systems and protective shelters against biological and chemical agent exposure, blast, and fragmentation effects of indirect and direct fire weapons.

EEL09: Soldier/Equipment Camouflage. Required capability to rapidly camouflage soldiers and equipment, and employ adaptive techniques, to prevent detection in a variety of topographic environments.

EEL10: Deception Capabilities. Required capability to install deployable and versatile deception systems (against widest range of topographic environments) to prevent visual, acoustic, and thermal signatures (including smoke) to mask friendly forces and mislead the threat commander in the deployment of forces.

EEL11: Situation Awareness. Required capability to rapidly deploy and employ an instantly established, smart networking communications system, automatically routing traffic, and not reliant upon an area microwave or multichannel system carrier. System must meet the Army Digitization Office criteria, be compatible and interoperative with enroute C4I capability, and provide uninterrupted high throughput links with the National Command Authority (NCA), Joint Chiefs of Staff (JCS), and the Joint Force Commander (JFC) from notification through arrival in the area of responsibility (AOR).

EEL12: Real Time Targeting. Required capability to integrate real time targeting data from advanced target detection systems, including space-based early warning systems, into ground, air, sea, and special operations platforms to facilitate near real time targeting.

EEL13: Identify and Locate Nontraditional Signatures. Required capability to locate and identify individuals or forces that do not exhibit traditional signatures during military operations.

EEL14: Identify, Locate, and Defeat targets Using Traditional and Nontraditional Signatures. Required capability to locate, identify, and defeat/disrupt threat C2/C4I and fire support electronic systems that exhibit traditional and non-traditional signatures during military operations.

EEL15: Space-Based Early Warning. Required capability to rapidly deploy a system capable of receiving, processing, and disseminating space-based early warning (including Identification, Friend or Foe [IFF]) and provide targeting data to weapon systems against, air breathers, TBMs, airborne platforms (i.e., UAV and fixed-/rotary-wing aircraft) and ground targets.

EEL16: Rapid Supply/Resupply of Early Entry Forces. Required capability to rapidly deploy and move resources into and throughout theaters during force projection operations and operate in and from improved and/or austere ports.

EEL17: Force Projection Operations. Required capability to implement rapid, real-time adjustments to deployment plans and assets during execution of force projection operations.

EEL18: Rapid Insertion of Army Equipment and Aviation. Required improved capability to self-deploy or preposition Army aviation assets for rapid insertion during force projection operations.

EEL19: Host/Nearby Nation Support. Required improved capability for early entry and follow-on forces to plan for and exploit the use of host nation and/or nearby-nation resources.

EEL20: Vessel Discharge. Required capability to discharge containers and other cargo (wheeled and tracked vehicles/ breakbulk cargo) from vessels anchored "in stream" to Army lighterage, roll-on, roll-off, (RORO) discharge platforms and causeway systems in sea state 3 (SS3) conditions and below. This capability is crucial to enable the Army to meet force projection requirements.

EEL21: Constructive Simulations. Required capability to use constructive simulations to experiment with new warfighting concepts and technology that support the projection of forces within a joint framework. Capability should address initial entry/forced entry and follow-on force arrival in a hostile, tactical environment and should be capable of simulating warfighting conditions. Capability should address the full spectrum of force projection including reception, sustainment, onward movement and integration issues (e.g., configuring host nation port and airfield facilities), and the ability to degrade, modify, or change to replicate threat capabilities. Capability should support sharing of data and ideas with technical and operational analysis agencies. Capability should also be designed to support mission planning architectures.

EEL22: *Mission Planning Tools.* Required capability to conduct joint crisis action mission planning, preparation, and rehearsal which supports the evaluation of early entry and follow-on force organization, deployment, employment and tailoring alternatives.

EEL23: Miniaturized Soldier Communication System. Required capability to conduct secure communications with low probability of detection/intercept both over-the-horizon and line-of-sight with standard and future Army communications systems in a lightweight miniaturized configuration. The system must allow early entry forces to rapidly receive and disseminate information seamlessly throughout the area of operations, interface with joint service C4I systems, the Army Tactical Command and

Control System (ATTCS), and DOD networks. The system requires throughput rates to support rapid data file transfer and support Search and Rescue (SAR) and Combat Search and Rescue (CSAR).

EEL24: Airborne C4I. Required capability to conduct enroute communication compatible with future, high capacity, trunk radio systems, which provide the commander and staff with high-capacity, multi-media communications processing (voice, data, imagery, and video), and enables interoperability with national and DOD networks.

C. DISMOUNTED BATTLE SPACE CONCEPT OVERVIEW

1. Characteristics of Dismounted Battle Space

a. Battle space is that volume of the battlefield determined by the maximum capabilities of a unit to acquire and engage the enemy with both organic and supporting systems. The size, shape, and density of a given unit's battle space, as it applies to both mounted and dismounted forces, is variable dependent upon METT-T and level of command.

b. The concept of battle space goes beyond the three dimensional geographic space of width, depth, and height. It is an important mental construct that involves the ability to visualize enemy and friendly activity. It embraces a holistic view of the entire range of possible conditions and available options that impact on the commander's ability to successfully execute his mission. Battle space also embraces the dimension of time.

c. Commanders seek to dominate the enemy within their battle space, producing decisive results with minimum loss of life. Using weapon systems with greater lethal reach than those of potential adversaries, commanders will be able to mass lethal effect with increasingly dispersed forces.

d. Forces operating in dismounted battle space include light, special operations, and dismounted elements of armored forces. These forces are organized into combined arms task forces at brigade level and below, with combat, combat support, and combat service support capabilities tailored for the specific combat or operation other than war mission.

e. Generation of overmatching combat power by forces operating in dismounted battle space is essential to decisively defeat enemy forces during combat and to rapidly accomplish the mission required during operations other than war.

f. Overmatch is a primarily consideration for conduct of successful dismounted battle space operations. Overmatch is desired in all aspects of combat power; maneuver, firepower, protection, and leadership.

(1) Maneuver Overmatch:

(a) Mobility of dismounted forces must be enhanced to permit high tempo, continuous day/night operations in all-weather conditions. Continuous operations are enhanced by lightening the dismounted soldier's load and increasing his ability to overcome terrain and obstacle restrictions as well as optimizing the performance of his equipment and high physiology.

(b) Dismounted mobility is significantly enhanced by providing situational awareness via the integration of external intelligence and soldier borne sensors. Time required to transit "danger areas" (zones of potential ambush, potential zones of hostile fire, etc.) can be exponentially reduced by providing dismounted squads, platoons, and companies with ability to see the presence or absence of enemy soldiers, direct fires systems, mines, etc.

(c) Mobility overmatch is also achieved via tactical airlift assets (rotary and fixed wing, Army and joint) which are survivable and capable of penetrating hostile terrain.

(2) Firepower/Fire Support Overmatch: Dismounted direct fires must overmatch an opponent in terms of target acquisition, identification, maximum effective range, and lethality effects. Indirect fires overmatch is essential to protect the force and permits the dismounted commander to mass lethal effects without massing (thereby endangering) friendly forces. Elements contributing to firepower/fire support overmatch include battlefield synchronization linkage to the dismounted soldier, common picture of the battlefield which integrates national through organic sensors, fire control systems capable of exploiting battlefield synchronization/situational awareness capabilities, extended range fires, and precision munitions. Goal of firepower/fire support overmatch is to enable the dismounted force to detect, engage, and destroy enemy forces before coming within the range of the enemy's acquisition and engagement capabilities.

(3) Force Protection. Overmatch in force protection accrues in large part from attainment of overmatch in mobility, firepower, and fire support. Other elements of force protection include winning the reconnaissance battle, and the development of advanced passive and active protection measures.

(a) Dismounted forces must win the reconnaissance—counter reconnaissance battle. The use of Reconnaissance, Intelligence, Surveillance, and Target Acquisition (RISTA) sensors and unmanned vehicles, protects the force and enhances firepower and maneuver.

(b) Advanced Passive Measures are required to reduce the signature of the dismounted force and provide a greater degree of operational freedom from air attacks and acquisition supporting hostile fires. Advances are required in low observable technologies, advanced conventional camouflage, and multispectural camouflage.

(4) Leadership and Dismounted Battle Space Battle Command. Leadership is key to the synchronization of the dismounted battle. Leaders must understand the time dimensions as well as the spatial dimensions of battlefield in order to seize the initiative, dictate terms of close combat, achieve depth in maneuver, and impose their will on the enemy. Fusion of relevant tactical data from soldier level sensors through national assets will permit leaders from fire team leaders through brigade commanders an overmatch in understanding of the battlefield dimensions which significantly enhances lethality, survivability, and decisive capabilities of the dismounted force.

2. Dismounted Battle Space Operational Capability Requirements (OCR)

Lethal Capabilities: Designated with an "A" suffix. In order to meet the force projection requirements of the National Military Strategy the Army must have the capability of overmatching lethality throughout the battlefield. Combat systems must have greater effective ranges, increased probabilities of kill, and decreased susceptibility to enemy acquisition, countermeasures, and natural obscurants.

Non-Lethal Capabilities: Designated with a "B" suffix. The Army has an increased requirement to respond to international crises that develop in the operations other than war environment. U.S. military forces will be required to apply force that is non-lethal to combatants and non-combatants, and, in selected cases, force that is non-destructive to materials or the environment.

DBS01A: Dismounted Soldier Engagement of Moving and Stationary Targets. Enhance ability of dismounted solider to engage moving and stationary with both direct and indirect fire. Provide overmatching lethality against current and future systems of potential adversaries.

DBS02A: Increased Lethality of Dismounted Soldier Weaponry. To defeat personnel, thin-skinned vehicles, bunkers, armor, fixed- and rotary-wing aircraft, and indirect fire weapon systems. Application of enhanced ammunition, leap-ahead ballistics technology, directed energy technology, and advanced fire control for dismounted soldier direct fire and indirect fire systems.

DBS02B: Dismounted Non-Lethal Means. Direct and indirect dismounted soldier capabilities for defeating personnel and vehicles without causing permanent injuries or incapacitation to personnel and mission kills or non-catastrophic defeat of material systems.

DBS03: Increased Dismounted Soldier Target Acquisition Capabilities. Require increased capabilities including information awareness and intelligence awareness.

DBS04A: Smart and Intelligent Mines. Tactically transportable by dismounted soldiers which provide a wide area stand-off capability, autonomous operations, and function as a sensor for other lethality and intelligence systems.

DBS05A: Enhanced Dismounted Soldier Indirect Fires. Require improved munitions, enhanced fire control, and precision guided munitions.

DBS06: Passive Capabilities. Dismounted soldiers require passive capabilities for protection against ballistic, directed energy, and electromagnetic effects, extreme environmental conditions, and non-battle injuries.

DBS07: Active Capabilities. Dismounted soldiers require active capabilities to enhance survivability including timely intelligence, extended target acquisition and engagement ranges, combat identification, and low observables, combat life saving, battle injury treatment and prevention, non-battle casualty prevention, and veterinary services.

DBS08: Dismounted Forces Acquisition Countermeasures. Dismounted forces which reduce or eliminate hostile forces capabilities to detect, locate, range, and engage dismounted solider with lethal effects are required to enhance dismounted soldiers' survivability. New, lighter weight, stronger materials are required to replace heavier armor.

DBS09: Signature Reduction. Signature reduction technologies for application to dismounted soldiers are required to reduce soldiers' signature in the visual, thermal, acoustic, and radar bandwidths. Low observable technologies, advanced conventional and multi-spectral camouflage is required to counter enemy acquisition capabilities.

DBS10: Indicators and Warnings for Dismounted Soldiers. Forces operating in dismounted battle space require the capability to access the full spectrum of intelligence information. This includes the capability to collect, analyze, produce, and disseminate timely intelligence data. Required intelligence data includes indicators and warnings, situational awareness (enemy and friendly), system targeting, and targeting development.

DBS11: Drop Zone and Landing Zone Intelligence. Capability required to generate and provide the dismounted forces with information on Drop Zones (DZ) and Landing Zones (LZ).

DBS12: Post Strike Assessments/Battle Damage Assessments. Forces require significantly enhanced capabilities for Post Strike and Battle Damage assessments. Ability required to generate and quickly disseminate assessments to forces actively engaging the target as well as command posts and fire direction centers engaging the target set.

DBS13: Integrated Target Acquisition. Capabilities are required which provide vertical and horizontal, near real time, target acquisition information throughout the task force. This capability is key to massing effects of fires without massing friendly forces.

DBS14: Extended Range of Target Acquisition. Extended range, all spectrum target acquisition will enhance the capabilities of individual soldiers, weapons platforms, and indirect fire systems. Target acquisition systems must provide the capability to have near real time sensor-to-shooter linkages which incorporate both brigade and below systems and echelon above brigade systems, including systems of other services, national level systems, and those of coalition forces.

DBS15: Sensor-to-Shooter Linkages. The task force commander must have the ability to plan and control the sensor-to-shooter linkages to effectively extend his battle space.

DBS16: Improved Weapons Pointing and Control. Capabilities required for day/night, all weather target location, tracking (including auto tracking), combat identification, weapons pointing and shooting, acquisition and full solution fire control to enhance weapons' effect on targets.

DBS17: Increased Control of Battle Tempo. Battle command systems are required to provide horizontal and vertical command and control capability in near real time, enabling dismounted forces to operate at faster tempo than the enemy. The capability to gather, analyze, and disseminate information on both friendly and enemy forces from multiple sources.

DBS18: Near Real Time Data Fusion. Dismounted forces require near real time data fusion and software commonality.

DBS19: Automated Planning and Rehearsal. Dismounted forces require the capability to conduct automated planning and rehearsals, split based C4, situational awareness, and logistics support.

DBS20: Dismounted Digitization. Systems must be digitized and capable of linking all battlefield elements from the individual soldier through the brigade level. They must also provide linkage to systems above brigade including joint, national, and coalition systems. These systems must provide vertical and horizontal information linkages with the capability to process information to prevent information overload.

DBS21: Dismounted Soldier Communications and Information. Lighter weight, smaller communication, and integrated personal computer equipment will be required to reduce soldier and vehicle loads while maintaining secure communications and information flow.

DBS22: Rapid Breaching of Obstacles by Dismounted Forces. Require capabilities to detect, identify, and breach or bypass natural or manmade obstacles to enhance dismounted forces mobility.

DBS23: Tactical Dismounted Mobility. Forces operating in the dismounted battle space require the capability for high rapid, agile mobility in close terrain, restrictive terrain, and during airborne, air assault, and waterborne operations.

DBS24: Mobility Enhancements. Forces operating in the dismounted battle space require increased/ enhanced mobility via the reduction of systems and vehicle weights, improved vehicular design, and integrated robotic and climatic control designs, and nutritional/medical enhancements.

DBS25: Reduced Soldier Load. Ground and air robotic platforms required to reduce the load of the soldier, relieving his burden of non-combat essential equipment.

DBS26: Training and Leader Development. Training and leader development will be key to maintaining combat ready soldiers and units. Success on the battlefield will require the interrelated and supporting individual, institutional, and unit training pillars adapting to the doctrine, organizational, and materiel systems that are emerging.

D. BATTLE COMMAND CONCEPT OVERVIEW

1. Characteristics of Battle Command

a. Battle Command is the ability to envision the desired end state (strategic, operational, tactical military objectives), translate the vision into an intent, formulate concept/courses of action, and provide the force of will to concentrate overwhelming combat power at the right time and place to win decisively with minimal casualties.

b. Decisions must be made at the correct time and place to ensure success by leaders who provide a command climate that breeds success, inspires moral and physical courage in the face of adversity, and contributes a steady and unshakable vision that focuses effort and resources toward current and projected requirements.

c. What distinguishes these timeless challenges in the modern era is the scope, intensity, and tempo that contemporary operations present to the commander. Future challenges encompass weapon systems of increased range and lethality that extend the depth of the battlefield.

d. Battle command will continue to be plagued by an abundance of near real time information impacted by the fog and friction of warfare and uncertainty. The increasing complexities of joint, combined, and interagency operations will place unparalleled demands on commanders.

e. Battle command under these conditions will remain predominantly an art form incorporating elements of scientific analysis, control, and direction wherein the experienced commander develops a seemingly intuitive feel guiding his decisions.

f. Battle command incorporate two vital components—the ability to decide and the ability to lead. Knowing what the commander must decide is a complex issue in and of itself. Decisions to pursue one course of action generate momentum which cannot easily be reversed, often precluding options for alternative courses of action. Often, decisions on the initial disposition of forces will predetermine the outcome of battle.

g. Decision making and problem solving are not done in isolation. The staff and subordinates assist the commander in fleshing out, modifying and improving the initial versions of plausible courses of action for evens which may not be totally clear at the time the decision is made.

h. Commanders cannot attempt to personal address each action within their cognizance. Knowing what actions and decisions required his attention and those which can be handled by the staff and subordinates is key to time management and a decentralized command environment.

i. Commanders cannot and should not attempt to know everything. Commanders and staffs must know what information is important for the commander to know. Additionally, the commander must glean vital information which others may be disciplined to pass to him. Commanders bear the ultimate responsibility for defining which critical information, friendly and enemy, which he must have.

j. Commanders must not be prisoners of a static command post. They must go where they can assess the risks and make adjustments by seeing, hearing, and understanding what is occurring. This in German, "fingerspitzengefuellen," feel of the battlefield permits commanders to understand the needs of the force and make adjustments which best support the organization.

k. Appropriate freedom of action must be afforded subordinates to permit initiative and agility in battle. Prioritization of actions, setting degrees of acceptable risk, and establish control measures permit an appropriate level of latitude to subordinate leaders.

l. Commanders strongly influence the outcome of battle by the timely and appropriate commitment of reserves, resources, and the use of available firepower.

m. Decisions must be both timely and resolute, changing only when the combat situations dictates change.

n. Commanders and staffs must be continually forward thinking. Anticipating and planning for the next course of action keep the commander and battle staff agile, synchronized, and focused on the final objective.

o. Control includes the assignment of coordination lines, subdivision of area of operations between friendly forces, and the report structure which flows vital information from commanders to commanders, usually through their respective staffs. Controls permit the Commander freedom to operate, to delegate authority, and aid subordinates in the prosecution of warfighting in accordance with the superior Commanders' intent, even while those Commanders focus on other critical points of the battlefield. Controls aid synchronization and posture the force for current and subsequent operations. Joint, Combined, and Coalition Operations are the expected norm for the future. Commanders and staffs must be able to employ the strengths of each member and compensate for specific weaknesses inherent within any force, including their own. Command and control measures used with multinational forces must be tailored to accommodate a myriad of political and military considerations.

p. Commander Responsibilities: The Commander is personally responsible for formulating the single unifying concept for a mission, knowing when and what decisions are required of him, and finally, having the will to direct and motivate the force to execute the decision to a purposeful end. The Commander assembles personnel, equipment and information in order to facilitate then command responsibilities. This process of Concept-Plan-Execute is applicable to Commanders at all echelons. Commander responsibilities include decisions, leading the human dimension of battle command.

(1) Decisions require that the Commander understand superior Commanders' intent, two level up. Decisions are based upon assessments and estimating the outcome of current operations. Commanders must visualize the desired future "end state" and identify probable courses of enemy action. Commanders must clearly articulate their intent to the staff and subordinate commanders, formulate concepts. Before the start of the operations, commanders determine the key decisions that he will make and given the battle staff the authority to make routine decisions within the constraints of his intent. Commanders Critical Information Requirements are established to assure the flow of the right information to the commander.

(2) Preparing the force. Commander uses rigorous, realistic training to mold and shape his organization, especially his battle staff to aid effective command and control of the force.

(3) Leading. Current and future battle Commanders must be leaders with the ability to visualize future states of the organization. In wartime, this translates to the visualizing beyond the current and intermediate battles to a future end state for the

unit/situation. Leader development must focus on the human dimension of battle command to build trust, confidence, and to motivate organizations to accomplish the mission. Requires a climate conducive to teaching, risk sharing, demanding integrity, and discipline. Motivation, dedication, initiative, espirit, and cohesion are all outcomes based on the command climate.

2. Battle Command Systems Operational Capability Requirements

Recent and current operations continue to reinforce the concept that future military operations will be increasingly complex and ambiguous. Our quest for decisive victory at minimum cost leads us to exploit technologies to increase lethality, survivability, and operational tempo. However, at the heart of it all remains the competent battle commander with an intuitive sense. As operations become more complicated, battle commanders must make faster, more complex decisions. To make the best decision, the commander requires clear and timely information, decision support aids, and better means of communicating intent and mission. Battle Command Battle Lab OCRs reflect the capabilities required by our future commanders to exercise battle command throughout the force projection cycle in war, peacekeeping, peacemaking, humanitarian assistance, counterdrug, and disaster relief missions.

BATTLE COMMAND SYSTEMS

BC01: Battlefield Information Control: *To fulfill the vision articulated in TRADOC Pamphlet 525-5, Force XXI Operations, and the Battle Command Concept, the battle command system must have the capability to collect, process, and disseminate in real- and near real-time information on the friendly and enemy situation, command directives, and other essential information.*

These three aspects of information control are described individually. Collecting: To provide a meaningful virtual, continuous picture of the entire battlespace, requires timely and accurate information from all available sources throughout the depth of the commander's battle space. To provide the maximum coverage of the battlespace and inaccessible Named Areas of Interest (NAIs) and Targeted Areas of Interest (TAIs), the collection system must orchestrate multi-echelon sensor coverage from organic, non-military intelligence, joint, multinational, UAV, and ground sensors. Sensors must detect, identify, and locate active and passive targets including C2 nodes that are underground, above ground, waterborne, airborne, or in space. Sensors must also provide warnings of NBC threats, theater missile attacks, and provide near real time battle damage assessment.

Sensors should have cross-cueing capability. Automatic target recognition technologies should be incorporated within sensors where possible. The most salient features of sensor images should be fused to provide the most complete picture of the battlefield. Information must be collected from sensors for all levels of operations regardless of natural or man-made environmental conditions (weather, terrain, obscurants, electronic warfare, day/night, etc.). Sensors must be invisible to detection by the enemy when collecting information. If detected, sensors must have protection from enemy fire and should contain preventive measures to protect against engagement from friendly fire. Processing: To support the commander's critical information requirements, future command and control systems must have a robust, high speed distributive processing capability in conditions where decision times are compressed and vast amounts of information must be filtered, fused, and correlated in near real time. Systems must minimize data transmission requirements and operator workloads, and maximize automated decision aids and automated target recognition, and be compatible with current and planned C4I hardware. Systems must have automated filters for controlling information flow from large databases and high capacity storage means. Distributing: In order to influence the battle at the critical time and place, information and command directives must be communicated accurately, in real- and near real-time, between commanders, staffs, and weapon platforms while in the air, on the ground, on the sea, or in space.

BC02: Battlefield Information Passage: *To fulfill the vision articulated in TRADOC Pamphlet 525-5, Force XXI Operations, and the Battle Command Concept, a capability is needed for all commanders, their staffs, and all battlefield functional areas to seamlessly pass and share information, via integrated digital communications and computer networks, in both hierarchical networks (vertically and horizontally) and non-hierarchical networks, between battlefield functional areas and from the tactical level through the strategic.*

The seamless, secure, global information architecture must support integrated combat operations with a focus on the mobile warfighting commander. The information architecture must (1) provide horizontal and vertical integration of secure and non-secure voice, data, graphics, imagery, and video information; (2) facilitate operations planning, information collection, and information dissemination; (3) enhance the commander's ability to acquire information from sensor systems, battlefield functional area systems, and from subordinate, adjacent, and higher organizations; (4) support both analog and digital capabilities; (5) integrate commercial and tactical communications networks; (6) provide a capability to transfer information within the architecture without requiring specific knowledge of the mechanism or platform characteristics that make up the communications and automation hardware; and (7) be rapidly deployable. Implied are requirements for streamlined communications procedures and for global connectivity of extended-range communications assets, as well as integrated communications between the various interagency, joint, combined, and coalition forces including national command authority, operations (command and control), intelligence, logistics, administrative functions, and the numerous potential echelons of a Force Projection Task Force. Ideally, the adaptive nature of the information architecture and full use of the electromagnetic spectrum should reduce or eliminate degradation factors caused by weather, terrain, distances, obstacles, Electromagnetic Pulse, co-site RF interference, or jamming between sender and receiver or from supporting communications nodes.

BC03: Decision and Planning Support: *To fulfill the vision articulated in TRADOC Pamphlet 525-5, Force XXI Operations, and the Battle Command Concept, systems must have the capability of assisting the commander and battle staff in mission planning, preparation, and execution.*

Decision making and operations planning requires expert systems, decision aids, and artificial intelligence capabilities to improve quality of and reduce decision making time. Aids must take advantage of information available on seamless information networks to plan and rehearse operations and conduct split-based C4I, medical, and logistics support. Embedded training and simulation tools must be incorporated into decision support software for commander/staff training, mission rehearsal, and other tasks that are critical either because of the complexity of the task or the time sensitivity of the results. Decision aids are required to facilitate in-depth analysis of information and support "wargaming" potential scenarios. An example of decision aids requirements is an automated IPB process that integrates and depicts the affects of weather and terrain on operations, allows synchronization matrices and collection plans to be quickly updated, and provides realistic, interactive wargaming.

BC04: Smart Pull / Brilliant Push: *To fulfill the vision articulated in TRADOC Pamphlet 525-5, Force XXI Operations, and the Battle Command Concept, systems must have the capability to pull down information as it is needed and to automatically receive information that is critical to the situation.*

With greater amounts of data and information available on the battlefield and increased operational tempo, commanders and staffs will have reduced times to filter through information relevant to their situation. Information relevant to all commanders and staffs should be broadcast directly to them. Through the use of automated decision aids and programmable filters, commanders and staffs will be better able to identify and articulate their critical information requirements. This, in turn, will allow for critical information to be automatically displayed as it becomes available. In other situations, the system will facilitate the commanders and staffs requests for more specific and detailed information that can be "pulled down" from any information source on the battlefield using system menus. Systems should have the capability of automatically notifying outside support organizations when a warfighter has exceeded programmed parameters (for example: consumed a significant portion of a critical commodity such as fuel or ammunition or exceeded a control measure).

BC05: Information Presentation: *To fulfill the vision articulated in TRADOC Pamphlet 525-5, Force XXI Operations, and the Battle Command Concept, there must be a capability to tailor information systems to the style of the user and to appropriately present information pertinent to the situation throughout the range of force projection operations.*

Information should be displayed in a manner that best supports the acquisition, exchange, and use of information. Data (i.e., terrain, operational graphics, and status information) displays should support the intuitive commander and the decision making process by aggregating numerous pieces of information in standardized visual displays and locations using standardized symbology. Three-dimensional representation of information (i.e., terrain, airspace management, or weapons engagement envelopes) should be realistically portrayed. Information displays must support on-the-move operations. Decision oriented graphics symbology should be displayed clearly. Operators must have the ability to change graphics interactively. The ability for the commander to either adapt quickly to a particular layout or to modify the layout should not effect the underlying information sources. Operator training requirements must be minimized. Hardware and software for automation and communications systems must be user friendly in high stress, physical, and mental environments. The use of multiple-layer menus should be avoided. Automation tools should also minimize "man-in-the-loop" requirements and allow commanders to focus on critical war-fighting tasks. Large screen devices should be suitable for operation in static and mobile CPs and should accommodate the interaction of more than three personnel, keeping in mind the space limitations of some Cps.

BC06: Electronic Tethering: *To fulfill the vision articulated in TRADOC Pamphlet 525-5, Force XXI Operations, and the Battle Command Concept, systems must* *provide the capability for the commander to remain electronically connected to his information sources while he is enroute, moving, or stationary anywhere on the battlefield.*

Commanders must have the freedom to move around the battlefield to locations where they can best influence the battle at the critical time and place. While they cannot be tied physically to operations centers, they must be tethered electronically to access time sensitive operational and intelligence information to allow them to continuously plan, communicate intent, issue orders, and monitor and coordinate operations. Command and control systems must be capable of linking all battlefield elements from the individual soldier through the national command authority. Systems must support battle command functions wherever the commander is located. Systems must be small and lightweight, easily transportable, and facilitate rapid movement and emplacement. C2 platforms must be mobile and transportable yet ensure that designs and human engineering are adequate to house and support battle command personnel and systems for continuous operations. This includes, but is not limited to, adequate space, power and internal communications.

BC07: Common Picture: *To fulfill the vision articulated in TRADOC Pamphlet 525-5, Force XXI Operations, and the Battle Command Concept, battle command systems must have the capability of providing a tailorable, scaleable, and relevant common picture.*

Having a relevant common picture will enable the commander to operate within the enemy's decision cycle by synchronizing forces and dictating the operational tempo. This relevant common picture must be comprised of timely, accurate, and relevant friendly and enemy situational and status information (situational awareness) laid over a common, near-real-time representation of the area of operation (including elevation and natural and man-made features). Having real-time situational awareness across the battlefield will enable the commander to intuitively picture the friendly and enemy situation and reduce battlefield uncertainty by displaying friendly and known enemy force location and status. The relevant common picture must be scaleable to appropriate levels of command, tailorable by function, and based on variable user determined parameters. Enabling technologies allow weather and terrain products and situational updates in textual and graphic formats to be integrated.

BC08: Split-Based Connectivity: *To fulfill the vision articulated in TRADOC Pamphlet 525-5, Force XXI Operations, and the Battle Command Concept, selected elements must have the capability to connect CONUS-based command* *headquarters, national intelligence data bases, and other split-based type operational activities to forward deployed maneuver and support units.*

Future operations may be supported by selected elements that never deploy from home station, or operate strictly out of rear, base, or sanctuary areas. Communications systems supporting split-based operations must be deployable, robust, assured, and provide a seamless state-of-the-art system of C4I across the operational continuum (including joint and combined forces) on a continuous basis.

BC09: System Interoperability: *To fulfill the vision articulated in TRADOC Pamphlet 525-5, Force XXI Operations, and the Battle Command Concept, systems must be interoperable with other U.S. Army, sister service, government and non-government agencies, and allied systems.*

Forces require total, uninterrupted, interoperable communications between government and non-government agencies, and joint and combined forces throughout the battlespace from the National Command Authority to operator level.

BC10: Target-to-Shooter Information Fusion: *To fulfill the vision articulated in TRADOC Pamphlet 525-5, Force XXI Operations, and the Battle Command Concept, there must be a capability to link near real time enemy information over large areas, with long range precision munitions.*

The domination of extended battlespace will require agile and robust deep and simultaneous attack capabilities. Battle command systems must be able to extend the battlespace in time and space; eliminate the time required to shape the battlespace; and facilitate full dimensional attack of the enemy's center of gravity. All acquisition systems will require a target to shooter fusion link in order to guide indirect fires and attack aircraft onto the target. This system must provide target acquisition and recognition/ identification, target value analysis, prioritization of targets, and deconfliction of targeting data and airspace usage. Once the target list is approved, it must be relayed to long range precision indirect and/or attack aircraft units or aircraft in flight. Systems must operate in near-real-time to facilitate rapid decision making and shooter response to acquire short exposure targets.

BC11: Hands-Free Operation: *To fulfill the vision articulated in TRADOC Pamphlet 525-5, Force XXI Operations, and the Battle Command Concept, the user must have the capability of hands free equipment operation while stationary or on-the-move.*

Commanders and their staffs must have the capability to operate and control automation and communications equipment hands free when either stationary or on-the-move in a tactical environment in joint and combined operations. This capability must exist in noisy, unstable, and stressful conditions. Enabling technologies include: voice, eye, and/or touch activation, heads-up displays, voice synthesis, automatic language translation, interactive natural language voice commands, and reduction or elimination of ambient noises. These capabilities are required to facilitate operations by minimizing computer operator interface requirements such as system setup (e.g., frequency settings on a radio), initialization, data manipulation functions, and transmission of messages while on the move.

BC12: Upgrade Exploitation: *To fulfill the vision articulated in TRADOC Pamphlet 525-5, Force XXI Operations, and the Battle Command Concept, systems must be easily upgradable to fully exploit expanding technologies.*

New technologies will be developed at rates even faster than today; however, it is not economically feasible to completely replace Battle Command Support Systems at the same rate. Therefore, systems must be designed to be easily upgradable to exploit new technologies rapidly and to the fullest extent. Module replacement or additions of modules should be pre-planned and allow for horizontal integration across platforms. Software should be modular, easily tailored to accept future changes, and maximize compatibility with current and planned hardware. New technologies must not only allow for interoperability between legacy and current systems, but anticipate future system capabilities. They must be versatile, allow for rapid distribution, and be affordable so that they can be introduced throughout the Army. New technologies must require little to no user train-up. Upgrades must not distract a unit from its assigned mission and task.

BATTLE COMMAND SUPPORT TEAMS (BCST)

BC13: Commander to Battle Command Support Teams (BCST) Connectivity: *To fulfill the vision articulated in TRADOC Pamphlet 525-5, Force XXI Operations, and the Battle Command Concept, BCSTs must have the capability to locate forward on the battlefield and remain electronically linked to the commander, regardless where he or the BCST is.*

Commanders and staffs enroute to the theater or moving across fluid battlefields must be able to continuously plan, communicate intent, issue orders, and monitor and coordinate operations. An adaptive warfighter information network with flexible ranges must provide the capability to interoperate with superior, adjacent, and subordinate commanders and their battlefield operating systems. BCSTs must have the capability to operate from mobile platforms. These platforms must be adequate to house and support battle command personnel and systems for continuous operations. They must be able to maintain the pace of the operational tempo, and withstand small arms and indirect fires and NBC attack.

BC14: Staff Support: *To fulfill the vision articulated in TRADOC Pamphlet 525-5, Force XXI Operations, and the Battle Command Concept, BCSTs must have the capability of BCST to support the commander in controlling current operations and adjusting plans for future operations.*

The staff must be an extension of the commander, see things as he does, and share his responsibility for the mission so he can reach the critical decisions with the best possible information and lead from where he can best affect the action. Staffs will utilize the systems described in BC01 through BC12. Skilled staffs work within the commander's intent to direct and control units and allocate the means to support that intent. They assist the commander in anticipating the outcome of the current operation and developing the concept for the follow-on mission. They understand, and can apply, a common doctrine. The battle staff must also understand what information the commander deems important for making decisions and provide it in an accurate and timely manner. It is the product of staff work that serves the needs of the commander. Battle staffs must be organized to ensure the command process is sustained, especially when the commander must rest or in the event he becomes a battle casualty. Underlying this capability is the requirement to recruit, develop, and retain quality people. Recruiting programs must be developed and employed to determine early the capabilities and potential of commanders and staffs. Training programs must be developed and harness new technologies to improve the comprehension and retention of key leadership and staff skills.

BC15: Team Building: *To fulfill the vision articulated in TRADOC Pamphlet 525-5, Force XXI Operations, and the Battle Command Concept, there must be a capability to tailor BCSTs to the mission and commander's requirements.*

Modular, functionally-based force designs that can better support the current force and are aligned with Force XXI development initiatives are required to support continuous operations, task organization, and incremental force deployments. Concepts must focus on development of organizations that provide for increased flexibility and mobility, while eliminating redundant "cold war" headquarters and streamline other Force XXI structures and organizations. The goal is to field an "adaptable" force with improved force tailoring, adaptive packaging, and deployability. The network systems must have the capability for smart networking and instant communications. It should grow stronger as units are added rather than weaker.

BC16: Battle Command Support Team (BCST) to CONUS Connectivity: *To fulfill the vision articulated in TRADOC Pamphlet 525-5, Force XXI Operations, and the Battle Command Concept, the BCSTs must have the capability of accessing information from CONUS-based command headquarters, national intelligence data bases, and split-based operational activities.*

Force XXI Operations must have the capability to be supported by selected elements of Battle Command Support Teams that never deploy from home station, or operate strictly out of rear areas. Battle Command Systems (described in OCRs BC01 through BC12) will provide BCSTs the capability to conduct split-based operations, operate with virtual staffs, and obtain information from any location in the world quickly and seamlessly. Staffs must be trained to operate systems and understand their capabilities.

BC17: Battle Command Support Team (BCST) Footprint: *To fulfill the vision articulated in TRADOC Pamphlet 525-5, Force XXI Operations, and the Battle Command Concept, BCSTs must be smaller, yet be able to perform necessary functions.*

Smaller Battle Command Support Teams (BCSTs) are desirable to reduce strategic lift requirements, present smaller targets, enhance mobility, and reduce sustainment requirements. In order that BCSTs be reduced in size, but still perform the same functions, technologies must be applied that will reduce the workload on soldiers. Enabling technologies include decision support software and planning aids, user friendly systems that optimize work performance, systems that automate staff functions, allow workload sharing, and predict high workload periods and miniaturized hardware. Deployed BCSTs may also be made smaller through the use of virtual staffs. Using advanced command, control, and communications systems, small BCSTs could be linked to larger staffs in the rear, in a sanctuary, or even CONUS. Utilizing a shared, relevant common picture, rearward staffs could provide timely and accurate planning, operational. and administrative support to the forward located BCST. System capability requirements are described in OCRs BC01 through BC12. Other actions required to make BCSTs smaller are more efficient and effective man-machine information interface, reorganization of staff structure around information flows that reduce fragments, stovepipes, and hand-offs. Staffs should be internetted and at least partially nonhierarchal to conduct cross-BOS processes.

BC18: Digitized-Battle Command Support Teams (BCST) to Non-digital Unit Interfacing: *To fulfill the vision articulated in TRADOC Pamphlet 525-5, Force XXI Operations, and the Battle Command Concept, liaison teams must have the capability to share information with non-digitized units.*

Liaison teams in non-digitized units must have the capability to exchange sensitive and non-sensitive data with U.S. Headquarters. This data includes doctrine, organization, unit locations, amounts of equipment by type, weapon capabilities, Warning Orders, OPORDs, and FRAGOs. The system providing this capability must be lightweight, durable, and connected to the relevant common picture. It must have automatic translation, graphics, and video/audio capabilities to allow the non-digitized commander to interface with his digitized U.S. counterpart. It must be able to receive and impart data regardless of terrain, weather, and enemy jamming/intercept capabilities. This system must have an internal power source, but be able to utilize external power if available. There is also a need to have security parameters installed which prevent the unauthorized use of the system or technologies.

INFORMATION OPERATIONS

BC19: Information Attack: *To fulfill the vision articulated in TRADOC Pamphlet 525-5, Force XXI Operations, and the Battle Command Concept, there must be a capability to disrupt an adversary's ability to exercise authority and direction over his forces.*

Sensors are required to detect, identify, accurately locate, and schematically map an adversary's C2 nodes in order to maximize counter C2 operations that exploit, deceive, damage, or destroy the adversary's C2 system. Such systems must be able to identify threat forces that do not exhibit traditional electromagnetic signatures. Future Counter-C2 development must consider multi-function, modular systems to defeat night vision devices and adversary optics and electro-optics; indirect fire electronic weapons to defeat deep adversary electronics; improving the survivability of jammers and increasing their frequency coverage and range; developing a military capability to attack an adversary's information systems internally (computer attacks); improving the capability to perform electronic deception; and developing smart weapons that seek out and destroy high payoff information systems that are engaged in either the collection, processing, dissemination, or display of information.

BC20: Information Protection: *To fulfill the vision articulated in TRADOC Pamphlet 525-5, Force XXI Operations, and the Battle Command Concept, friendly command and control capabilities must be protected.*

C4I systems must survive to operate under nearly all weather conditions, on dirty battlefields, and despite enemy jamming efforts. Systems should provide warning of unauthorized penetration and monitoring. Systems at all echelons must be protected against the NBC and Electronic Warfare (EW) threat. Systems should also provide redundant, automatic capability to acquire, distribute, and process information even in the event of destruction of a primary processing facility, loss of an individual system, or in the event of isolated data loss at a particular node of a C2 system. Additionally, systems should have computer virus detection, protection, and source identification. Encryption capabilities should increase denial thresholds of current systems to the potential for enemy exploitation. Capabilities should facilitate automatic operations and minimize man-in-the-loop requirements. Capabilities should be embedded, but must be seamless when accessed in joint and combined operations. The ability to process all levels of security without the necessity of operating at the highest classification level on the same system is critical for rapid and efficient processing and communication of intelligence information. Signals should be made invisible with transmission masking and the origins of friendly signal sources hidden or disguised so that actual locations are not revealed to the enemy. Automatic controls should be embedded in C4I systems in order to disguise the signature produced and make it look as if there were not a C4I system operating. The controlling effect should be flexible enough to produce varying signatures in order to avoid pattern detection. Transmission of signals must be reduced to the least amount of time possible (e.g., improved data compression and the increased use of packet switching). Decoys should simulate the signatures (sight, sound, thermal image, and electronic, for example) of a command post realistically enough to deceive enemy sensors. Systems should have the capability to penetrate enemy C4I operations, without alerting the operators that their computer and information systems have been compromised. Once inside the enemy's C4I structure, the capability must exist to present information to the enemy that deceives them about the true objectives of the operation. Given imminent capture, a fail safe means must exist to destroy sensitive information residing on C4I systems locally or at remote locations.

BC21: Information Exploitation: *To fulfill the vision articulated in TRADOC Pamphlet 525-5, Force XXI Operations, and the Battle Command Concept, there must be a capability to exploit an adversary's information system.*

To facilitate the exploitation of an adversary's C2 system, the friendly C4I system must consist of integrated ground, airborne, and space-based multi-discipline sensor/collection systems that support situation development. Fusion of sensor data at the sensor platform will minimize communication bandwidth requirements and allow for integration of multi-spectral information. It will be necessary to collect information from an adversary's information age systems such as digital and LPI communications. The C4I system must allow for detection and location of an adversary's intelligence collection and sensor and electronic attack systems. These systems must be easily reprogrammable for countering diverse threat weapon systems. Tools need to be developed to allow for analysis of an adversary's C2 system. Distributed all source analysis and dissemination systems will be required to facilitate seamless access to intelligence information at all echelons. The ability to pull intelligence from higher echelons as desired/required as well as to disseminate tailored intelligence products both horizontally and vertically to multiple users is required.

BC22: Information Enable: *To fulfill the vision articulated in TRADOC Pamphlet 525-5, Force XXI Operations, and the Battle Command Concept, there must be a capability to enable or facilitate friendly information exchange.*

Friendly C4I systems must facilitate seamless, real time information exchange that provides warfighters with the information they require regardless of echelon, physical location, or security level. Digitization of the battlefield, which consists of processors and digital communications all using common formats, will permit a common view of the battlefield which allows for situational awareness, synchronization of battlefield activities, and command and control on the move. C4I systems must provide for information exchange at the rates required to facilitate up-to-date situational awareness at all necessary locations. Automated multilevel security processing within C4I systems must be provided. C4I architectures must allow for information exchange among a force's home station, the logistics agencies, and intelligence agencies. Deploying forces need information while enroute and in-theater. These communications must be reliable and flexible. Some types of intelligence collection will require special forms of communication to facilitate efficient and secure information exchange. Standardized graphics are required that can be shared with joint, coalition, and multi-national forces.

LEADER DEVELOPMENT

BC23: Commander and Battle Staff Training: *To fulfill the vision articulated in TRADOC Pamphlet 525-5, Force XXI Operations, and the Battle Command Concept, the capability must be available to train commanders and battle staffs using integrated battle command systems and live, virtual, and constructive simulations.*

Training for commanders and battle staffs must integrate live, virtual, and constructive simulations across the total force. Training capabilities must be designed into all systems and these capabilities should replicate combat conditions. Training systems will be linked together seamlessly. Training should also allow for extensive Combat Support and Combat Service Support participation to include non-traditional players such as medical and JAG. Training and simulation must include all tactical communication systems. Subordinate units participating must have the capability to do so from many different and diverse locations including across the continent and globe. The training system must be weather and terrain independent and be user friendly. Such a system must allow for the capture, storage, and processing of historical data for later analysis and use in the after action review process. The training system will also provide for a video feed for an after action review between the players.

BC24: Force XXI Training: *To fulfill the vision articulated in TRADOC Pamphlet 525-5, Force XXI Operations, and the Battle Commander Concept, the commander and his critical staff must comprehend the organization, structure, capabilities, and limitations of Force XXI C4I architectures (organic and split-based).*

There is a requirement to instruct future commanders in the organization, structure, and capabilities of the Force XXI C4I architectures. This requirement must be met before the commander arrives to take command of his unit. This training may take place through a variety of hands-on simulations and exercises that teach and test the commander's understanding of the C4I architecture. There is also a requirement for critical staff officers, such as the G-3, to have a full understanding of the C4I architecture as well.

BC25: Joint/Coalition Doctrine: *To fulfill the vision articulated in TRADOC Pamphlet 525-5, Force XXI Operations, and the Battle Command Concept, the commander must have the capability to rapidly integrate his forces into a joint/coalition force projection environment which spans the continuum of military operations.*

The Force XXI commander and staff will require an extensive knowledge of joint and coalition doctrine. They must have a clear understanding of how future joint/coalition partners intend to operate in war and OOTW, and of their strengths and weaknesses. Liaison officers must understand the joint/coalition partner's organization, doctrine, capabilities, equipment, civil agency procedures, intent, and in certain cases languages.

BC26: Commanding Modular Organizations: *To fulfill the vision articulated in TRADOC Pamphlet 525-5, Force XXI Operations, and the Battle Command Concept, the commander must have the capability to maximize the benefits of modularly structured organizations (tactical, operational, and strategic).*

Commanders must be schooled in the task organization and employment of modular organizations. While the modular concept will actually allow a better mix and size of forces available to the commander, it will also provide him additional challenges of units that may not have trained, exercised, or been employed together previously. C4I systems must link all organizations and training in common doctrine and tactics, techniques, and procedures. Commanders must receive training/experience in the human dimensions of fighting teams organized from modular units. This will include the training and simulation systems addressed in OCR BC22.

BC27: Media Impact: *To fulfill the vision articulated in TRADOC Pamphlet 525-5, Force XXI Operations, and the Battle Command Concept, the commander must have the capability to either exploit or react to the influence of the media on operations.*

Commanders need to be educated on the capabilities of the media in all its forms: electronic, written, and audio. Commanders must be constantly aware of the changing Global Information Environment, its effect on the opinions, attitudes, and beliefs held by the American public, political leaders, soldiers and their families, allies, adversaries, and other important audiences, and the impact of these opinions, attitudes, and beliefs on the Army and its operations. Commercial satellite technology has the ability to provide detailed, graphic, and live coverage of and information about events from anywhere in the world to everywhere in the world. This ability will continue to influence our operations. At all levels, battle commanders must be taught how to enable, enhance, and protect the use of information in the friendly decision and execution process while influencing (degrading and controlling) an adversary's decisions and actions through the manipulation of the Global Information Environment. Battle commanders need to understand the immediacy of the impact of media coverage so they can anticipate adjustments to their plans and operations. Also their plans and operations will form world opinion and affect strategic decisions in a more profound and immediate way than in the past.

E. COMBAT SERVICE SUPPORT CONCEPT OVERVIEW

1. Characteristics of Combat Service Support

Combat Service Support required for the accomplishment of the Army's Post Cold War missions need to effectively transition the Army to a CONUS-Based Force Projection stance.

a. A Total Distribution System (TDS) is required to effectively integrate material management and distribution management. The key elements of TDS are:

(1) Containerization and Packaging improvements to speed shipping (sea, air, rail, and truck), reduce transloading handling requirements, and to better protect supplies and material in shipment and storage throughout the pipeline from manufacturer to the user. The need improved packaging includes the capability to be decontaminated. Additionally, containers capable of transporting leaking chemical munitions to decontamination points are needed.

(2) Distribution Management improvements are needed to permit accurate tracking of customer location and delivery point grid coordinates (position) through battle planning and execution visibility. This visibility includes accurate tracking of supplies and material intended for the customer throughout the distribution pipeline.

(3) Intransit Visibility/Total Asset visibility needed incorporates linkage systems that permit immediate availability of data pertaining to the location of military assets to support an effective Distribution Management System.

b. Soldier Sustainment needed incorporates logistics capabilities to support the individual soldier in forward areas. Focus will be on medical support, field services, and personnel services.

(1) The combat health support system is a continuum from the forward edge of the battle area through the CONUS base. It is a system that provides medical management throughout the levels of care on the integrated battlefield. Combat Health Support (CHS) requires capabilities to simultaneously provide medical support to deploying forces; provide health care services to the CONUS base; and establish a CHS system within the theater. Additionally, there will be a requirement to provide medical support to redeployment and demobilization operations at the conclusion of military combat operations. Furthermore, CHS requirement will surface in support of operations other than war (OOTW). Typical OOTW operations include disaster relief, humanitarian and nation

assistance, support to domestic civil authorities, and various peacekeeping activities. The preventive medicine system must improve soldier sustainability through medical threat analysis and prevention of endemic disease or injury from environmental, occupational, biological and chemical warfare agent hazards. Rapid casualty location and acquisition, combined with prompt, effective resuscitation and early surgical management are required to reduce the killed in action and died of wounds rate. Highly mobile forward surgical teams are required to perform urgent resuscitative surgery for casualties who require surgical stabilization prior to further evacuation. Ground and air evacuation platforms require increased patient transport capacity, enhanced enroute monitoring and treatment capability, and safety features. Medical organizations must be modular in design to provide the necessary flexibility, mobility, and increased capability required to support a force projection Army. Health care personnel at all echelons of care must be able to communicate with one another by audio, video, and electronic media. Combat stress operational capabilities require far-forward prevention and intervention for combat stress over the continuum of operations. Comprehensive veterinary medical and surgical programs are required to maintain the health of government animals. Veterinary inspections are required in the following areas: subsistence at point of origin, Department of Defense operational rations: commercial food, water, and ice establishments, and surveillance of biologically/chemically contaminated subsistence. A requirement exists to provide a seamless state-of-the-art system of combat health support command and control.

(2) Field Services required includes improve water purification, storage, distribution, and the capability to provide support to the individual soldier. Improvement are needed in capability to provide nutritious, microbiologically safe food in a wide variety of environmental and tactical situations. Improvements are needed in personal hygiene services such as advanced laundry, shower, exile repair and renovation, personal clothing, equipment decontamination and personnel decontamination in modern tentage and shelters.

(3) Personnel Services within DoD there needs to be standard, integrated, automated finance and accounting system which can be deployed with finance units for wartime and contingency operations. The system must be available to all military Services and be capable of providing requisite finance and accounting support to commanders and Service members, to include such functions as pay, travel, commercial accounts, disbursement, and accounting.

c. System Sustainment improvements are needed to better sustain Army, Joint, and Coalition weapon systems without the luxury of a well developed mature theater. This also includes the capability of tactical CSS units to keep pace with maneuver units and provide CSS during movement. Requirements exist for forward area container handling systems, improved Reliability, Availability, Maintainability - Durability (RAM-D), simplified and more accurate diagnostics and repair procedures, and a prognostics capability that will better predict, provision for, and automatically feed system sustainment software being developed. Improvements are needed in fuels, lubricants, and associated products that will enhance the performance of mechanical systems. Also need improvements in petroleum quality analysis, fuel distribution, and rapid refuel capability. Interoperability and standardization with joint and likely coalition partners is essential to reduce transportation/distribution workload.

2. Combat Service Support Operational Capabilities Requirements

CSS01: Logistics Command, Control, Communication, and Automation (C3A). Logistics C3A is required for effective command and control of logistics operations supporting force projection. This includes application of technology to support CONUS-based management of theater logistics operations, and must accommodate the linking of communications and automation technologies to provide total integrated CSS/CS/CBT situational awareness. There is a requirement for integration of (or seamless access to) existing logistics Standard Army Management Information Systems (STAMISs) into an Integrated CSS STAMIS (ICS3). To ensure interface between the strategic, operational, and tactical areas of operation CSS units require low cost seamless, global, wireless, high data communication links. There is also a requirement for identification and development of joint interactive decision aid systems to enhance strategic, operational, and tactical logistics operations. These simulations should have the dual capability of being an effective training tool during normal unit training, and large-scale training exercises, and while also providing logistics interfaces into Louisiana Maneuvers (LAM) and into Distributed Interactive Simulations (DIS). They also need low cost seamless, high data rate, reliable communication links and the capability to interact with constructive and virtual simulations. Logistics C3A includes the use of automatic identification technology (AIT) for source data automation of supplies, maintenance, personnel (friendly, enemy prisoners of war), and equipment. Due to the large amounts of information which could overwhelm the soldier, Personal Digital Assistants (PDAs) are required to assist soldiers in organizing and displaying key information, and to act as a primary input interface between the soldier and the logistics C3A systems. Advanced technologies are sought to provide the capabilities to model logistical operations and concepts and provide tools (such as simulation engines) that will allow verification of the impact of new technologies or concepts on logistical operations. Also, CSS units need a capability to rapidly (within minutes) retrieve (from remotely located national and multi-national sources), store, distribute (electronically or physically), and print color digitized maps on varying sizes of paper-based products. This is needed for individual and organizational use in a field environment to support operations with host nation/coalition forces and to support logistics movement in undeveloped theaters of operations.

CSS02: In-Transit/Total Asset Visibility/Distribution Management. Total distribution management requires total asset visibility with in-transit visibility as a critical component of all classes of supply, unit equipment, units, and movement platforms. Improvements are needed to track and control customer and supply location and delivery points. CSS units need the ability to seamlessly incorporate AIT (e.g., active and/or passive tagging systems, microelectronics devices, radio frequency (RF) wireless tags, bar codes, etc.) with read/write capability into the distribution system. They must also have the ability to fix location of items moving through the system on a real-time or near real-time basis.

CSS03: Containerization and Packaging. Improvements are needed in the technology used to optimize load configurations in CONUS, rapidly plan ship loading and stowage, identify and develop intermodal and multimodal platform concepts, and increase efficiency of material handling equipment (MHE) that is positioned to handle containers. There is a requirement for "smart" packaging that is recoverable, recyclable, lightweight, with little or no dunnage, and capable of being decontaminated and monitored for integrity and environmental parameters (e.g., susceptibility to temperature, moisture, etc).

CSS04: Operations Other Than War (OOTW). There is a need to incorporate technologies which will permit CSS units to operate in wartime like they operate in peacetime. This includes the use of low cost airdrop, food, clothing, housing, and medical technologies for humanitarian relief and contingency operations.

CSS05: Medical Command, Control, Communications, Computers, and Intelligence (C4I). A requirement exists to provide a seamless state-of-the-art system of combat health support command and control across the operational continuum, supporting joint and combined forces and OOTW. This system must support split-base operations on a continual operational basis and must be strategically deployable. Appropriate combat health support staff representation must be available at all Army command levels. C4I must provide for and manage horizontal technology insertion into all organizational designs, including advanced medical diagnostic communications for combat casualty care.

CSS06: Preventive Medicine. The preventive medicine system must improve soldier sustainability through prevention of endemic disease or injury from environmental, occupational, and biological or chemical warfare agent hazards. The preventive medicine system must be modular in design to provide a comprehensive support package adaptable to a full continuum of operations. It must conduct disease surveillance from the forward line of own troops (FLOT) to the continental United States using state-of-the-art automation and communication systems to produce a real-time, tactically significant disease profile. Preventive medicine must be capable of providing versatile, mobile, and enhanced disease vector control support to reduce vector-borne diseases in a theater of operations. It must possess the ability to provide rapid and comprehensive environmental monitoring to assess acute and chronic health risks encountered during military operations.

CSS07: Treatment of Battlefield Wounds, Injuries, and Disease. The medical treatment functional area includes those measures necessary to recover casualties, resuscitate, stabilize, and maintain stabilization during evacuation to the appropriate level of care. It incorporates the basic principles of preventive medicine, the treatment of acute trauma to include maxillofacial injuries, and the treatment of minor injuries and illnesses to include dental emergencies and diseases, and combat stress. Rapid casualty location and acquisition combined with prompt, effective resuscitation, and early surgical management will provide focus on reducing morbidity and mortality. Improved methods of physiologic resuscitation, improved diagnostic and treatment capabilities at unit-level and area-level treatment facilities, and enhanced enroute patient care during evacuation will reduce lost duty time for minor illnesses/infectious diseases or improve survival for the severely wounded or critically ill. There is a need to evaluate the impact of ocular laser exposure and strategies to minimize the performance degradation from such injuries as well as devices designed to protect against laser effects on the eyes. Integration of medical communications for combat casualty care and automated medical records are key to seamless medical care and will aid in the reduction of mortality and morbidity.

CSS08: Far-forward Surgical Support. The requirement to project surgery forward increases as a result of the extended battlefield. Highly mobile forward surgical teams are required to perform urgent resuscitative surgery for casualties who require surgical stabilization prior to further evacuation. Forward surgical teams require improved shelter systems that allow for strategic deployability, quick set-up, and a rapid-response surgical capability under environmentally controlled conditions. Forward surgical teams require future technology insertion, including medical communications for combat casualty care and reliable communications.

CSS09: Battlefield Hospitalization. Hospital care must be provided to all classes of patients across the operational continuum, including the unique medical aspects of OOTW. Inpatient medical and surgical services and outpatient clinic and consultant services on an area support basis are required. The deployment of functional hospital increments will support the requirements for task organization, incremental deployment, and split-base operations. Wired and wireless internal and external communications and information management systems are required to support the transmission of voice data and digital images between all echelons of care, including fixed medical treatment facilities within the continental United States. Continued development is required to reduce the weight, cube, and logistic requirements of Tables of Organization and Equipment (TOE) hospitals.

CSS10: Patient Evacuation. The Army Medical Department (AMEDD) must be able to provide a "seamless" medical evacuation (MEDEVAC) system throughout the operational spectrum, including the evolving missions of OOTW, combat search and rescue, and shore-to-ship MEDEVAC. Ground and air evacuation platforms must have the capability to provide continuous MEDEVAC support in all environmental conditions. Ground and air evacuation platforms must be able to communicate with supported and supporting units as well as with the medical infrastructure. They must also possess the ability to maintain situational awareness on the future, digitized battlefield. Medical evacuation organizations must be modular in design. Medical evacuation units must also provide state-of-the-art medical care compatible with the medical structure on the battlefield, and additionally must provide aviation medicine support to attached units. Ground and air evacuation platforms require increased patient transport capacity and enhanced enroute monitoring and treatment capability through integration of advanced medical diagnostic communications for combat casualty care.

CSS11: Combat Health Logistics System (CHLS) and Blood Management. The CHLS must be modular in design to provide the necessary flexibility, mobility, and increased capabilities required to support a force projection Army. The system must be anticipatory and project its support in multiple locations through split-base operations. Division-level Class VIII support includes receipt, storage, processing, disposal, and distribution of medical materiel; unit-level medical maintenance; receipt of type O red blood cells; and single optical fabrication and repair. Corps and echelons above corps support includes receipt, storage, processing, contracting, disposal, and distribution of medical materiel, unit and direct support/general support level medical maintenance; blood distribution and the limited capability to collect blood; single and multi-vision optical fabrication and repair; medical gas production and distribution; and the building of medical assemblages/resupply packages. The CHLS must centrally manage critical class VIII items, patient movement equipment, blood products, medical maintenance, and Class VIII contracting. It must be capable of coordinating logistics and transportation support with non-medical logistics organizations for all medical logistics activities within an area of operations. It must be able to support reception operations for prepositioned afloat medical materiel at ports of debarkation. The CHLS must employ state-of-the-art standardized medical logistics information management and communication systems to facilitate total asset and in-transit visibility, automated transmission of optical fabrication requests, management of blood and blood products, management of medical equipment readiness, and management of captured enemy medical materiel and equipment. These systems must be compatible with and connected to all services to accomplish the single integrated medical logistics management mission of the AMEDD.

CSS12: Medical Laboratory Support. Medical laboratory capabilities must be modular in design and retain the adaptability and flexibility to support split-base operations, OOTW, and force projection. Combat health support within the division requires limited laboratory capabilities including analytical procedures and blood products in support of disease diagnosis, patient monitoring, and surgical resuscitation. At corps and echelons above corps, laboratory support must provide appropriate capabilities to prevent or minimize the effects of endemic disease (including sexually transmitted diseases), hemorrhage and injury, and the medical effects of weapons systems. The Area Medical Laboratory is an independent laboratory that provides the capability to identify and evaluate health hazards in the area of operations through the use of unique medical laboratory analyses and rapid assessments of endemic disease, environmental and occupational health threats, and biological/chemical warfare agents. The Area Medical Laboratory's analytical, investigative, and consultative capabilities must provide responsive medical assessment and field confirmation of medical threats, infectious agents, and other hazardous substances. The medical laboratory support system must exploit state-of-the-art science and technology to provide a tailored package of analytical capabilities in a multi-disciplined array of services and professional consultation to sustain the health of the command.

CSS13: Provision of Combat Health Support in a Biological/ Chemical Environment. The combat health support system must be capable of operating in biologically and chemically contaminated environments. The biological/chemical environment markedly inhibits combat health support operations, seriously degrading the ability to triage, diagnose, and treat casualties while in protective equipment. Contamination renders medical equipment and supplies unusable. Collective protection shelters are not available to provide patient protection and treatment. Decontamination of patients by present methods is labor intensive, slow, and tedious and may aggravate injuries.

CSS14: Combat Stress Control. Combat stress control operational capabilities require far-forward prevention and intervention for combat stress over the continuum of operations. Prevention of stress induced error, disability, and misconduct during and after war and OOTW requires ongoing command consultation, company-level stress monitoring and unit debriefings, and immediate far-forward intervention and treatment for stress cases. Corps combat stress control assets and teams organic to divisions/brigades require tactical mobility, telecommunications, and advanced biofeedback capability. Effective combat stress control requires that Army stress control activities be conducted routinely with supported units in training and in garrison, including assistance to unit family support groups.

CSS15: Dental. Dental units must have the ability to provide emergency, preventive general, and specialty dental care across the entire range of military operations to include OOTW, joint, and combined operations. They will achieve the highest possible level of soldier dental fitness for America's Army. Dental units must be modular in design for task organization, strategic deployability, tactical mobility, and the ability to be deployed in functional emulative increments (FEI). Far Forward Dental Treatment requires that dental modules are 100 percent mobile, have the capability to provide emergency and preventive dental care, and ensure the immediate return of the soldier to duty with no evacuation of dental emergencies to the rear. Dental assets will amplify and augment medical care during combat and mass casualty situations. Dental Corps officers will provide command and control, technical supervision, and planning and training guidance to all dental units. Dental units require reliable communications and the capability for Medical Communication for Combat Casualty Care (MC4) throughout the theater of operations. They require a continuous/ seamless, digitized patient health record.

CSS16: Veterinary. The Army Veterinary Corps is the Department of Defense (DoD) executive agent for all theater-level veterinary services and support. Comprehensive veterinary medical and surgical programs are required to maintain the health of Government animals. Training of animal handlers and assessment, prevention, and control of militarily significant animal disease (zoonotic) threats are necessary for a thorough veterinary preventive medicine program. The treatment of Government animals for biological and chemical injuries requires comprehensive monitoring and diagnosis. Veterinary inspections are required in the following areas: subsistence at point of origin; DoD operational rations; commercial food, water, and ice establishments; and surveillance of biologically/chemically contaminated subsistence.

CSS17: Logistics Mobility. Mobility enhancements are required to address the strategic, operational, and tactical implications of the CONUS-based Force Projection Army. This involves prepositioning of materiel and supplies in or near critical regions, unit stationing, infrastructure to support mobilization and rapid joint deployment, and the movement of equipment and supplies through ports of debarkation. There is also a need for highly mobile resupply including actual weapon system rearm, improved airdrop capabilities (i.e., higher capacity, more accurate, greater efficiency, and improved survivability), domestic policy, and other modifications to better support highly mobile offensive operations (to include enemy prisoner of war evacuation). This includes use of lightweight materials, robotic and high mobility MHE, and enhancement of the forward area container handling system. Also requires day/night all weather capability for the tactical wheeled vehicle (TWV) fleet to allow support vehicles to keep pace with supported combat vehicles. There is also a requirement to have the availability of a Super Short Take-Off and Landing (SSTOL) cargo aircraft capability to deliver 30 tons onto an unimproved runway 350'-750' long.

CSS18: System Sustainment. There is a need to improve CSS systems to better sustain Army, Joint, and Coalition current and Force XXI systems on the battlefield. This includes the need to provide continuous support during all movements in and outside of a well developed, mature theater and to provide immediate essential support and services to combat, combat support, and other CSS units under a variety of circumstances and conditions. All CSS systems/equipment are required to be compatible with Force XXI digitization objectives to include controls, gauges, sensors, automated logistics data reporting, etc. There is a need for all CSS maintenance systems to be highly mobile and modernized to provide anticipatory capabilities for forward repair, emergency service, and recovery support to all wheel/track systems. There is a requirement to enhance the capability of soldiers and equipment to accomplish their mission; to improve the quality of hand and power tools; and to improve maintenance enclosures/shelters. CSS diagnostics and prognostics must be modernized to support Force XXI system needs. Test, measurement, and diagnostic automatic test equipment (TMDE) capabilities for electronic and mechanical systems are required as well as enhancement of BIT/BITE capabilities and artificial intelligence technology to enhance prognostic capabilities, and to predict maintenance, fuel, and ammunition requirements and automatically feed information to the centralized CSS managers and automated systems. Improved TMDE must reduce No Evidence of Failure (NEOF), resulting in time and monetary savings for ground and aviation units, and must have connectivity with fielded or projected automation systems. Improved BDAR kits are required to execute emergency repairs in training and combat situations. BDAR kit development is required in the areas of composite structures and fiber optics.

CSS19: Power Sources and Accessories. There is a requirement for lighter, smaller, all temperature, longer lasting, more energetic, and maintenance free power sources for communications/electronics equipment, all vehicles, air and water craft, individual soldier systems, and medical equipment. Power sources include but are not limited to batteries (primary, rechargeable, reserve, thermal, solar, or any new concepts), capacitors, fly wheels, or similar purpose technologies, and stand alone power sources such as fuel cells, generators, or photovoltaics. Also needed are easy-to-use tools and test equipment to include but not be limited to a universal all chemistry, smart/interactive, small, lightweight, portable battery charger, state of charge indicators (internal or external to the battery or the system), and load/no load testers. It is also required that supported systems or equipment have power reduction circuitry and facilitate the use of power management techniques and practices to allow longer intervals between power source replacement. All power sources must, to the maximum extent possible, be environmentally friendly.

CSS20: Field Services. Requirements exist for enhanced procedures and equipment to improve water treatment (including black and gray waste water's), storage, distribution, and water quality monitoring for chemical, biological, and radiological warfare agents in water provided to the individual soldier. Improvements of CSS capabilities are needed in the areas of airdrop, to include "just in time" air drop resupply capabilities; ration support (availability of hot, nutritious, performance enhancing meals); and the ability to rapidly, safely, and efficiently prepare meals. There is a need for small group coolers/ice-makers. There is a need for rapid erect/strike tents and shelters, lightweight reusable rigid tent floors, flexible multi-use field furniture, improved tentage heating equipment, and efficient and environmentally safe laundry and bath operations. Clothing and individual equipment, textile repair and renovation, equipment and personnel decontamination, lightweight field latrines (including self-service capabilities) incinerators/trash compactors, and human waste disposal are all in need of improvement. Improvements in quality of life for the individual soldier in austere field conditions for extended periods is needed. There is a requirement to provide responsive, flexible support to soldiers during any environmental or tactical situation. To support Force XXI, improvements are needed to enhance tactical fuel distribution equipment and rapid tactical refuel capabilities. There is also a requirement to improve petroleum quality analysis, and enhance quality of fuels and lubricants to improve performance of mechanical systems, and to develop single fuel systems.

CSS21: Logistics Survivability. There is a need to develop technologies to improve the survivability of critical materiel (munitions, fuels, and various other low density/high cost materiel) during all operations. Solutions are required to protect vital logistics nodes (ports, airheads, and storage areas) from mass destruction due to accidents or enemy attack. When applied, these technologies must provide efficient, multi-modal movement and handling survivability, storage and staging survivability (the capability to rapidly regenerate storage areas following an attack), and use of simulations and modeling to plan and train for logistics survivability. Movement and handling survivability capabilities must be developed to increase the velocity, flow control, and effectiveness of materiel distribution; prevent or minimize explosive reactions; enhance the use of CONUS pre-configured loads; improve logistics-over-the-shore (LOTS) operations; optimize shipload configurations for rapid off-loading and rapid movement of materiel away from vulnerable ports and airheads; and to provide responsive emergency resupply to forward forces. Storage and staging survivability capabilities must be developed to provide soldiers with computer software to better design survivable early entry storage areas; reduce enemy detection and identification of critical supplies; prevent mass detonation and explosive propagation of munitions stacks and fuel storage areas; and rapidly cleanup unexploded/unburned ordnance/ fuel and regenerate damaged storage areas.

CSS22: Personnel Service Support (PSS). PSS functions (Personnel, Finance, Chaplain, JAG, and Public Affairs) must be performed at the highest possible level, and must minimize the footprint by projecting functions of modular units, trained and equipped to perform split-based operations, in a Joint/ Combined War or OOTW environment. There is a need to integrate PSS and experimental Army Battlefield Systems to redesign functions, use personnel and medical source data information for casualty, readiness, replacement, information management, personnel accounting functions, and Army Battlefield command and communications systems in an integrated Force XXI Army. Requirements exist for a system that provides near real time tracking of personnel from unit level (division, battalion, company, etc.) to individuals across the battlefield presented on a digitized map. A system such as the Enhanced Position Location Reporting System (EPLRS) might be used for a wireless personnel management information system (MIS) with a knowledge-base (Artificial Intelligence) user friendly, easily accessible to other MIS, menu and voice driven real-time information capability. The system must have the capability to immediately examine data and provide cursory analysis to the G1, Personnel Group, Battalion, and Detachment Commanders. There is a need for a casualty tracking system that can immediately identify a casualty as it occurs, inform the joint chain of command, and alert medical support personnel (i.e., small unintrusive device attached to a soldier that sends bio-signals to a central information collection point). Requirements also exist for an automated mail tracking system that provides in-transit visibility and direct delivery from sender to receiver regardless of the number of location changes of the receiver; for a portable automated office/staff management system providing desktop computer applications VTC, FAX, E-mail, Internet access, satellite link, and print capability for G1s, Personnel and Finance Group, and Detachment Commanders. There is a need for a deployable Defense Finance Battlefield System (DFBS) that can provide access to the full range of functional Finance and Accounting systems (across all services) to include military and civilian personnel pay, travel, disbursing, commercial accounts/vendor services, Host Nation/Coalition Support, Imprest Funds, and Enemy Prisoner of War Payment Information System. The system must also provide accounting with dedicated support in-theater communication networks, such as Mobile Subscriber Equipment (MSE), Streamlined Automated Logistics Transmission System (SALTS), International Maritime Satellite (INMARSAT) Defense Data Network (DDN), Tri-Service Tactical Communication System (TRI-TAC), or the independent Tactical Satellite (TACSAT). The system must interface with current and projected joint systems.

CSS23: Logistics Force Design. Force structure changes are necessary to support force projection. Force design changes may be the result of modifications to other operational capabilities or structure changes established in their own right. An example of the latter is establishing modular structured Active and Reserve component (AC/RC) CSS units to support deployments of any ultimate end strength throughout the theater maturation. Technologies are needed that can help model the force to be selected, rapidly analyze the readiness, availability, and deployability of these modular AC/RC components, and assemble them with maximum capability.

CSS24: CSS Training Support. There is a requirement to free soldiers from the need to rely solely on prior learning to perform procedural or problem solving tasks by providing easily usable performance support aides. Technology 'advancements are needed in the application of artificial intelligence/expert systems to performance support aides and to enable the Army training system to be flexible and responsive in meeting the varied demands of immediate contingencies. There is also a need to provide training-on-demand to geographically dispersed active and reserve units and individual soldiers for immediate use in sustainment/ enhancement training.

CSS25: Employment of Non-Military. There is a need for the employment of non-military in military operations. Civilians will have a greater role in functions that become "CONUS-bound" as well as being deployed to provide critical in-theater capabilities which may not be regionally available to sustain operations. Examples include contracted aviation maintenance and AMC's Theater Support Group. Technologies such as telemaintenance, remote tutors, direct PC broadcast systems, etc., that facilitate employment of non-military in remote areas or in split-based operations are needed.

F. DEPTH AND SIMULTANEOUS ATTACK CONCEPT OVERVIEW

1. Characteristics of Depth and Simultaneous Attack

Deep and Simultaneous Attack is the concurrent application of joint and combined combat power against an enemy throughout the depth of the theater of operations. The objective of simultaneous attack in depth is to accelerate the enemy's disorganization, disintegration, and destruction. Overwhelming firepower is applied simultaneously throughout the battlefield, holding all of the enemy's critical functions at risk. Enemy essential information nodes will be the target of precision deep strikes in order to cripple the ability to maintain the integrity of his forces. The enemy faces the dilemma of multiple threats and attacks that overwhelm his ability to cope and respond. Fighting deep allows us to control the temp of operations, providing us the opportunity to seize and retain the initiative. Through our control of the battle tempo, we create a condition where the enemy has no place to hide and no time to rest.

Deep attack operations greatly enhance a Commanders ability to accomplish the mission, while protecting the force. They still shape and develop the battlefield by setting the conditions for operational maneuver and help dictate the terms for the close fight. However, they now can extend the battlefield in time and space by giving the Commander the opportunity to expose and attack essential objectives. Deep attack operations protect the force by neutralizing the enemy's acquisition and attack assets. By striking at the enemy deep, we reduce enemy forces throughout the battlefield, creating favorable force ratios long before any direct fire engagement.

The feasibility of the deep and simultaneous attacks depends on three conditions. The first is the ability to see the entire battlefield. This includes access to national and theater reconnaissance, surveillance, and targeting assets to locate and classify targets. The second is having the advantage in relative combat power. The Commander must have a range of complementary attack systems to provide operational fires throughout the battlefield against the full array of enemy targets. The third condition is the capability to synchronize these joint and combined systems and operations. Future operations will be conducted by a force that will be joint, combined or coalition in composition within 48 hours after deployment. In order to create a single, extended battlefield, targeting information from all available sources must be linked to a common decision making process, which executes fires using all accessible delivery means. The joint nature of deep operations implies that the standards and protocols incorporated in future technology developments are a key issue. All of these capabilities must be versatile, deployable, lethal, and expandable to support the power projection paradigm of today's Army.

a. Real Time Targeting is the ability to see the enemy in real-time at long-range, and share this critical information instantly with global connectivity. Targeting is divided into three processes: detection, decision making, and dissemination. These processes do not necessarily occur sequentially; in fact they often overlap. Detection includes the capability to survey the battlefield, search for predetermined targets, and gather sufficient data to enable confirmation of a target's identify prior to attacking it. Decision making involves defining target priorities, identifying engagement areas, allocating sensors (refocus on probably targets), specifying trigger events (determine target priority and confirm ID), allocating munitions, and determining the means of attack and the method of control (centralized or decentralized). Finally, the information must be disseminated rapidly from collector to shooter with a minimum of handling in order increase responsiveness.

b. Methods to Defeat Critical Targets includes assets such as missile logistical sites, infrastructure, command and control, follow on forces, precision strike assets, chemical and biological facilities, tactical and operational centers of gravity.

2. Depth and Simultaneous Attack Operational Capabilities Requirements

DSA01: Extend Ranges of Deep Attack Systems. Future systems must provide for extended ranges allowing the attack of targets at great depth, in order to adequately defeat future missile threats and to conduct precision strikes against critical targets developed at the Corps and EAC.

DSA02: Extend Ranges of Theater Missile Defense Systems. Tactical Ballistic Missile Counterfire systems and Forward Area Air Defense systems, including aviation, air defense, field artillery, and Special Operations Forces systems to achieve effective Theater Missile Defense.

DSA03: Smart and Brilliant Munitions for Deep Attack. Current arsenal of attack munitions are predominantly "dumb" munitions and have limited submunitions options. Future deep attack munitions must include greater reliance upon smart and brilliant munitions and submunitions. Munitions and submunitions must have a greater range of application for flexibility of operations against a wide range of target types/profiles. Significantly improved or elimination of munitions/submunitions dud rates to eliminate unexploded ordnance hazards.

DSA04: Theater Missile Two-Tiered Defense. Current air defense systems must have enhanced capabilities to conduct a two-tiered Theater Missile Defense.

DSA05: Enhanced Survivability of Deep Attack Systems. Currently, the majority of systems supporting deep operations have limited survivability capabilities. Improvements are required for detection avoidance and/or increased armaments protection, to include warning and alerting the force simultaneously within Active Defense architecture before the Tactical Ballistic Missile (TBM) impacts and to discriminate between Weapons of Mass Destruction (WMD) and conventional warheads.

DSA06: Fratricide Avoidance. There is limited protection against fratricide. Future requirements include increased protection against friendly fire engagements with on-board friend or foe identification means and enhanced battlefield tracking systems.

DSA07: Real-Time, On-Board, All-Weather Precision Terrain Location. Current mapping capabilities are limited. Future systems must include digitized mapping linked to satellite operations providing up to date location capabilities. Single source of all mapping/terrain data and coordinates is required.

DSA08: Robust, Streamlined, Multi-Node Processing. Sensor data gathered at Corps and EAC must pass through a number of communications nodes before targeting data is available to shooters. A robust streamlined processing system is required to facilitate rapid decision making, thus improving shooter responsiveness. A seamless architecture allowing real time data to reach aviation, air defense, and field artillery shooters is required to support Joint Precision Strike and Theater Missile Defense operations.

DSA09: Real-Time Location and Identification of Targets. Current sensor capabilities that attempt to classify and locate targets are inadequate. Deep attack systems must have real time sensor data that provides sufficient detail in location and identification of targets, reducing time lines by eliminating man-in-the-loop analysis and improving overall responsiveness in Joint Precision Strike and Theater Missile Defense.

DSA10: Real-Time Seamless National Targeting Dissemination. Limited connectivity and data base management exists among national sources, Corps, and EAC. Future capabilities must provide real time collection of targeting data from national sources tied directly to Corps and EAC intelligence collection centers with the capability of linking specified shooter elements into a seamless national targeting dissemination system. This will facilitate the improved attack capability for critical targets to include missile logistical sites, infrastructure, and other key targets such as command and control, follow-on forces, and targets normally associated with precision strike requirements.

DSA11: Long Dwell Surveillance at Corps and EAC. Currently the numbers and types of tactical sensors available to the Corps and EAC are limited and have constrained dwell-time capabilities to search required areas of interest. Future capabilities include an increase in dedicated target acquisition systems for Corps and EAC.

DSA12: Day/Night All Weather, All Terrain Sensors. Currently, acquisition systems are weather and terrain dependent. Sensors must have a day/night, all weather, all terrain capability that provides accurate location and identification of targets, to include capability to discriminate between WMD and conventional warheads throughout the depth of the battlefield.

DSA13: Accurate, Real-Time BDA. Limited Battle Damage Assessment is available to commanders. Future sensors must have the ability to provide accurate real time BDA throughout the depth of the battlefield.

DSA14: Rapid Location and Identification of Passive Targets. Passive targets are generally not detectable with today's technology. Future capabilities and attack systems must include the ability for sensors to locate and identify passive targets as soon as possible allowing for early defeat of theater missile, logistical forces, chemical and biological facilities, as well as other critical targets generally associated with tactical and operational centers of gravity.

DSA15: Automated Interoperable Communications. Current communications and automation interoperability is limited. Future capabilities must include the ability for EAC and Corps to have total, uninterrupted communications and automated linkage throughout the depth of the battlefield. Additionally, there is a need for easy access to functional area data without time consuming sorting on the part of the users. Improving interoperability will greatly assist in defeating critical targets.

DSA16: Artificial Intelligence (AI) Decision Aids. Future capabilities must include an automated artificial intelligence network that streamlines coordination and planning steps in support of deep attack operations.

DSA17: Information Fusion Technology Supporting Precision Strike. Fusion of intelligence information and deep attack coordination and planning is fragmented and characterized by extended man-in-the-loop operations. Deep operations coordination cells are required to support Corps and EAC in planning, coordination, and execution of deep attack operations to include precision strike, theater missile defense, and the synchronization of associated air defense and aviation operations.

DSA18: Near Real-Time Deconfliction of Airspace and Targeting Data. Deconfliction of airspace coordination is too slow and cumbersome. Effective coordination requires capabilities for near real-time deconfliction of targeting data and airspace usage, possibly directly linked to shooters and aircraft, allowing for a streamlined, decentralized capability that would reduce overall coordination time.

DSA19: Communications Interoperability Between Joint and Coalition Forces. Currently there is limited communications interoperability between joint and coalition forces. Future capabilities must include devices that provide automatic interfacing among joint and major coalition forces in support of deep attack operations.

DSA20: Terrain Independent Communications and Information Distribution. Currently, there is inadequate communications from corps to subordinate units. Future capabilities must reduce the time required for installation and networking of communications systems and reduce terrain dependency.

DSA21: Rapidly Deployable Attack Systems. Current surface-to-air and surface-to-surface attack systems have limited strategic and theater deployability. Future capabilities must include attack systems that can be easily and rapidly deployed.

DSA22: Enhanced Mobility for TMD and Precision Strike Attack Systems. Current surface-to-air and surface-to-surface attack, C2, and support systems have limited tactical mobility. Future capabilities must include systems with tactical mobility comparable to the supported force.

G. MOUNTED BATTLE CONCEPT OVERVIEW

1. Characteristics of Mounted Battle Space

Battle space is a construct, a way to think about fighting—a visualization by commanders at every level of the entire battlefield and all phases of the campaign and operation. While a new and important label, battle space is an old construct. Historically, the seasoned and successful leader reports a new level of awareness of the battlefield—before, during, and after battle. The leader reports an ability to see success and, more importantly, recognize critical points were he can fail. His intent is clear, concise, and focused. He understands where, when, and why he wants to meet and defeat the enemy. He also does not have to use his radio very often. The leader must arrive on the battlefield with a seasoned understanding of battlefield dynamics. Training commanders in understanding the battle space construct is becoming much more important.

"Battle space is both an art (honed by intellect curiosity and, most of all, by experience) and a science (in that much can be taught and learned)." Proper use of this construct prevents our combat, combat support, and service support units from becoming surprised or paralyzed by unexpected enemy actions. From the introduction of our forces, we dominate the battlefield by dominating maneuver.

The construct demands the leader understand the time and space limits, not necessarily constrained by terrain, where his force can detect, acquire, and engage the enemy. It also involves the leader mentally combining his experiences, the effect of friendly and enemy information, and weapon systems with time and space parameters. The result is an ability by the leader to visualize, in three dimensions, the cause and effect of action and counteraction by both his and his opponents' forces. Use of the construct produces actions necessary to be taken by the leader designed to dominate maneuver.

Application of battle space involves the leader and battle command in a complex equation involving terrain, the enemy, mobility and agility, force protection, and weapons. We need to understand the role and potential effect of technology on each component.

(1) Battle Command

(a) As the glue that bonds the battle space construct, battle command involves the creation of reliable and redundant command, control, and communication. The leader fights with all systems and units horizontally integrated. His task is to use battle command supported by battle space to optimize each units contribution to the fight. Battle Command and Battle space are identical twins, a lot alike, but yet distinctly different. The leader must be able to maneuver forces, rapidly apply overwhelming firepower, and see the enemy throughout the depths of the battlefield. His lean but functional battle command system must provide intelligence and a prism for the leader to use in shaping his vision.

(b) Emerging technologies will allow a leaner command (and staff) apparatus enabling us to plan and act more quickly than the enemy keeping him off balance. New communication technologies (assuming they are compatible) will reduce time required and available for our troop-leading procedures and execution of maneuver. We can disseminate critical information, issue FRAGOs, and exploit opportunities far more rapidly than can our potential enemies. Reliable, secure, long range communications and position locating devices will permit us to disperse our forces and reduce our vulnerabilities while enabling us to rapidly mass assets to seize any advantage our intelligence capabilities uncover.

(c) The commander's ability to see the battlefield will be changing in a fundamental way. The spectrum of intelligence gathering tools, from global to tactical assets, will provide a clearer picture of the battlefield than ever before. Knowledge of the enemy's positions, intentions, and capabilities will give us significant advantages on the battlefield. The challenge is to develop technology and procedures which ensure that the ground commander will be provided with analyzed and timely intelligence. The commander must then have the ability to rapidly collapse and shape this information into a format which fighters need to destroy or neutralize the enemy.

(d) The commander will need to develop an advanced awareness of the need for timing, mass, and security, Given this "post-graduate" level of understanding of battlefield dynamics, he will be able to control his battlefield through a well-timed application of mass, a consideration of the time required to exploit mass, and an awareness of the exact conditions of security. The battlefield commander will blend time, mass, and security to control both the vertical and horizontal dimensions of the battlefield. He must be able to visualize the relationship between these dynamics, and he must strive for simplicity of plans.

(2) Terrain and Weather

(a) Skilled commanders understand how contours of the land and the disposition of forces lend themselves to decisive battle. They use terrain, including natural and man-made obstacles, to the best possible advantage. Obstacles are integrated into the maneuver plan and synchronized with the terrain and weather to support decisive operations at the best time and place. Weather is used to leverage advantage in the favor of friendly forces. Our ability to operate in limited visibility conditions or over weather effected terrain often gives advantages to our forces.

(b) While technology will have little effect on the actual terrain, we can anticipate new terrain-enhancing tools to more rapidly understand line of sight relationships, trafficability, and terrain-shaping maneuvers. As we bring digitization to our equipment, we will be able to find new applications for these terrain enhancing tools. Weather has always played a major role in determining the outcome of battle. In the future, the effect of weather will offer us more advantage. As we continue to condition and equip our forces to operate in marginal weather, we will extend our leverage. Technology can continue to help.

(3) Mobility and Agility

(a) As the key to dominating maneuver, mobility is first a state of mind possessed by good commanders. Closely related to terrain is a leader's understanding of his requirement for mobility and agility and the need to use them to gain advantage over his enemy. If you believe the enemy has an advantage, commanders must find a way to neutralize it. This dynamic relationship is the hinge on which the door of victory swings. Mobility and agility are the tool of innovation used by the commander to provide momentum to control his opponent.

(b) In the future, gaining early, critical information on the enemy will define more precisely the Commanders battle space. A by-product of this process will be the ability to maintain a range advantage. Extending the range at which task forces commence combat actions will achieve three distinct advantages over the enemy.

- Enhance our agility by destroying enemy forces before they can effectively engage us and throughout the depth of the battlefield.

- Reduce the vulnerability of our forces by using unmanned sensors to increase the acquisition ranges, destroy his forces, and cause premature deployment (while increasing the dispersion of the friendly force). This will enhance agility and mobility.

- Increase our ability to maneuver by improving our control, communications, and base of fire. As a direct result of this improvement we will increase our mobility and agility.

(4) Force Protection

(a) Force protection currently involves some special technologies, but more importantly formations, maneuvers, and procedures designed to keep the force safe. These tactical measures remain necessary for the leader. Commanders continue to need redundancy and depth in planning for force protection. The bulwark of such protection will remain formations; however, given the value our nation places on protecting its soldiers, we must enhance protection.

(b) We are entering a new era in force protection. Special armor, reactive armor, composite material, and protection packages will allow us to field lighter, more capable vehicles. Active and passive protection such as decoys, electronic countermeasures, stealth technology, and vehicle-integrated defense systems will raise vehicle survivability to new levels. Networking combat systems with digital communications technology will allow the integration of each element of the combined arms team as it has never before been integrated. The resulting synergism will markedly increase collective protection. Efforts to counter smart and brilliant munitions will cause us to adjust how we use our weapons as well as the physical measures we take to provide higher levels of protection.

(5) Weapons

(a) Our arsenal of weapons remains the core of our ability to control the battlefield. They provide the hammer we use to shape the battlefield metal. While over the past 15 years we have witnessed an exponential increase in both the effect and strength of our arsenal, recently, we have experienced an ability to increase the distance between systems and yet maintain the effect of mass. This enables us to control more terrain with less force.

(b) By increasing ranges at which we detect, acquire, identify, engage, and destroy or neutralize our adversary in the close fight, we will continue to own several distinct advantages over the enemy so we can increasingly mass effects and not forces. First, we begin the destruction of his force with direct and indirect fires before he can effectively engage us with his direct fire systems, and often before he can detect us. This allows us to increase our lethality and seize and maintain the initiative. Second, we can reduce the vulnerability of our forces by using the increased ranges of our systems in the direct fire fight, allowing us to cover broader frontages with fewer forces. Third, we enhance our ability to maneuver by improving our base of fire and enhance the flexibility of our force. These advantages contribute to maintaining the initiative, disrupting the enemy commander's ability to move, and imposing our will upon the enemy.

2. Mounted Battle Space Operational Capability Requirements

MTD01: Firepower. Future systems must provide overmatching lethality against current and future systems of potential adversaries. Systems must be capable of firing on-the-move and operating effectively day or night in adverse weather conditions, in cluttered background environments, and in the presence of threat countermeasures, to include jamming, screening, and use of low observable and active defense systems. Advanced fire control systems are required which improve probability of hit, allow rapid tracking/engagement of multiple targets, and allow munitions firing inside the threat's reaction time. Require improved mines and mine delivery techniques which will restrict the mobility of the threat. Lethality must be enhanced and range increased, either through the development of capabilities such as improved kinetic energy kill mechanisms, mine disbursement munitions, chemical energy munitions designs, smart munitions, and fuel air explosives, or through the development of new types of weapons such as electro-magnetic launch, directed energy, lasers, microwave, and particle beams. Targets include armored vehicles and all ground threats as well as fixed- and rotary-wing aircraft. Systems must have the capability to operate with increased distance between them and yet maintain the effect of mass. Weapons and/or their platforms must have the capability to be networked, integrated, and synchronized into digitized fire support and situational awareness systems. Future enhancements to these systems must incorporate spoken human-machine dialogue which will measurably accelerate information acquisition, input, translation, distribution, and output of various forms.

MTD02: Target Acquisition. Require improved target acquisition capability to include information awareness, intelligence awareness, and advanced fire control with a reduction in manpower intensive tasks. Spoken human-machine dialogue will be required to minimize manpower intensive tasks, accelerate flow of information, and to minimize target acquisition time. Must have the capability to operate from moving platforms and to engage and kill moving and stationary targets, with direct and indirect fire out to the extent of the brigade commander's battle space. Targets include personnel, bunkers, armor, thin-skinned vehicles, fixed- and rotary-wing aircraft, and indirect fire systems. Essential that low profile targets with sophisticated countermeasures can be acquired in all weather conditions, day or night, and in the most cluttered battlefield environments. Mounted aerial and ground platforms will require targeting, location, and acquisition systems, both manned and unmanned, from ground, air, and space-based systems capable of rapid detection, recognition, identification, hand-off or engagement of both ground and aerial targets at ranges in excess of the threat's detection and weapons systems. Targeting and hand-off capability is required for ground-to-ground, air-to-air, air-to-ground, and ground-to-air systems. Systems must have the capability to hand off specific targets to either line-of-sight (LOS), or non line-of-sight (NLOS) weapons which can immediately fire at the target without independently acquiring the target. Systems should have the capability to either automatically conduct battle damage assessment (BDA) as engagement occurs or allow crew to make BDA quickly enough to avoid engaging targets that have already been killed or disabled.

MTD03: Mobility. Mounted air and ground systems must possess the mobility and agility required to survive, to control battle tempo, and to dominate the maneuver battle. The mounted force must be able to quickly detect, avoid, or breach and cross natural and man-made obstacles. This will require innovative improvements to platform suspension systems, drive systems, and design. Platforms and crews must be able to perform at maximum potential in various NBC and other hazardous environments. Increased range of operations and fuel efficiency is desired for ground and air platforms. Strategic and cross country air and ground transportability enhancements are required via the reduction of subsystems/platform weights, improved platform composition and design, increased lift capability, improved ground haul capacity, and improved reliability, availability, and maintainability.

MTD04: Advanced Propulsion. Require propulsion systems that are more efficient in power-to-weight and power-to-volume ratios, and smaller, lighter, and more fuel efficient air and ground platforms. Improved drive technology, such as electric drive, is required to permit vehicle designers the opportunity to make radical, innovative alterations in platform design.

MTD05: In-Stride Natural and Man-made Obstacle Avoidance/ Breaching. Ground platforms must possess the mobility and agility to dominate the maneuver battle. The mounted force must be able to quickly detect, breach, and in-stride cross or avoid man-made and natural obstacles on the battlefield using manned and unmanned or robotic systems. Real time access to terrain and weather data must be available from ground, air, and space systems for synchronization with the maneuver plan. Terrain diagnostic tools are required which will provide a more rapid assessment of terrain line of sight relationships, trafficability, and maneuver obstacles.

MTD06: Power Generation. Substantially improved electrical generation, storage, and conditioning capabilities are required to enhance vehicle propulsion, to support weapons systems, digital tactics, techniques and procedures, and to support new capabilities such as electro-magnetic guns, directed energy weapons, and area/individual mounted platform force protection systems. Alternate power sources, such as improved batteries and auxiliary power units are required.

MTD07: Survivability. Require reduced vulnerability of air, space, and ground platforms, through the use of synergistic combination of improved threat acquisition, signature reduction, early warning, hit avoidance, active defense, and increased protection against platform penetration. Enhanced 360 degree and overhead, underneath protection of aerial and ground systems and unit elements (through area protection) is required. Capability is required to survive ballistic impact, thermal effects, overpressure effects of munitions, electro-magnetic pulse, directed energy weapons, and lasers. Early NBC warning is required for individual soldiers and mounted platform crews via remote ground, air, and space detection systems. Detection of multiple agents and characterization of new agents is required from remote and platform based systems which are designed to minimize weight, maximize system miniaturization, obtain lower detection limits, improve biological detection, and be logistically supportable. Jamming of and active intercept of beams, and projectiles is required. Active, passive, structural, or other new and lightweight innovative forms of protective technology such as composite materials and battle damage diagnostics which provide crew warnings of impending system destruction are desired. Require enhanced platform capabilities to rapidly create defilade and cover in all types of terrain and battlefield conditions. Air platforms require a lightweight obstacle avoidance system capable of warning the crew of wires and other inflight hazards encountered during contour and nap-of-the-earth flight. Spoken human-machine dialogue will be required to minimize delays in information processing, interpretation of voice communications with coalition and enemy forces, and to provide early audible threat identification and platform status.

MTD08: Low Signature/Low Observable. New materials, vehicle shaping, and treatment of visual, acoustic, infrared, and radar signatures must be developed which will reduce the probability of air and ground platforms being acquired, engaged, and hit by the threat. These capabilities must include the ability to rapidly create defilade and cover in all types of terrain and battlefield conditions.

MTD09: Smoke and Obscurants. Mounted ground forces require improved smoke materials, which include the capability to selectively block wavelengths in the IR, millimeter range, and methods of delivery to maximize their ability to screen movements, protect against enemy detection, counter intelligence, acquisition, and reduce hit probability, while minimizing interference with the ability to see and engage the enemy.

MTD10: Susceptibility to Threat Detection. Mounted forces require improved system integrated active and passive security measures. Measures are required to enhance Operational Security (OPSEC), Signals Security (SIGSEC), and Counter-Reconnaissance, Intelligence, Surveillance, and Target Acquisition (C-RISTA). Signature reduction technologies to reduce air and ground platform signature in the visual, thermal, acoustic, and radar bandwidths and low observable technologies, advanced conventional and multi-spectral camouflage, and defilade creation capabilities are required to enhance survivability.

MTD11: Individual Protective Equipment for Mounted Forces. Individual protective equipment must have reduced weight, be wearable for extended periods without degrading individual performance, and must be ergonomically compatible with weapons and vehicle systems. Systems must incorporate protection against ballistic/NBC/laser and other directed energy systems. Individual soldiers and crew members require an integrated protective ensemble which has the capability to be tied to platforms of both ground and air platforms.

MTD12: Prevention of Fratricide. Desire systems that significantly increase situational awareness at all levels. Information must be provided in a seamless fashion irrespective of the echelons involved. Desire systems that positively identify friendly and enemy systems at the maximum engagement range of weapons systems. Require systems that neither increase vehicle signature nor delay firing when a target is acquired. Spoken human-machine dialogue will be instrumental in the reduction of fratricide through the use of voice recognition systems.

MTD13: NBC Decontamination. Mounted platforms and crews must possess the capability to safely and rapidly provide initial decontamination of platform and crew using platform-based systems for increased mobility/ survivability. Specialized decontamination equipment must be developed which can maintain battlefield tempo and will provide rapid and total decontamination of platforms and crews under various combat/environmental conditions.

MTD14: Mounted Command and Control on the Move (C2OTM). Mounted forces require robust, long-range, seamless, ground, air, and space systems/ subsystems that will maximize the commander's ability to synchronize operations; be constantly in communication with key subordinates; and to establish, control, and alter tempo as required to seize and maintain maneuver dominance. This must be accomplished while both the commander and the commanded force are on the move. Air and ground commanders must have the capability to maintain situational awareness, to rapidly send and receive graphics, imagery, intelligence information, weather and terrain information, and plans and orders in real-time and on demand. Communications and situational awareness must be maintained while commanders are transferring from one vehicle to another and while they are dismounted. Air and ground commanders must be able to maintain the same awareness of the situation and the same contact with subordinates when they leave their vehicles and are dismounted or riding in other vehicles. Automated decision support aids are necessary to assist the commander and his staff in synthesizing information, developing options, and making timely decisions. Battle command systems must be flexible enough to be integrated into mounted platforms and mobile command posts. New communications systems must be secure, reliable, compatible, and use automated processing. Communication and automation must be interoperable between joint and coalition forces for which spoken human-machine dialogue will be essential to obtaining accurate and error free interpretations without delay. Full consideration must be given to the weight, survivability, mobility, and future systems integration. New systems must not detract from the mobility, deployability, or warfighting capability of the current mounted systems.

MTD15: Digitization of the Mounted Force. Horizontal integration of the battlefield must be expanded through the digitization of information. Digitizing the battlefield will allow leaders to gain critical information, analyze, synchronize, integrate, and employ all warfighting systems. Mounted systems must have securable, jam-resistant, automated systems capable of rapidly sending and receiving text, graphics, and imagery in real-time and on demand from ground, air and space systems. Units require a mission planning and management system capable of pre-mission planning, data loading, and mission rehearsal. It is imperative that software and hardware be created which is flexible enough to respond rapidly to change, as well as meeting the needs of various types of users.

MTD16: Mounted Forces Situational Awareness. Mounted systems require improvements in situational awareness to enhance survivability, provide command and control, gain maneuver dominance, and to dictate battle tempo. Require capability for commanders to be provided the information from ground, air, and space systems necessary for them to visualize the entire battlefield as it exists in real time. Commanders must be able to use dependable spoken human-machine dialogue to rapidly access, update, retrieve, display, and transfer information on digitized terrain, weather, man-made obstacles/barriers, and early warning of NBC contamination hazards, to support a wide range of intelligence information in the preparation of the battlefield, to higher, lower, adjacent, joint and allied forces. Require the capability to transmit/receive multi-discipline predictive intelligence and warning data to include imagery.

MTD17: Battle Planning/ Rehearsal. Future systems must be capable of supporting both combat operations and training operations. The same systems used for training must be suitable for use in realistic battle planning and rehearsal. Advanced, spoken human-machine dialogue interactive trainers for mounted air and ground force technologies must possess the ability to conduct simultaneous interactive training for the total force. The capability to conduct advanced virtual prototyping with a networking capability is essential.

MTD18: Command Posts (CP). Commanders and staffs must operate out of highly survivable, mobile, stealthy ground, and airborne command posts, compatible with the Force XXI battlefield, that function on the move. Command posts must be automated using spoken human-machine dialogue, seamless ground, air, and space systems, and be configured to allow all required staff functions to be performed with reduced staffing. A dedicated ground CP vehicle is desired, and, short of that, a CP system is required, which can be readily moved into the vehicle of the commander's choice, i.e., High Mobility Multi-purpose Wheeled Vehicle (HMMWV) or Bradley Fighting Vehicle (BFV), and plugged-in and operational in less than 15 minutes.

MTD19: Sensors for Mounted Forces. Every vehicle on the battlefield must be sensor. Sensor capabilities must be expanded to include the use of robotic aerial/ground data collection and target acquisition systems which are durable and are effective in day/night, all weather, cluttered environment conditions. Smart and intelligent mines, ground and air deliverable, capable of autonomous operation, which function as sensors for target acquisition information, intelligence, situational awareness efforts, and for the identification and classification of NBC and other hazardous environments are required. Robust, streamlined sensor data processing equipment is required to transmit real time information to facilitate rapid decision making and shooter response. These systems must be designed to be carried internally or externally by ground, air, or space platforms and locally or remotely launched or emplaced and controlled. Sensor systems must be able to communicate seamlessly, using available communications systems. Audible sensors, linked into spoken human-machine dialogue systems will quickly interpret audible sound/voice information.

MTD20: Simulation. Require training systems which operate identically to the systems they are replicating, and which will allow soldiers to utilize training equipment without prior training or experience. Advanced technologies are sought which will enhance virtual and constructive simulations to include live simulation instrumentation. The capability to link live, virtual, and constructive simulations from the individual mounted system to a full combined arms brigade is desired. The simulations must be seamless, distributed, and interactive, provide aggregation and degradation of forces, and include advancements in methods and models for determining fidelity requirements. Must have modules that allow expeditious validation of simulations. Must be compatible with Distributed Information Systems (IDs). Conductivity between the virtual and live training, whether in the laboratory or in the field, must be established. Simulation technologies must possess the capability to conduct simultaneously interactive training from the individual system to the brigade level across battlefield operating systems. There is a need for future training simulation systems which will use spoken human-machine dialogue and will allow the user to construct his own environment as required, and without the aid of computer programmers. This will allow the user to make rapid changes in the training environment as required by changing needs.

H. TRADOC'S TRAINING RESEARCH AND DEVELOPMENT (R&D) REQUIREMENTS

1. Training Challenge Overview

One of the Army's enabling strategies to meet future challenges is to *maintain the edge* with *quality soldiers who are trained to razor sharpness.* As the cornerstone of a trained and ready Army, TRADOC's training community has the mission of providing high quality training to soldiers and leaders today, and developing effective training programs and products for the future. The post cold-war drawdown and declining defense budgets require trainers to seek cost-effective means to continue providing the tough realistic training that contributed to victory in Operation Desert Storm. At the same time that trainers face economic challenges and the need to adapt to the changing roles and missions of the force projection Army, technological opportunities are available that may radically change the nature of training in the future. Close interaction between the training and R&D communities is essential to ensure that R&D efforts will allow TRADOC to meet critical future training requirements.

2. Management of Technological Change in Army Training

The Training Research and Development Action Plan (TRADAP) is a mechanism by which the Office of the Deputy Chief of Staff for Training, HQ TRADOC, is managing technological change in Army training. It is an effort to harness technology to support development of cost-effective future training strategies. A central focus of TRADAP has been the explicit definition of training R&D requirements in terms of the research needed in selected technology areas. Based on input from the training and R&D communities, these requirements have been initially prioritized and published in the TRADOC Training R&D Priorities document. R&D requirements have also been crosswalked with ongoing R&D projects to identify areas where additional training research is needed. The overall TRADAP effort is intended to make the Army training community a better informed and more involved customer of training R&D.

3. Future Training and Research Requirements

Training R&D priorities are driven by future training requirements. These requirements are based on changing roles and missions of the force projection Army, technological opportunities, the need to maintain training effectiveness at reduced costs, and the complexity and lethality of the battlefield. Future training requirements are listed below along with related technologies on which additional research is needed.

TRD01: Provide accessible, cost-effective training that is environmentally sensitive, safe, versatile and realistic. Numerous factors including environmental concerns, reduced range and exercise areas, and pressure to trim OPTEMPO and ammunition budgets continue to propel the Army toward a device-based training strategy. This type of strategy employs a training-effective and cost-effective mix of Training Aids, Devices, Simulations and Simulators (TADSS), and other training methods to accomplish individual and collective performance goals. It is important that the use of these strategies, as well as the individual TADSS, be based on empirical data as to their effectiveness. Key criteria for an effective TADSS training strategy include: the minimum essential realism to ensure training transfer to job performance; use across a wide spectrum of rapidly changing contingency missions and associated training needs; and ready availability to enable soldiers to train individually or collectively when and where they need. The further development of advanced simulation technologies paves the way toward a device-based strategy that meets the above criteria. Specific technologies that require additional research are:

(1) Knowledge of TADSS Fidelity Requirements. Research should address enabling technologies, methods, and models for determining fidelity requirements for a given TADSS (including synthetic environment/virtual reality applications). Typically, increasing fidelity requirements results in increased acquisition costs for TADSS. Yet, increased fidelity itself does not necessarily guarantee better transfer of training. Only those cues and responses essential to learning the task must be simulated. R&D is needed to identify which features of a simulated/synthetic environment (perceptual cues) are essential to optimize training transfer. Efficient methods for the measurement of fidelity requirements also must be developed. Eventually, research findings in this area need to be consolidated into design principles/standards for creating TADSS with the minimum essential degree of realism.

(2) Virtual Reality (VR). VR technology offers tremendous potential paybacks and savings to the Army. We are on the threshold of VR technology and can see the application to combat developments and training. VR offers combat simulators the capability of integrating complete crew training for a combat weapon system. This dynamic technology, for example, could also provide for inexpensive driver training of Army vehicles. The technology is easily transported and can provide opportunities for training to be conducted on board ships with deployed forces or contingency mission training. VR research should focus on a generated generic synthetic environment and a technology to portal into an existing synthetic environment.

(3) Dynamic Synthetic Environment. Dynamic synthetic environments with realistic atmospheric effects, terrain features, and dynamic virtual objects will bring realism to the world of simulation and the synthetic battlefield. Emphasis must be placed on developing low cost, high fidelity computer-generated imagery that is consistent with human visual capabilities. A methodology needs to be developed that will allow an efficient way of dynamically changing the terrain elevation to produce craters, fox- holes, and engineering obstacles. These features should then become part of the terrain database and affect both mobility and visual rendering of the terrain to the combat simulation. Sufficiently applying this capability to cultural features such as buildings, bridges, and other structures will maximize the training transfer in mission rehearsal and training exercises. Development of an algorithm for object characteristics such as structural material is required to produce natural effects when an object is impacted by a specific combat system. When the synthetic world can display in various terrain environments what a human would see in a real world environment, the training realism is increased. Conducting terrain analysis, performing mission rehearsal, and battlefield planning, etc., would benefit from this technology.

(4) Embedded Training (ET). ET is a capability designed into or added onto hardware and software systems that enables it to provide the cues necessary to train individuals, crews, and units. Look for technology to train individual/ crew gunnery and driver tasks. Expand focus on development of ET technology to light forces. With the advent of the digital battlefield, ET technology needs to include ways to train battle command using operational hardware versus standalone simulations. Use of ET technology with VR technology to train collective tasks offers potential savings in the development of simulations. Research should also address how to reduce the impact of ET technologies on hardware/software system reliability.

(5) Live Simulation Instrumentation Technology. This technology will provide the capability to determine and transmit in real-time a player location and weapon systems attitude for man pack and vehicular-based systems. This technology could then be integrated into a simulated synthetic environment which would include constructive, virtual, and live environments.

TRD02: Train leadership skills appropriate for any event along the range of military operations. Today and in the foreseeable future Commanders face a formidable leadership challenge—how can Commanders lead effectively on the high technology, joint, combined, and interagency battlefield to accomplish a wide variety of disparate missions? There are a number of interrelated and complex training and performance support requirements that must be met to answer this challenge. For example, research is needed to determine how to train Commanders better at locations other than the CTCs (e.g., home station) on a wide variety of scenarios so that Commanders can practice decision making skills prior to using them on the battlefield or at CTCs. Also, effective command and control decision making can be hampered by the rapid and continual influx of information if there is no capability to identify and pay attention to that information most important for the commander to know. R&D is needed to improve a Commander's situational awareness and after action review capability without creating information overload. Research in this latter area, aimed at improving ways of collecting and disseminating battlefield information to battle staffs, may well translate into applications for both training and the operational environment. Technologies requiring additional research include:

(1) Knowledge of complex decision making. Although some research is ongoing in this area, more research is needed to understand fully what constitutes good command decision making; the kinds of decision errors commanders make in particular situations (e.g., under varying degrees of combat stress); the primary causes of errors; and how, when, and where commanders should be trained and provided performance aids to prevent decision errors. The influences on decision making by interactions between and among battle staff members and other aspects of group dynamics is also worthy of further investigation. More advanced research is needed to apply what is known about complex decision making to the development of training and performance aids for commanders and battle staffs and to evaluate the effectiveness of different approaches in terms of training transfer and performance enhancement on the battlefield.

(2) Voice recognition. Advancements in voice recognition technology are necessary to support commanders in battle/training environments, enhance language training (i.e., interrogators, special forces), and serve as an input/output interface for performance support aids. Technologies must be developed that enable commanders to interact with computers to request displays of units, tactical formations (enemy/friendly), terrain, or battle plans in order to oversee the actual or synthetic battlefield. Technologies also need to be developed allowing voice communication in English with a computer that contains foreign language databases and is capable of language translation, language training, and supports interrogation of POWs.

TRD03: Prepare leaders and soldiers to be adaptable and innovative. A smaller Army and the anticipated consolidation of many military occupational specialties will place greater demands on each soldier. Innovation and adaptation to a variety of missions is enhanced if the soldier is freed from performing many procedural tasks or problem solving tasks from learned material. Research and development is needed into technologies that enable the individual to access critical information to support performance. Performance support aids can range from embedding decision functions into systems to developing portable devices such as a maintenance aid that guides a mechanic through troubleshooting and repair procedures. Progress is being made in this area but there are a variety of avenues of research to pursue. Some key research areas are:

(1) Artificially intelligent/expert system performance aids. There is a need for R&D into performance support aids that capitalize on artificial intelligence and expert system technology. Research is ongoing but practical, affordable applications are scarce. To bring this technology to maturity, further exploration may be worthwhile in areas such as: methods to adapt system to user's cognitive style and present knowledge base; efficient methodologies to construct knowledge domains; and design and evaluation criteria. Artificial intelligence and expert system technologies have application potential as training tools, performance support aids, and dual-use applicability in private sector industry and education.

(2) Helmet mounted/helmet visor display system. A mechanism, such as a helmet mounted device, is needed to bring information to individuals for purposes such as a commander's situational awareness or an operator's procedural I guidance in required tasks. R&D is needed to improve physical attributes such as resolution, color reproduction, graphic representation, fusion of multiple sensors, non-interference with other elements of the crew station, etc. More importantly, research is needed to determine where and under what circumstances such devices will enhance performance, whether performance will be degraded or, at best, remain unchanged. The effects of stress, noise platform motion, and other hostile environmental factors while employing such devices must be accounted for, to effectively invest I devices of this nature for training of the battlefield.

(3) Electronic performance support systems. It is likely that the Army, like private industry, will move more away from formal schooling toward the use of electronic performance support systems (EPSS) on the job. R&D is needed to explore the high payoff occupational specialty areas for the development of EPSS, to determine their applicability to Army performance oriented training, and to explore the use of networks (LANs and WANs) for meeting performance support requirements.

TRD04: Train for contingency missions. One consequence of the shift from a threat-based Army to a capabilities-based Army is the need for a flexible and responsive training system to meet various demands. Core competencies trained in schoolhouses and units need to be augmented by "just-in-time" training packages tailored to provide training for the immediate contingency. Diminishing training personnel resources and the increasing need for rapidly designed, developed, and implemented training packages requires innovative methods and tools. Technological advances in the Army's training development system may have important spin-off applications for the nation's education system.

(1) Unit training strategies. For the foreseeable future, Army units will have to be able to train on core combat competencies on a regular basis and be able to supplement those on short notice when likely contingency missions are identified and assigned. This will have to be done in an environment that is increasingly dependent on simulations and other non-OPTEMP consuming training alternatives. Research data is needed to support units in designing effective training strategies using available training resources, time, and personnel, as missions and resource constraints change. This requires information on the effectiveness of TADSS, home-station training, training management systems, and prototype alternative training strategies linked to training time available.

(2) Training design and development and implementation for contingency missions. Training developers need the ability to rapidly develop and configure training for a variety of media that can be exported to geographically dispersed reserve and active components in CONUS, used during pre-mobilization in units, or transported to a theater of operations for immediate use as sustainment or enhancement training. To accomplish this, R&D is needed in media capabilities, expert training development systems, and the potential of linking training developers across services to facilitate joint training design and development. _R&D is also needed to explore the application of distance learning technologies to implementation of "just-in-time" training. Possible R&D topics include the development of portable devices for distance learning (e.g., hand held devices for computer-based training and communications linkages and infrastructure requirements to support distance learning at remote sites both mobile and stationary. A related issue in need of R&D is the use of CD-ROM technology for "just-in-time" training and performance support in the unit. R&D is needed to determine how to design and present materials in ways that are optimal for learning and what training development tools are needed to produce cost effective CD-ROM based "just-in-time" training and performance support systems.

TRD05: Promote Joint, Combined and Interagency Perspective in Training. In the future, the Army will continue to emphasize the importance of joint training exercises to prepare the Army to fight from battalion task force to theater level as a part of a joint/combined force. A force projection Army and rapid deployable forces must be trained in employing maximum fire power capabilities of all forces available to the Commander. A commander may have Army/Marine or multi-national units attached to his command. Training of joint, combined, and multi-national forces can be accomplished economically through simulation in synthetic environments. R&D is needed to: further the development of easily reconfigurable joint/combined force training simulations for use during exercises; and to develop a simulation capability for individual commanders and battle staffs to practice skills on a variety of joint/combined operations scenarios prior to exercises or use on the battlefield. Also, Army training will continue to emphasize the importance of effective communication between joint, combined, or interagency force elements. Research is needed that identifies the best ways to train or aid Commanders to interact effectively with their joint, combined, or other agency counterparts. Finally, out of economic necessity, the future promises closer work between the services to resolve common training problems. The merger of the Services' personnel/training research labs under DoD project Reliance is a major step in this direction. Another likely interservice efficiency will be joint training of select occupations that are common to all the services. Some R&D should be directed at enabling the services to develop and deliver joint training. Specific technologies that require additional research are:

(1) Knowledge regarding training development and delivery issues associated with a DoD-wide training system. Research is needed to explore the feasibility of combining selected training development activities and to identify the training technology and media requirements needed to effect a successful merger. Technologies that require further consideration in this context include interoperable video-teletraining networks; training development expert systems; and multi-media delivery systems. Research should also consider the implications of the "information superhighway" for meeting interservice and interagency training requirements. An early step in this research must be the identification of occupations with a sufficient number of common skill requirements across services to permit joint training development and delivery.

(2) Simulation in synthetic environments. Research in this area is needed to begin immediately integrating other services' resources into battalion and brigade level simulations to train other services combat capabilities. A longer-term goal for research is to develop the ability to construct, on demand, a variety of synthetic environments to conduct joint/service training. ARPA's Advanced Distributed Simulation Synthetic Battlefield Advanced Technology Demonstration I captures this vision for the future in which live, constructive, and virtual simulations will be integrated into a seamless battlefield. Numerous enabling technologies require further work to support these developments, among them: voice-connected speech, digital scanning, optical character recognition, distributed computing, advanced networks, behaviorally accurate SAFOR digitized terrain databases, and graphical 3D displays.

Table C-1. OCR Crosswalk Matrix

Army Modernization Objectives

	Dominate Maneuver	Win Info War	Precision Strike	Protect the Force	Project & Sustain
Battle Command	BC02 BC09 BC04 BC10 BC06 BC12 BC07 BC14 BC08 BC17	All Battle Command OCRs	BC01 BC09 BC02 BC10 BC03 BC13 BC06 BC14 BC07 BC17 BC08 BC20	BC01 BC18 BC06 BC21 BC08 BC22 BC09 BC13 BC17	BC02 BC13 BC04 BC14 BC06 BC18 BC07 BC20 BC09 BC21 BC10
Combat Service Support	CSS05 CSS06 CSS10 CSS12 CSS25	CSS02 CSS03 CSS06 CSS07		CSS01 CSS16 CSS04 CSS17 CSS10 CSS18 CSS11 CSS19 CSS12 CSS21 CSS13 CSS22 CSS14 CSS29 CSS15	CSS02 CSS25 CSS03 CSS26 CSS05 CSS27 CSS06 CSS28 CSS07 CSS22 CSS23 CSS24
Depth & Simult. Attack	DSA07 DSA08 DSA09 DSA10 DSA13 DSA14 DSA19 DSA20 DSA21 DSA22	DSA07 DSA14 DSA08 DSA15 DSA09 DSA16 DSA10 DSA17 DSA11 DSA18 DSA12 DSA19 DSA13 DSA20	DSA01 DSA11 DSA02 DSA12 DSA03 DSA14 DSA05 DSA15 DSA06 DSA16 DSA07 DSA17 DSA09 DSA19 DSA10	DSA01 DSA02 DSA04 DSA05 DSA06 DSA09 DSA14 DSA17 DSA21 DSA22	DSA03 DSA19 DSA21 DSA22
Dismounted Battle Space	DBS01A DBS17 DBS02A DBS18 DBS03 DBS22 DBS11 DBS23 DBS15 DBS24 DBS16 DBS25	DBS03 DBS13 DBS08 DBS14 DBS09 DBS18 DBS10 DBS19 DBS11 DBS20 DBS12 DBS21	DBS05 DBS15 DBS16 DBS20	DBS01A DBS10 DBS03 DBS14 DBS05A DBS07 DBS08 DBS09	DBS11 DBS19 DBS24 DSB25
Mounted Battle Space	MTD01 MTD20 MTD02 MTD22 MTD03 MTD25 MTD04 MTD26 MTD05 MTD27 MTD09 MTD28 MTD11 MTD29 MTD17 MTD30 MTD19	MTD03 MTD23 MTD06 MTD24 MTD07 MTD11 MTD18 MTD19 MTD20 MTD21 MTD22	MTD05 MTD18 MTD19 MTD22	MTD01 MTD14 MTD04 MTD15 MTD07 MTD16 MTD08 MTD17 MTD09 MTD10 MTD11 MTD12 MTD13	MTD25 MTD27 MTS28 MTD29 MTD30
Early Entry Lethality & Surviv.	EEL01 EEL02 EEL04 EEL17 EEL20	EEL06 EEL12 EEL13 EEL14 EEL17	EEL02 EEL05 EEL06 EEL13	EEL01 EEL09 EEL02 EEL10 EEL04 EEL11 EEL05 EEL16 EEL08 EEL26	EEL03 EEL20 EEL12 EEL21 EEL15 EEL22 EEL18 EEL23 EEL19 EEL24

ANNEX D

SPACE, STRATEGIC, AND THEATER MISSILE DEFENSE TECHNOLOGIES

CONTENTS

FIGURES

TABLES

I. INTRODUCTION

Several recent exercises have clearly shown the growing importance of Space and Missile Defense operations to joint warfighters. USASSDC is the Army's lead command to ensure soldiers, today and in the future, have the best space and missile defense capabilities in the world.

LTG Edward G. Anderson III

The U.S. Army Space & Strategic Defense Command (USASSDC) develops capabilities to support the Missile Defense and related DoD Space Programs objectives. The USASSDC goals and objectives continue to evolve as the environment in which we live demands a re-evaluation of the strategy for the Command. What does not change is the vision of the organization, which calls for continued improvements to our process "to meet the challenge given the turbulent world environment, of providing into the next decade effective, affordable, and high quality technology solutions for Space, Theater, and National Missile Defense."

The environment, the Command's vision, and customer demands resulted in the following USASSDC goals:

1. Provide near-term technology to support a Theater Missile Defense (TMD) deployment between 1997-2000 and beyond.
2. Provide technology to develop and maintain the option to deploy a cost-effective, operationally effective, and ABM treaty compliant system designed to protect the United States against limited ballistic missile threats, including accidental or unauthorized launches or third world attacks.
3. Execute the Ballistic Missile Defense Organization (BMDO) Research and technology missions.
    - Maintain a prudent research and technology base program towards developing a more advanced Ballistic Missile Defense (BMD).
    - Serve as the Army focal point for Missile Defense technology.
    - Provide responsive program support and infrastructure.
4. Maintain USASSDC as the Center of Excellence in space and missile defense.
5. Develop and operate the USASSDC Missile Defense Battle Integration Center (MDBIC) to accomplish the Army TMD (ATMD) four-pillar integration (active defense, passive defense, attack operations, and Battle Management/

Command, Control, Communications, Computers, and Intelligence (BMC4I)).

6. Provide the targets and test and evaluation support for BMD programs.
7. As the Army advocate for Space, TMD, and National Missile Defense (NMD), USASSDC provides technology and advanced system(s) concepts to support combat development, operations, and training for BMD.
8. Manage Kwajalein Atoll, an element of the DoD Major Range and Test Facilities Base, and the High Energy Laser Systems Test Facility (HELSTF) in support of customer requirements.
9. Serve as the Army component of the U.S. Space Command.
   - Operate and manage the Army Space Program Office (ASPO) Tactical Exploitation of National Capabilities (TENCAP) programs.
   - Operate the DSCS Ground Stations.
   - Act as the Army proponent for space products.
   - Operate the ground-based component of the NMD when deployed.
10. Transfer technologies to the Army, DoD, other government agencies (federal, state, and local), and commercial activities.
11. Provide technology and management matrix support to the Program Executive Office Air & Missile Defense (PEO AMD).
12. Improve management and cost effectiveness.

The priorities of the Command are to provide America's warfighters with over-matching capabilities to dominate all dimensions of the battlefield in the following areas:

1. *Theater Missile Defense* (TMD): protect friendly forces against theater ballistic missiles.
2. *National Missile Defense* (NMD): rapidly field a treaty compliant U.S.-based missile defense system.
3. *Space*: provide timely, responsive, reliable space capabilities and products for battlefield domination.

From its headquarters in Arlington, VA, USASSDC oversees a number of Army elements around the globe to accomplish its challenging mission. Huntsville, AL, is the home of the Deputy Commander, the Missile Defense and Space Technology Center (MDSTC), and the Missile Defense Battle Integration Center (MDBIC). Other elements of the Command are: the U.S. Army Space Command (USARSPACE) located in Colorado Springs, CO; the U.S. Army Space Program Office (ASPO), located in Fairfax, VA; U.S.

Army Kwajalein Atoll/Kwajalein Missile Range (USAKA/KMR) located in the Republic of the Marshall Islands; and the HELSTF located at White Sands Missile Range, NM.

This annex emphasizes DoD funded, Army managed programs and provides leveraging opportunities into other Army Programs. The annex provides an overview of the Army PEO AMD system elements and the associated USASSDC technology programs supporting these elements. Supporting capabilities and technology transfer are also discussed. For more information regarding any of the systems, technologies, or capabilities in this annex, contact Mr. Troy Street (USASSDC-MDSTC) at (205) 955-5209.

II. TECHNOLOGY TRANSITION

A. Systems/System Upgrades

Systems and system upgrades focus on defining critical design characteristics, addressing manufacturing technological deficiencies, and assessing production feasibility. Analysis, simulation models, or prototypes are used to optimize design and resolve problems. Also included is the design, fabrication, testing, and evaluation of a complete system. This includes the principal items necessary for its production, operation, and support; and serves to validate the production process. Reliability and maintenance design, testing, and evaluation of components should also be integrated.

The USASSDC continues to provide research and technology matrix support to these program elements through the USASSDC MDSTC, located in Huntsville, AL. The USASSDC MDBIC will accomplish the Army TMD four-pillar integration (Attack Operations, Active Defense, Passive Defense, BM/C4I) for the Army TMD Advocate.

1. Theater Missile Defense Systems

The overall mission of the U.S. Army's Theater Missile Defense (TMD) program is to protect deployed U.S. forces, U.S. allies, and other important countries, including areas of vital interest to the United States, from threat theater missile attacks. The theater missile threat includes tactical ballistic missiles (TBMs), cruise missiles (CMs), unmanned air vehicles (UAVs), remotely piloted vehicles (RPVs), tactical air-to-surface missiles, and anti-radiation missiles (ARMs).

Primary to meeting the TMD program mission, TMD systems support the four operational TMD pillars (attack operations, active defense, passive defense, and BM/C4I) defined by the Joint Chiefs of Staff TMD Mission Need Statement (June 1991) and JCS Pub 3-01.5, *Doctrine for a Joint Theater Missile Defense* (30 March 1994). Below are brief descriptions of the major TMD systems that are supported by USASSDC. For more detailed information regarding TMD systems, refer to USASSDC's *Theater Missile Defense Primer* (April 1996) and the *Army Modernization Plan.*

Theater High Altitude Area Defense (THAAD) System

The THAAD is the Army's upper tier system that will protect wide areas, dispersed assets, and population centers against theater ballistic missile attacks. Its hit-to-kill technology will provide high lethality against a broader range of threat missiles. THAAD will be interoperable with both existing and future air defense systems and other external data sources.

The THAAD system consists of the missile and kill vehicle; truck mounted launchers; radar; and Battle Management Command, Control, and Communications (BMC3I). The mobile launcher will protect and transport the interceptor, in addition to firing them. Interceptors will consist of a missile round and a kinetic kill vehicle that will destroy targets by using hit-to-kill technology. The THAAD radar will provide surveillance, target tracking, and fire control, and provide a communication link with in-flight THAAD interceptors. The radar will also be able to classify missile threats and cue interceptors from other BMD systems in the theater. The BMC3I will manage and integrate all THAAD components by providing instructions, communications, and by processing and fusing sensor data. It will also link the THAAD system to other missile and air defense systems. THAAD completed its final design review in May 1994 and is currently in Demonstration/Validation. Following completion of all necessary flight tests, a prototype THAAD User Operational Evaluation System (UOES) is scheduled for availability in FY99 with first unit equipped projected for FY06.

Objectives	Capabilities
• Defeat tactical theater ballistic missiles • Upper tier of two tiered defense • Capable of both Endo- & Exo-atmospheric intercepts	• Upper tier wide area defense against TBMs • Endo/Exo-atmospheric intercepts • Hit-to-kill lethality • Rapidly deployable by C-130 • Infrared (IR) seeker for terminal guidance • Upper/lower tier cueing • Cueing to other systems • Modular • Early warning threat • Fire Control

PATRIOT Advanced Capability–3

The PATRIOT is a long-range, mobile, fielded Army air defense system, which uses guided missiles to simultaneously engage and destroy multiple targets at varying ranges. The PATRIOT Air Defense Missile System is undergoing a total system upgrade program known as PAC-3 and will be the lower tier of a two-tier active theater missile defense. The PAC-3 will enhance PATRIOT's capability against TBMs as well as current and future Air Breathing Threats (ABTs) (advanced manned aircraft, cruise missiles, and pilotless vehicles).

The PAC-3 system consists of a radar set, an Engagement Control Station (ECS), a launching station, and interceptors. The radar station provides warning and tracking of incoming threats. It also provides a continuous update link with in-flight interceptors. Radar upgrades will improve its multifunction capabilities, low altitude performance, TBM detection, performance in the presence of clutter, and will double the average power capability of the current transmitter. Communications upgrades will improve the dissemination of digital data and voice transmissions and provide a communications link to the TMD architecture. The ECS computes fire solutions for the interceptor, provides fire control, and provides a communications link with other PATRIOT units. The ECS is the central nervous system of PAC-3 operations. Control station upgrades automate intelligence and operations planning functions, as well as convert to common computer hardware. The launch station transports, protects, and launches the missiles. The PAC-3 missile uses its high maneuverability and hit-to-kill accuracy to destroy its target in a catastrophic collision. The PAC-3 Missile improves PATRIOT's capability to counter advanced, high-speed TBM threats and provides a design capability against low radar cross section ABT targets in all operational environments. Significant upgrades will improve PATRIOT by FY99.

Objectives	Capabilities
• Provide system enhancements that fully respond to PAC-3 ORD requirements and STAR threat • Incrementally satisfy ORD requirements through phased fielding of system enhancements • Demonstrate improved capability against air breathing and TBM threats • Initial fielding of PAC-3 in Late FY99	• Hit-to-kill • Lethality enhancements • Lower tier point/limited area defense against TBMs and air breathing threats • Increases the number of missiles from 32 to 56 with two PAC-3 launcher stations • Designed to allow for an increase in the number of missiles from 32 to 68 using three PAC-3 launcher stations per fire unit • ECS can control up to four PAC-3 launchers • Radar and software upgrades • Rapidly deployable by C-130 • Remote launch • C-band semi-active track-via-missile guidance • Active Ka-band dual mode MMW seeker for terminal homing • Lightweight-agile • High firepower • Upgraded PATRIOT radar • Fast response attitude control motors

Corps SAM/Medium Extended Air Defense System (MEADS)

By FY05, The Corps SAM/MEADS Program will develop a new mobile air and missile defense system that will protect Corps critical assets and maneuver forces against tactical ballistic missiles (TBMs), cruise missiles, unmanned aerial vehicles, tactical air-to-surface missiles, anti-radiation missiles, and fixed- and rotary-wing aircraft. Corps SAM/ MEADS will be the critical lower tier component of the active defense pillar and is envisioned as the future centerpiece of the Army Corps Air and Missile Defense. The Corps SAM/MEADS will require half the air lift of PATRIOT, providing greater protection for early entry forces. The system will consist of a sensor, launcher, missile, and Tactical Operations Center (TOC), and will be capable of stand-alone operational capability. The system will be compatible/interoperable with other Army AD systems (i.e., THAAD, PATRIOT PAC-3, and FAAD) and will interface with joint and allied sensors and BM/C4I networks.

Objectives	Capabilities
• 360 degrees protection against TBMs, CMs, and other ABTs • Transportability consistent with protection of Maneuver Force • Highly survivable and operationally versatile distributed architecture • High firepower with low manpower and low airlift	• Lower tier point/limited area defense against TBMs and ABTs • Highly mobile • Rapidly deployable by C-130 • 360-degree coverage • Netted-distributed architecture • Compatible/interoperable • High firepower-rapid reload

Joint Tactical Ground Station (JTAGS)

The JTAGS links strategic sensor information directly to theater (field army/ corps/division) terminals to provide early warning, cueing, and targeting data to support the pillars. JTAGS is critical to theater operations in that it provides the essential information to enhance active defense, passive defense, and attack operations. A P3I program is currently under development to support future space-based IR systems.

Objectives	Capabilities
• Field joint tactical ground stations to provide in-theater real time tactical warning, alerting and cueing information • Use direct down-link from DSP and follow-on space-based sensors	• Exploits space-based IR data • Real-time, in-theater use • Tactical network interface

Advanced Concept Technology Demonstration (ACTD)

The **Tactical High Energy Laser (THEL)** weapon system concept is a mobile, high energy laser weapon that uses proven laser beam generation technologies, proven beam pointing technologies, and existing sensors and communication networks to provide a bold new active defense capability in counter air missions against current threats that are proliferating throughout the world. The THEL can be integrated into the short- to medium-range air defense architecture to provide an innovative solution not offered by other systems or technologies for the acquisition and close-in engagement problems associated with these type of threats, thereby significantly enhancing the defensive coverage to combat forces and theater level assets. The THEL low cost per kill (a few thousand dollars per kill or less) will also provide a very cost-effective defense against low cost air threats.

A joint U.S.-Israeli program has been initiated to develop a THEL demonstrator utilizing deuterium fluoride chemical laser technologies. Approximately 21 months will be required to design and build the system, followed by 12 to 18 months of field testing at the High Energy Laser Systems Test Facility and in Israel. This program will deliver a THEL Demonstrator with limited operational capability to defend against short-range rockets by March 1998. Future development of a User Operational Evaluation System (UOES) interim configuration using advanced laser technologies for use in contingency operations is also planned, based on the results of ongoing THEL concept definition studies and dependent upon availability of outyear funding.

On 18 July 1996, a Memorandum of Agreement (MOA) between the United States and the State of Israel was signed initiating the cooperative THEL Demonstrator Advanced Concept Technology Demonstration (ACTD). On 23 July 1996, a sole source contract was awarded to TRW, the THEL Demonstrator prime contractor. The U.S. and Israeli THEL team members have completed a Concept Design Review (CoDR) in Israel for the demonstrator. The U.S. Army Air Defense Artillery School (USAADASCH) is planning to develop a Mission Needs Statement (MNS) and an Operational Requirements Document (ORD) for the UOES interim configuration. THEL weapon system concept definition studies using advanced technologies were awarded to four contractors on 30 September 1996 to support planning for the UOES interim configuration.

The **Depressed Altitude Guided Gun Round (DAGGR)** weapon system concept leverages mature radar and projectile technologies into an advanced, highly mobile (C-130 transportable) defensive system.

Operationally, DAGGR will provide an on-the-move rapid response air defense system to provide 360 degree threat search, perform acquisition/tracking of targets, conduct non-cooperative identification, and provide command guidance to perform hit-to-kill intercepts. An Advanced Concept Technology Demonstration will consist of a series of field experiments of increasing difficulty to assess the ability to negate the stressing threat.

The **Joint Aerostat Program** came into existence when the Army tasked the U.S. Army Space and Strategic Defense Command to set up a joint-service project office to develop the Defense Department's first priority element for defense against land attack cruise missiles. The Joint Aerostat Project Management Office for Cruise Missile Defense was set up in February 1996 by USASSDC MDSTC to develop an aerostat that can provide both surveillance and fire control for defense systems such as the Army's Patriot PAC-3 and the Navy's SM2 missile that can shoot down cruise missiles.

An aerostat is a large, unpowered balloon moored to the ground by a long cable. From its position above the battlefield, an aerostat-based sensor will allow incoming cruise missiles to be detected, tracked, and engaged by surface-based air defense systems even before the targets can be seen by the systems usual radars. Aerostats have several characteristics which may make them especially suited to cruise missile defense. They are less expensive to buy and operate than comparable fixed-wing aircraft. This makes them the most affordable alternative for achieving a near-term cruise missile defense. They can stay aloft up to 30 days at a time providing 24-hour per day coverage over extended areas.

The internal pressure of an aerostat is about the same as the exterior pressure. This makes them extremely difficult to shoot down. These balloons can absorb lots of punctures before they lose altitude. When they do, they come down so slowly that they can be reeled in, repaired easily, and sent right back up. In the long term, aerostats would complement fixed-wing aircraft performing a similar mission, and this will provide the United States more robust and flexible cruise missile defenses. Mooring systems for large aerostats covering major portions of a theater of operations would probably be relatively permanent. For short- or medium-range surveillance and fire control, aerostats would be smaller and the mooring systems could be transportable or ground-mobile. Currently, the program plans to issue multiple concept definition contracts and then down-select to a single contractor for development. In parallel to the concept studies, an Army aerostat testbed has been established at Fort Bliss, Texas, using off-the-shelf equipment.

A concept called the **Air Defense Tactical Operations Center (ADTOC)** is being developed that will incorporate Air Defense/Theater Missile Defense force operations (FO) and engagement operations (EO) functions into a single Command, Control, Communications, and Intelligence (C3I) system. The Army Air Defense Artillery (ADA) objective for C3I is a standard, modular, and interoperable system that integrates FO and EO functions into a common ADTOC. Different configurations of the ADTOC will interface with and eventually replace existing ADA TOCs, command posts, fire control centers, and fire control systems. Any new system developed for the Air Defense Battlefield Operating System will use the ADTOC as its C3I system at all echelons of employment. The ADTOC will support FAAD, high-to-medium air defense systems (i.e., PATRIOT, HAWK, Corps SAM), anti-tactical ballistic missile systems (i.e., THAAD), and other systems that are assigned to the Air Defense Battlefield Operating System.

Selected Technology Demonstrations

To achieve the required operational capabilities, a balanced materiel development and demonstration strategy must be followed which includes technology initiatives in advanced focal plane arrays, data fusion, micro-electronics, ladar technologies, simulations and testbeds for battle planning and rehearsal, survivability and lethality assessment, endo- and exoatmospheric hit-to-kill vehicles, directed energy weapons, new materials and structures for lightweight, low-signature vehicles and airframes; and a unit-oriented training architecture that fully exploits the material capability. Selected key near-term technology demonstrations that will lead to the modernization of TMD systems are shown in Table D-1 and summarized below.

Table D-1. Theater Missile Defense Demonstration and System Summary

ATDs/ACTDs	Selected Technology Demonstrations
• ATDs (Advanced Technology Demonstrations) do not currently exist for the Army Strategic Defense Program • Tactical High Energy Laser (THEL)	• TMD Critical Measurements Program (TCMP) • Kill Assessment Program • Real-Time Discrimination Program • Advanced Sensor Technology Program (ASTP • Anti-Radiation Missile (ARM) and Smart Weapon Countermeasures • InSb (Indium Antimonide) FPA Technology improvements
Systems/Advanced Concepts	
Systems	***Advanced Concepts***
• Theater High altitude Defense (THAAD) • PATRIOT Advanced Capability-3 (PAC-3) • Corps Surface-to-Air-Missile (SAM)/Medium Extended Air Defense System (MEADS) • Joint Tactical Ground Station (JTAGS)	• Depressed Altitude Guided Gun Round (DAGGR) • Air Defense/TMD Operation Center (ADTOC) • Joint Aerostat Program

Advanced Sensor Technology Program (ASTP) (95-02). Evolving threats such as maneuvering Reentry Vehicles (RVs), penetration aids, and precision decoys require enhancement of current discrimination capabilities. The ASTP is initiated to improve sensor system performance and enhance discrimination robustness. The approach to achieving enhanced discrimination capability is to fuse multiple sensor data to obtain an optimum identification and to take advantage of the different target feature information available from each sensor. For example, target discrimination can be significantly improved by fusing the temperature/emissivity area data obtained with a passive IR sensor and the spatially resolved signature available with a ladar. This program will develop the technology base to permit the next generation of smart, fused, adaptable sensors to be fielded.

The two areas of focus are integration/demonstrations and sensor technology. In the integration/demonstration area, the objective is to perform a detailed analysis to quantify the benefits of fused sensors and define the sensor requirements for various platforms and applications. This analysis will be the basis for establishing component and system performance goals. Additionally, program demonstrations will be defined to facilitate program focus and permit measurement of progress. Also, it will be proposed to provide a versatile test bed, based on the Rapid Optical Beam Steering (ROBS) design, to permit integration and evaluation of sensors developed in this program. These efforts will be supplemented with registered, fused sensor measurements made at the Army Missile Optical Range (AMOR). **Supports:** THAAD, ADTOC.

Anti-Radiation Missile (ARM) and Smart Weapons Countermeasures (93-02). The ARM/Smart Weapons Countermeasure Analysis program investigates and tests techniques to increase radar survivability by camouflage, concealment and deception technologies, inherent electronic countermeasures, adjunct electronic countermeasures, ballistic hardening techniques, and active interdiction measures.

The USASSDC has developed the ARM countermeasures evaluator (ACE) to evaluate radar ECCM techniques to defeat the ARM threat. The ACE is located at the Huntsville Advanced Research Center (ARC) where RF signals replicating a radar's transmitted wave form are directly injected into actual ARM guidance and control microwave circuitry. By repeated closed loop missile in flight simulations, the ARM's susceptibility to various signal processing techniques can be determined and the radar's vulnerability reduced accordingly. **Supports:** THAAD, PATRIOT PAC-3, ADTOC.

Kill Assessment Program (94-99). The objective is to collect, obtain, and analyze data, and to develop algorithms using that data which will support rapid and accurate kill assessment in an operational TBM defense system. Under this task, data from lethality sled tests and WSMR intercepts will be collected and analyzed. Application of this data will be made to TBM scenarios and candidate kill assessment algorithms will be developed and analyzed. Plans are in place and preliminary data tapes have been received from several of the WSMR radars and optical sensors. Plans are in place for collecting radar and blast wave data on upcoming sled tests. Correlation between the effectiveness (lethality) of the engagement and properly calibrated observational data is crucial to the development of candidate kill assessment algorithms. A judicious selection of tests to be observed (or performed) will be necessary to collect representative data for the broadest range of threats and engagement results. In FY97, the most significant part of the program will focus on preparing for and analyzing THAAD intercepts. These are the most relevant tests and it is important that data from a variety of sensors be collected and analyzed to permit development and testing of kill assessment techniques. **Supports:** THAAD, ADTOC.

InSb (Indium Antimonide) FPA Technology Improvements. An InSb FPA was selected for the alternative seeker for the THAAD program as it offers significant sensitivity improvements for subsystem/system risk mitigation. The InSb seeker has not yet been selected as the baseline seeker because there are still serious concerns about stability of the correction coefficients and the successful application of GD-AOC.

The THAAD InSb seeker as currently designed uses a gimbal dithered active offset correction GD-AOC approach as the InSb baseline operating mode. However, a single point correction technique has been designed for the seeker as a backup mode of operation. The active correction technique provides known stability of the passive correction coefficients with temperature cycles and time. Further understanding of the stability of the InSb FPA may allow us to directly transition to our backup mode for WSMR testing in case GD-AOC performance issues (not known to date) are not cost or schedule effective to correct.

The primary focus will be on non-uniformity stability. Ten InSb FPAs will be fabricated for this testing. Ten individual dewars will be procured to allow longer term testing form each FPA. The physical properties that cause uniformity variations and their elimination will be studied for longer term effects and documentation. Changes in non-uniformity with number of cool-down cycles as well as change predictability will also be evaluated. **Supports:** THAAD, ADTOC.

Real-Time Discrimination Program (87-02). This program seeks to develop integrated real-time discrimination algorithms/architectures that can be utilized by elements of future BMD systems. In order to achieve this goal, the Lexington Discrimination System (LDS) has been developed to provide an environment in which discrimination algorithms/architectures can be evaluated in real time using field measurement data. The program consists of: (1) development of radar discrimination algorithms, (2) maintenance and upgrade of the LDS Test-Bed, (3) conversion of radar and optical algorithms to real time program format, (4) evaluation/validation of real-time algorithms on the test-bed, (5) combination and interface of algorithms into discrimination architectures and statistical evaluation of various architecture configurations, (6) examination of field data to discover new, useful discrimination phenomenology, and (7) investigation of promising discrimination techniques. This program is the culmination of over 20 years of discrimination research and currently has over 30 operational real-time active and passive algorithms and two active algorithm architectures available on the LDS Test Bed. The real-world experience and insights gained through study and development of discrimination techniques using real data in a completely causal manner will provide the foundation for future discrimination solutions. **Supports:** THAAD, ADTOC.

Theater Missile Defense Critical Measurements Program (TCMP) (92-99). The objective of TCMP is to reduce TMD weapon system risks with sensor data collection that addresses functional performance/algorithm robustness and to characterize potential theater countermeasures. The TCMP will launch a series of sub-orbital flights with theater type target vehicles, which will be observed by various optical and radar sensor platforms. The program will address critical TMD discrimination issues, characterize potential theater countermeasures, analyze data, and develop discrimination concepts and algorithms for proposed TMD systems. The program started in 2Q FY92 with the first two launches conducted in 2QFY93. The program will continue to FY99 and will address TMD system requirements that are traceable to PATRIOT, AEGIS, and THAAD Radar. TCMP launches were successfully conducted in July 1996. Another launch is scheduled for FY97. **Supports:** THAAD, PATRIOT PAC-3, ADTOC.

It is important that air defense modernization and related technology base program efforts exhibit a linkage with modernization plans in other Mission Areas. This linkage is important for decision makers when prioritizing all of the Army's modernization efforts. Figure D-1 portrays the linkage of air defense S/ACs and other modernization plans.

	THEATER MISSILE DEFENSE SYSTEMS/ADVANCED CONCEPTS	MODERNIZATION PLAN ANNEXES					
		Missile Defense	Air Defense	Space	IEW	C4	Fire Support
Systems	Theater High Altitude Area Defense (THAAD)	●	●	○	○		○
	PATRIOT Advanced Capability-3 (PAC-3)	●	●		○		○
	Corps SAM / MEADS	●	●		○		
	Joint Tactical Ground Station (JTAGS)	●	●	○		○	●
Advanced Concepts	Air Defense/TMD Operation Center (ADTOC)	●	●			○	
	Tactical High Energy Laser (THEL)	●	●				●
	Aerostat	●	●				●
	Depressed Altitude Guided Gun Round (DAGGR)	●	●				●

● System plays a significant role in the Modernization Plan.
○ System makes a contribution to the Modernization Strategy.

Figure D-1. Correlation Between TMD S/ACs and Other Army Modernization Plan Annexes

2. National Missile Defense

A U.S. Defense Acquisition & Technology Memorandum dated 9 April 1996 designated National Missile Defense (NMD) an ACAT 1D program and directed BMDO to form a Joint Program Office.

The NMD program will focus on achieving and maintaining technical readiness and reduce the time it would take to field a BMD system in response to emerging Intercontinental Ballistic Missile (ICBM) threats to the United States. This section describes the major NMD elements managed within the Army, which include a Ground-Based Interceptor (GBI); a Ground-Based Radar Prototype (GBR-P); and Battle Management, Command, Control, & Communications (BMC3). USASSDC continues to provide research and technology matrix support to these system elements.

Near-Term Objectives

- Develop test elements of initial NMD System within three years
- Conduct integrated system test at USAKA in FY99
- Conduct EKV sensor/interceptor flight tests at USAKA in FY97-99
- Support capability to deploy within three years of decision

The **GBI** element is developing, demonstrating, and validating the technology and components for a state-of-the-art, low cost, lightweight, non-nuclear hit-to-kill missile to intercept and destroy enemy Intercontinental Ballistic missiles during the midcourse phase of flight. The current focus of GBI includes the Exoatmospheric Kill Vehicle (EKV) and the Payload Launch Vehicle. EKV seeker fly-by tests are planned for FY97 to demonstrate seeker operation in the actual engagement environment and reduce risks for subsequent intercept flight tests.

The **GBR-P** is a solid-state X-Band phased array radar that will resolve the critical technology issues associated with development and deployment of a NMD-GBR and to provide the primary fire control sensor to support integrated NMD system testing. The critical issues include discrimination, target object map, kill assessment, and electromechanical scan. The GBR-P development will leverage off the ongoing THAAD Demonstration/Validation Radar Program and includes algorithm development, real-time software, and hardware-in-the-loop simulations. The GBR-P software development will modify and expand on software common with the THAAD Radar and incorporate unique NMD requirements for resolution of NMD-GBR technology issues.

The **BMC3** element provides the overall Site-Level command and control required for coordinated integrated planning and execution of NMD operations. The BMC3 is a distributed system consisting of processors, software, man-machine interfaces, and communications media. It is built on an open system framework that will use, where possible, existing hardware and software. As a result, the BMC3 element will adapt to various threats, NMD architectures, contingency deployment options, and evolving operational requirements. The main objectives of the BMC3 element are to develop prototypes to validate the necessary Site-Level command and control structure, to develop the communications architecture for all of the information flows for the NMD system, and to serve as the vehicle for NMD system integration.

A concept known as the U.S. Army's **Kinetic Energy Anti-Satellite (KE ASAT)** program is intended to provide the United States with the capability to interdict hostile satellites. The KE ASAT consists of missile and weapon control subsystems. The major components of the missile subsystem are the booster, kill vehicle, shroud, and launch support system. The weapon control subsystem is composed of a battery control center and a mission control element which performs readiness and engagement planning, command and control.

The military advantage provided to potential enemies by space systems is no longer a future or potential threat. It must be considered a fact of life today. The work done by both the Army and the Air Force on the KE ASAT program has laid the technical foundation for a viable contingency operational capability.

3. Space

For information on the exploitation of space assets, capabilities, and products, refer to Volume I, Chapter III, Section Q, of the ASTMP.

III. TECHNOLOGY DEVELOPMENT

The general objective of the technology programs is to develop and maintain a technology base and a research capability which supports functional performance requirements of theater defense and missile defense systems for BMDO and PEO AMD. The USASSDC has a long history of technology development to support future projects and reduce project risk.

A. Missile Defense and Space Technology Center (MDSTC); Huntsville, AL

The MDSTC manages technology base research and development for the BMDO and provides significant technical support to the Army PEO-AMD. The Center also supports Army space requirements.

These technology programs are being developed to support the missile defense technology base. The programs will be coordinated and integrated as needed with other Army technology base programs. These technologies can provide a significant contribution to future Army space requirements which include: communications; Reconnaissance, Surveillance, and Target Acquisition (RSTA); fire support; position location, and navigation; and computational sciences for the Army in Space. The MDSTC continuously supports these programs to capitalize on technology opportunities, reduce technology barriers, and exploit emerging technology options for essential defensive capabilities in current and future missile defense and theater missions.

1. Advanced Technology Directorate

The Advanced Technology Directorate (ATD) plans and conducts highly innovative high-risk Research and Development (R&D) in technology areas which cannot be readily integrated into the MDSTC projects and directorates, but whose payoff would be absolutely essential to the fulfillment of the Command's mission. This R&D is coordinated through the Small Business Innovative Research (SBIR), Innovative Science and Technology, and Small Business Technology Transfer (STTR) programs. They also plan and conduct a long-term basic science program with relevance to the Center's projects and programs, and provide needed expertise to solve significant technical problems in all of the Center's projects and programs. This also includes materials and structures, power technology development for strategic defense, information processing, computer technology, and communications technology. The directorate currently is exploring acousto-optical processing, laser satellite communications, radar range-doppler images, and innovative threat destruction mechanisms.

2. Sensors Directorate Technologies

The Sensors Directorate plans, formulates, and executes the Center's exploratory research advanced technology developments, the technology validation of passive and active sensors, microelectronics, and discrimination concepts in support of the U.S. Army and BMDO, TMD, NMD, and Air Defense Initiative objectives. The Sensors Directorate also operates the Center's sensor systems in support of TMD demonstration/validation (DEM/VAL) tests, NMD technology demonstrations, and joint forces integration exercises. Data collected provides weapon system performance validation, target signatures for algorithm development, and event characterization. The Sensors technology programs emphasize, but are not limited to, optics, radar, ladar, discrimination, radiation hardening, and the AST.

Endo- and exoatmospheric missile defense regimes require sensors that cover both the infrared optical and radar spectra, as well as uniting the two in a laser radar or ladar. Research and development of the following advanced components is ongoing:

- *Optics*—National calibration standards, modeling, and improved hardened components are being developed.

- *Ladar*—Small, lightweight, high performance laser components are under development for preplanned product improvement of the ground-based interceptor to provide smart interceptor capability.
- *High-Performance Microelectronics*—Nonvolatile memories, static random access memories, analog-to-digital converters, and precision voltage references are being improved and hardened to withstand the rigors of space and nuclear weapon radiation.

A complementary sensor suite on a variety of platforms operated by the Directorate provides a full range of infrared, radar, visual, and interferometer/spectrometer coverage to meet user requirements.

- *Airborne Surveillance Testbed* provides three-band long wave, infrared data at extended range and real-time data processing and handover.
- *High Altitude Learjet Observatory/Infrared Instrumentation System* aircraft supports close-in imaging with the flexibility of accommodating different sensor configurations.

The Directorate also supports Army involvement in the Ballistic Missile Defense Organization's Midcourse Space Experiment effort to demonstrate space-based sensor technologies and establish a sensor fusion database. The Theater Missile Defense Critical Measurements Program will acquire data and answer key phenomenology questions on threat-like TMD targets.

Data are predicted, simulated, collected, analyzed, interpreted, archived, and disseminated by the Sensors Directorate. Results are incorporated into algorithms and architectures used by the missile defense community.

- *Optical Signature Code* is the standard for predicting and simulating target signatures and guiding analysis of results.
- *Optical Data Analysis Center* brings together a host of expertise, software, and computer hardware to perform analyses of ballistic missile defense and theater missile defense data, show its utility to defense systems, and research advanced information technology applicable to missile defense.
- *Missile Defense Scientific and Technical Information Center* serves as the central repository for Ballistic Missile Defense Organization test, measurement, and experiment data. It archives and disseminates data collected for national and theater missile defense requirements.

AEROSTAT Office

The Army tasked the U.S. Army Space and Strategic Defense Command to set up a joint-service project office to develop the Defense Department's first priority element for defense against land attack cruise missiles. The Joint Aerostat Project Management Office for Cruise Missile Defense was set up in February 1996 by USASSDC MDSTC to develop an aerostat that can provide both surveillance and fire control for defense systems such as the Army's Patriot PAC-3 and the Navy's SM2 missile that can shoot down cruise missiles.

An aerostat is a large, unpowered balloon moored to the ground by a long cable. From its position above the battlefield, an aerostat-based sensor will allow incoming cruise missiles to be detected, tracked, and engaged by surface-based air defense systems even before the targets can be seen by the systems' usual radars. Aerostats have several characteristics which may make them especially suited to cruise missile defense. They are less expensive to buy and operate than comparable fixed-wing aircraft. This makes them the most affordable alternative for achieving a near-term cruise missile defense. They can stay aloft up to 30 days at a time providing 24-hour per day coverage over extended areas.

The internal pressure of an aerostat is about the same as the exterior pressure. This makes them extremely difficult to shoot down. These balloons can absorb lots of punctures before they lose altitude. When they do, they come down so slowly that they can be reeled in, repaired easily, and sent right back up. In the long term, aerostats would complement fixed-wing aircraft performing a similar mission, and this will provide the United States more robust and flexible cruise missile defenses. Mooring systems for large aerostats covering major portions of a theater of operations would probably be relatively permanent. For short- or medium-range surveillance and fire control, aerostats would be smaller and the mooring systems could be transportable or ground mobile. Currently, the program plans to issue multiple concept definition contracts and then down-select to a single contractor for development. In parallel to the concept studies, an Army aerostat testbed has been established at Fort Bliss, Texas, using off-the-shelf equipment.

Space Applications

A Space Applications and Technology Office was established in 1995 to encourage leverage of space-related technologies off of work already ongoing or planned in the technical community to ensure state-of-the-art support for the warfighter. The office is working on sensors, communications technologies, unmanned aerial vehicle applications, compact radiation-hardened processors, intelligent processing, and control of space and is the lead agency on three of the Army's top 200 science and technology objectives.

The Space Applications and Technology Office's goal is to provide superior capabilities to the warfighter through the exploitation of space-related technologies. This office plays a vital role in ensuring that the Army warfighter has those state-of-the-art space-related capabilities available for use by leveraging billions of dollars off work already ongoing or planned in the technical community.

The office works in the areas of, but is not limited to, sensors, communications technologies, unmanned aerial vehicle applications, compact radiation hardened processors, intelligent processing, and space control.

3. Weapons Directorate Technologies

The Weapons Directorate develops and demonstrates technologies required for kinetic energy weapons, directed energy weapons, structures, and materials and conducts lethality and vulnerability analysis of various threat objects.

The directorate has been highly successful in transitioning technology into the Army acquisition system through the Army PEO AMD, including the THAAD and PAC-3 programs. It also developed the cooperative U.S.-Israeli Arrow missile program for the PEO's management.

Kinetic energy weapons destroy incoming enemy targets with non-nuclear, direct hit-to-kill intercepts of strategic and tactical ballistic missiles in (endoatmospheric) and out (exoatmospheric) of the atmosphere. Key kinetic energy weapon projects include the following:

- The U.S. Navy has selected the SSDC-managed LEAP (Lightweight Exo-Atmospheric Projectile) kill vehicle for use in its Upper Tier.
- The Atmospheric Interceptor Technology (AIT) program will develop, integrate, and demonstrate high performance lightweight interceptor technology for hypersonic flight within the atmosphere.
- The U.S. Army's Kinetic Energy Anti-Satellite (KE ASAT) program will provide the United States with the capability to interdict hostile satellites, preventing enemy space-based surveillance and targeting of U.S. battlefield assets.
- The DAGGR (Depressed Altitude Guided Gun Round) program is developing a radar-guided, hit-to-kill projectile capable of fast, accurate, all-weather

interdiction of point defense threats, such as air-to-ground missiles, short-range rockets, unmanned aerial vehicles, and cruise missiles.

The Weapons Directorate is also pursuing high energy lasers to contribute to the development of space-, aircraft-, or ground-based weapons capable of killing boost and post-boost reentry vehicles, cruise missiles, and other airborne tactical targets.

- The THEL (Tactical High Energy Laser) offers a cost effective, speed of light, continuous kill capability against multiple, low signature, maneuvering tactical threats. Anywhere it can track it can kill. High energy laser effectiveness tests have demonstrated significant capability against the evolving air threat, using realistic targets and timelines.

The Weapons Directorate conducts extensive lethality testing in order to provide real-time user support to weapon developers and missile defense architecture planners. They develop, validate, and maintain a systems-level lethality-prediction-criteria data base and conduct model, full-scale laboratory, sled, and flight tests. The scale model tests use light gas guns at Arnold Engineering Development Center, Naval Research Laboratory, University of Alabama in Huntsville, and the Army Research Laboratory. Hit-to-kill sled tests at Holloman Air Force Base, NM, provide full-scale test data against chemical, biological, high explosive, and simulated nuclear targets. Participation in flight tests at White Sands Missile Range, NM, allows evaluation of simulated bulk chemical and chemical submunition payload lethality for hit-to-kill intercepts.

4. Targets, Test, and Evaluation Directorate Technologies

The Targets, Test and Evaluation (TT&E) Directorate develops theater and strategic missile targets for Army, Air Force, and Navy PEOs and provides test and evaluation support to the DoD, BMDO, USASSDC itself, and other agencies. In addition, TT&E manages the design, development, and flight test of high-fidelity, threat-emulating payloads. The directorate also manages the treaty-compliant Strategic Target System (STARS) and provides targets for the National Missile Defense in support of the GBI, GBR-P, and Space and Missile Tracking Systems Programs. The STARS offers a unique capability to carry exoatmospheric payloads for U.S. testing and experimentation. The directorate developed the STORM and HERA target missiles for use in TMD testing. The STORM was used successfully in the PAC-3 downselect process, and the HERA will be used in testing of the THAAD missile system and PAC-3 EMD. The directorate provides complete test support for these target systems, including test range coordination, site facilities, booster and payload integration, ground and launch support equipment, and data analyses activities.

5. Program Analysis And Integration Directorate (PA&ID)

The Program Analysis and Integration Directorate (PA&ID) is one of five major directorates that make up Missile Defense and Space Technology Center (MDSTC). PA&ID provides the primary command expertise for program analysis, technology transfer and assessment, integration for program analysis and validation operations, operations research studies and analyses, economic and cost analyses, and cost effectiveness support for all planning and programmatic activities related to the MDSTC.

6. Advanced Systems Concepts Office (ASCO)

The ASCO provides engineering analysis of advanced concepts to identify innovative ways to apply existing technology to current and projected missile defense battlefield requirements. The ASCO offers expertise in system requirements, systems analysis, and engineering of technologies with high potential for robust, cost-effective solutions for future missile defense deficiencies.

Table D-2 illustrates the USASSDC technology and current TMD/NMD system relationship. The left side of the table gives a detailed list of USASSDC technologies. The top side of the table lists the TMD and NMD elements which these technologies support. A dot signifies that a technology is applicable to that system, as defined by the Technology Directorates. For more detailed descriptions on USASSDC technologies and programs, refer to the USASSDC MDSTC Technology Master Plan or the USASSDC Automated Technology Transfer Catalog (ATC). To obtain a copy of either the MDSTC Master Plan or the ATC, contact the Program Analysis and Integration Office, (205) 955-3069; or Mr. Russell Alexander, (205) 955-4763.

Table D-2. Current TMD/NMD System/Technology Relationships

TECHNOLOGY EFFORTS	TMD SYSTEMS					NMD ELEMENTS			TECHNOLOGY DESCRIPTION
	ARROW	Corps SAM/MEADS	JTAGS	PATRIOT PAC-3	THAAD	BMC3	GBI	GBR-P	
Advanced Technology									
Advanced Acousto-Optic (AO) Modulator					●			●	A polymer-based AO modulator is being developed for tunable imaging sensor applications.
Avalanche Photodiode Array							●		Contact M. Lavan, (205) 955-1759, for information.
Chaos (Nonlinear Dynamics)					●			●	The design of laser, microwave sources, and particle accelerators; phase locking of lasers and antennas; beam propagation through the atmosphere; interaction of laser energy and microwaves with targets; and remote assessment of target damage.
Decision Aids						●			Using inference engines such as neural nets, conceptual graphs, expert systems, and hybrid systems, develop tools, based on expert knowledge, that act as decision aids.
Electron Multiplier on Infrared Focal Plane Arrays		●		●	●		●		Development of solid-state electron multiplication on an impurity band conduction focal plane array promises greater sensitivity (single photon detection), higher signal-to-noise and wider dynamic range.
Foreign Technology Transfer					●			●	Identify, analyze, procure, and test foreign technology applicable to space and BMD, including prime and pulse power, power conditioning, RF and laser sources, radars, and advanced sensors.
High Bandwidth Wide Field of View Lasercom Demonstration					●	●			A satellite-to-ground demonstration is scheduled after satellite launch in July 1997 on STRV-2.
High Power Multi-Segmented Semiconductor Laser						●			Develop a compact and efficient semiconductor laser source with high output power (greater than 1W) in a circularly symmetric output beam.
High Quantum Efficiency Visible to Near IR Photocathode					●		●		Contact M. Lavan, (205) 955-1759, for information.
Improved Heat Sink Materials for Electronics	●	●		●	●	●	●	●	Control the coefficient of thermal expansion of a new high thermal conductivity fiber.

(Continued)

● = Tech. Applicable to System (as defined by MDSTC)

Table D-2. Current TMD/NMD System/Technology Relationships (Continued)

TECHNOLOGY EFFORTS	TMD SYSTEMS					NMD ELEMENTS			TECHNOLOGY DESCRIPTION
	ARROW	Corps SAM/MEADS	JTAGS	PATRIOT PAC-3	THAAD	BMC3	GBI	GBR-P	
Advanced Technology (Continued)									
Laser Detecting and Ranging (LIDAR)					●		●		Differential Absorption LIDAR and Raman Shift LIDARs are being evaluated based upon U.S. and Russian technologies.
Low Cost Optical Structures		●		●	●		●		Fabricate, demonstrate, and test a complete space telescope assembly constructed entirely of SiC.
Miniature Interceptor Technology		●		●	●		●		Develop miniature interceptor components that will reduce size and weight, improve control, reduce on-board power consumption, increase accuracy of guidance and control, increase divert capability, and increase reliability and ruggedness.
Monolithicaly Intercon-nected Thin Silicon Cell Arrays					●	●		●	Demonstrate the potential of a new class of solar cell array products that will be lightweight, high power, high voltage, and radiation resistant.
Multispectral Adaptive Filter					●			●	Tunable acousto-optic filters are spectrally agile and electronically tunable and represent the most promising technology for implementation of multispectral imaging sensors.
New Materials for LWIR Detector					●		●		Contact M. Lavan, (205) 955-1759, for information.
Plasmatron for Toxic Chemical Destruction									A plasma "torch" is being developed that will permit the safe and economical destruction of chemical and biological materials.
Polarimetric Signatures for Discrimination					●		●		A novel optical system has been developed which measures the linear polarization elements of the Stokes vector simultaneously on a single detector focal plane.
Radio Frequency (RF) Inductorless Integrated Circuits	●	●		●	●	●	●	●	Fabricate monolithic prototypes for six inductorless RF circuits: ultra-stable oscillators, voltage-controlled oscillators, tuned amplifiers, tuned bandpass filters, harmonic generators, and capacitive mixers.

(Continued)

● = Tech. Applicable to System (as defined by MDSTC)

Table D-2. Current TMD/NMD System/Technology Relationships (Continued)

TECHNOLOGY EFFORTS	TMD SYSTEMS					NMD ELEMENTS			TECHNOLOGY DESCRIPTION
	ARROW	Corps SAM/MEADS	JTAGS	PATRIOT PAC-3	THAAD	BMC3	GBI	GBR-P	
Advanced Technology (Continued)									
Rapid Manufacture of Carbon/Carbon Composites	●	●		●	●		●		Develop a process of manufacturing carbon-carbon composites with reduced fabrication time and reduced costs using an iron oxide catalyst deposited onto the carbon fibers to markedly increase the rate of deposition of carbon on the fibers.
Tunable Holographic Filter					●		●		Develop a tunable holographic notch filter.
Zero-Erosion Rocket Engine Throats					●		●		Contact M. Lavan, (205) 955-1759, for information.
Sensors									
A/D Converter Technology & Signal Processor Throughput & Dynamic Range				●	●				Define A/D technology to support dynamic ranges along with necessary throughput, size, weight, cooling, and prime power requirements.
Advanced Sensor Technology Program (ASTP)				●	●		●	●	Develop the technology base needed to field next generation smart, fused, adaptable sensors.
Automated Hardened Microcircuit Design		●		●	●	●	●	●	Microcircuit design program, based on known fabrication techniques and proven circuit design software, modifies conventional chip designs to meet system requirements for a nuclear environment.
Hardened VLSI Program	●	●		●	●	●	●	●	Establish hardened processes and supporting technologies through design, development, production, and test demonstration of circuits directed toward addressing specific BMDO system requirements.
InSb (Indium Antimonide) Focal Plane Array (FPA) Technology Improvements					●				Seeker which uses an active correction technique, as opposed to the old baseline seeker (Platinum Silicide) which utilizes a passive calibration technique. InSb FPA offers significant sensitivity improvements for system risk mitigation.

● = Tech. Applicable to System (as defined by MDSTC)

(Continued)

Table D-2. Current TMD/NMD System/Technology Relationships (Continued)

TECHNOLOGY EFFORTS	TMD SYSTEMS					NMD ELEMENTS			TECHNOLOGY DESCRIPTION
	ARROW	Corps SAM/MEADS	JTAGS	PATRIOT PAC-3	THAAD	BMC3	GBI	GBR-P	
Sensors (Continued)									
Kill Assessment				●	●				Collect and analyze data, and develop algorithms using that data to support rapid and accurate kill assessment in an operational TBM defense system.
LADAR Component Technology				●	●		●	●	Develop fieldable LADAR transmitter and receiver components for missile defense applications that include discrimination, precision tracking, fire control, and kill assessment.
Mosaic Array Data Compression & Processing (MADCAP) Module		●		●	●		●		Develop on or near focal plane signal processing concepts for near-term and advanced IR sensors.
Multiple Folded Ladar (MFL) Seeker							●		The MFL transmitter is being developed for the BMD requirement for a low weight, low volume, active discriminating interceptor.
MSX Late Midcourse Targets							●		Collect and analyze target and background phenomenology data to address BMDO midcourse sensor requirements.
Optical Signatures Code (OSC)		●		●	●		●	●	OSC provides a comprehensive and validated optical signature simulation capability to support all phases of BMDO system development to maintain responsiveness to evolving threats, missions, and element needs.
PtSi (Platinum Silicide) FPA Advanced Electro-Optics					●				Develop electro-optics technologies to include hardened PtSi FPA technologies which will improve radiation hardness. Transfer to the THAAD program.
Radar Signature				●	●			●	By developing real time discrimination algorithms, identify available technologies, such as ECM or IR, that are applicable to the PATRIOT system.
Real-Time Discrimination Program				●	●	●	●	●	Develop integrated real-time discrimination algorithms/architectures that can be utilized by elements of future BMD systems. Using the LDS Test Bed, discrimination algorithms/architectures can be evaluated in real time using field measurement data.

● = Tech. Applicable to System (as defined by MDSTC)

(Continued)

Table D-2. Current TMD/NMD System/Technology Relationships (Continued)

TECHNOLOGY EFFORTS	TMD SYSTEMS					NMD ELEMENTS			TECHNOLOGY DESCRIPTION
	ARROW	Corps SAM/MEADS	JTAGS	PATRIOT PAC-3	THAAD	BMC3	GBI	GBR-P	
Sensors (Continued)									
Theater Missile Defense Critical Measurements Program (TCMP)		●		●	●		●	●	The objective is to reduce TMD weapon system risks with sensor data collection that addresses functional performance/algorithm robustness and to characterize potential theater countermeasures.
Ultra Large Scale Integrated Circuit (ULSIC)			●			●			Develop and demonstrate a technology to support the fabrication of radhard ULSICs, e.g., 1-4 Meg SRAM.
Weapons Directorate (Lethality Technologies)									
Assessment and Modeling	●	●		●	●		●		Develop the analytical tools necessary to determine an overall probability of kill given interceptor/target endgame parameters.
Biological Targets	●	●		●	●		●		Determine effectiveness of current near-term KE weapons against Agents of Biological Origin (ABO) threat targets and lethal kill mechanisms required for immediate hard kill of ABO threat targets.
Chemical Targets	●	●		●	●		●		Determine sensitivity of bulk target hydraulic ram to projectile impact location, velocity, angle, and fluence; insitu destruction of chemical agents by shock environments associated with HVL impacts; and HTK lethality against chemical submunition targets.
High Explosive (HE) Targets	●	●		●	●		●		Determine unitary and submunition threat explosive initiation criteria for chunky projectiles and HTK concepts; HTK and projectile requirements to kill HE warheads; and incorporate results into analytical models used for lethality assessments.
Nuclear Targets	●	●		●	●		●		Determine impact parameter requirements to evoke kill modes for Soviet and rest-of-the-world threat designs, evaluate both HTK and fragment warhead concepts, and develop analytical models that relate these parameters to observed kill modes.
Submunition Chemical Targets	●	●		●	●		●		Conduct impact tests using high fidelity interceptor & target models to evaluate PAC-3 and THAAD HTK lethality against chemical submunition targets; and develop analytic models that predict the number of submunitions destroyed as a function of engagement conditions.

● = Tech. Applicable to System (as defined by MDSTC)

(Continued)

Table D-2. Current TMD/NMD System/Technology Relationships (Continued)

TECHNOLOGY EFFORTS	TMD SYSTEMS					NMD ELEMENTS			TECHNOLOGY DESCRIPTION
	ARROW	Corps SAM/MEADS	JTAGS	PATRIOT PAC-3	THAAD	BMC3	GBI	GBR-P	
Weapons Directorate Technologies									
Advanced Discriminating LADAR Technology (ADLT) [Part of the Discriminating Interceptor Technology Program (DITP)]							●		Develop, integrate, test, & validate advanced active seekers for strategic and theater exo HTK interceptors with onboard robust discrimination for technology infusion into the EKV, the NMD System, and other strategic or theater interceptor systems.
Advanced Vectoring Carbon-Carbon EKV Nozzle	●	●		●	●		●		Design, develop, and demonstrate vectoring EKV nozzle using thrust vector control managed by omniaxis movement of nozzle made of lightweight braided carbon-carbon materials and incorporating a low cost, multi-pivot point flexseal.
Atmospheric Interceptor Technology (AIT) Program		●			●		●		The objective of the AIT program is to develop, design, fabricate, and test lightweight hypersonic atmospheric technologies to support advanced TMD missiles and NMD interceptors.
Chemical Laser								●	Overtone Technology Development Program. Laser nozzle advancement technology to improve power density, specific power, and simplicity of manufacturing.
Depressed Altitude Guided Gun Round (DAGGR)				●	●			●	The DAGGR weapon system concept leverages mature radar and projectile technologies into an advanced, highly mobile (C-130 transportable), defensive system.
Discriminating Interceptor Technology Program (DITP)					●		●	●	Develop the technology base needed to field next generation smart, fused, adaptable seekers. Improve seeker system performance and enhance discrimination robustness.
Endoatmospheric Seeker Window and Window Cooling Tech. Development (Part of the AIT Program)		●			●				Develop and demonstrate window/window cooling technologies and concepts to counter the severe aero-thermal effects of hypervelocity atmospheric intercepts and address critical issues regarding the flight of hypervelocity missiles inside the atmosphere.
Fast Frame Seeker Program	●	●			●		●		Fabricate a focal plane array with on-FPA electronics to enable a seeker to operate at frame rates in excess of 1000 Hz to do temporal filtering, spatial filtering, & electronic image stabilization to support discrimination and a very responsive endgame.

● = Tech. Applicable to System (as defined by MDSTC)

(Continued)

Table D-2. Current TMD/NMD System/Technology Relationships (Continued)

TECHNOLOGY EFFORTS	TMD SYSTEMS					NMD ELEMENTS			TECHNOLOGY DESCRIPTION
	ARROW	Corps SAM	JTAGS	PATRIOT PAC-3	THAAD	BMC3	GBI	GBR-P	
Weapons Technologies (Continued)									
Free Electron Laser (FEL)								●	Contact Mr. W. Reeves, (205) 955-3801, for more information.
Near Net Shape Optical Sapphire Windows	●	●			●				Develop an optical sapphire window utilizing edge defined film fed growth techniques to directly generate near net shaped optical sapphire window blanks with the crystallographic c-axis perpendicular to the window surface.
PAC-3 Attitude Control Motor				●					Development of a high performance attitude control motor for application to PAC-3.
Polyacrylonitrile (PAN) Fiber					●				Develop, demonstrate, and quality a domestic PAN fiber.
Pilotline Experiment Tech. (PET) Program				●			●		Address FPA issues, including high speed on-chip readout electronics, nuclear hardening, and focal plane producibility, and pursue production quantities of nuclear-hardened FPA assemblies with extended wavelength sensitivity.
Targets, Test, & Evaluation Directorate									
Storm Target System				●	●				Booster configuration for launching a maneuvering RV capable of carrying various payloads. Onboard instrumentation provides telemetered acceleration, velocity, target status, and damage location & submunition survivability information.
Hera Target System					●				Follow-on to the Storm Target, providing ballistic, pile driver, unitary, and maneuvering Reentry Vehicles (RVs).
THAAD/PAC-3 Target Support				●	●				Emulate trajectories, velocities, and inadvertent manuevers; deploy decoys and debris at selectable altitudes; and carry models of sub-munition warheads. Identify technologies for instrumenting test targets to support kill assessment function.
Strategic Target System (STARS)				●	●		●		A flexible payload delivery system capable of being configured to meet a variety of experimental requirements. The vehicle is a three-stage guided missile, and the configuration uses a post boost vehicle for launching targets.
National Missile Defense (NMD) Targets							●	●	Provides a launch vehicle and target payload to support the NMD Integrated Flight Tests. The launch vehicle is a standard ICBM three-stage Minuteman booster with a Multi-Service Launch System front section capable of separating from the third stage.

● = Tech. Applicable to System (as defined by MDSTC)

(Continued)

Table D-2. Current TMD/NMD System/Technology Relationships (Continued)

TECHNOLOGY EFFORTS	TMD SYSTEMS					NMD ELEMENTS			TECHNOLOGY DESCRIPTION
	ARROW	Corps SAM/MEADS	JTAGS	PATRIOT PAC-3	THAAD	BMC3	GBI	GBR-P	
Missile Defense Battle Integration Center (MDBIC)									
Pre-Launch Interdiction Demonstrations									(Project Strong Safety) Demonstrate systems, using currently available technologies, to defeat very short range rockets and mortar threats to friendly forces, non-combatants, and materials/ facilities in war and operations other than war.
UAV/BPI/Attack Operations		●		●	●		●		Demonstrate greatly improved boost phase and attack operations capabilities via integrated operation of UAVs, sensors, weapons, and C3I systems, using currently available technologies.
Synthetic Theater of War for Theater Missile Defense (STOW TMD)	●	●	●	●	●				A set of software tools designed to simulate the TMD battle in setting in which constructive, virtual, and live simulations are linked in a seamless environment to support training, acquisition, and research and development efforts.
MBDIC Survivability Technologies									
Anti-Radiation Missile (ARM) Countermeasures	●	●	●	●	●	●	●	●	The ARM countermeasures evaluator was developed to evaluate radar ECCM techniques to defeat the ARM threat.
Camouflage, Conceal-ment, & Deception (CCD) & Low Observa-ble (LO) Survivability Enhancement Options (SEO)	●	●	●	●	●	●	●	●	Applied or developed for vehicles and equipment that are part of the TMD task force.
Conventional Weapons Survivability	●	●	●	●					Hardening technology to mitigate blast and fragmentation effects is being applied to the vehicles and shelters organic to the several TMD systems.
Nuclear, Natural, RF, Kinetic Debris Model Development (Environment & Effects)	●	●	●	●	●	●	●	●	Develop new or improve existing nuclear, natural, and man-made hostile environment definition models necessary to support BMD system and element level survivability analysis and simulations in a defense suppression threat environment.
NMD Survivability/ Operability Modeling, Simulations, and Test Facilities	●	●	●	●	●	●	●	●	Develop nuclear, natural, and man-made hostile environment definition test capabilities to support SEO analysis and test bed applications. Develop, integrate, and verify SEOs to reduce NMD risk requirements are met.

(Continued)

● = Tech. Applicable to System (as defined by MDSTC)

Table D-2. Current TMD/NMD System/Technology Relationships (Continued)

TECHNOLOGY EFFORTS	TMD SYSTEMS: ARROW	TMD SYSTEMS: Corps SAM/MEADS	TMD SYSTEMS: JTAGS	TMD SYSTEMS: PATRIOT PAC-3	TMD SYSTEMS: THAAD	NMD ELEMENTS: BMC3	NMD ELEMENTS: GBI	NMD ELEMENTS: GBR-P	TECHNOLOGY DESCRIPTION
MDBIC Survivability Technologies (Continued)									
TMD SEO Development	●	●	●	●	●			●	Develop nuclear ballistic fragment, chemical/biological, and CCD survivability techniques to meet Army TMD requirements; develop POP hardware for component, subsystem, and element level tests; and plan and conduct experiments which demonstrate Army TMD element S/O.
Top Down Survivability (TDS) Program	●	●	●	●	●			●	Identifies survivability and operability issues confronting an objective system and candidate resolution approaches to mitigate the associated risks with the main focus on non-traditional, advanced threats.

● = Tech. Applicable to System (as defined by MDSTC)

B. Missile Defense Battle Integration Center (MDBIC)

The MDBIC was established in January 1995 to give SSDC and the Army a computerized simulation capability to integrate and evaluate Theater Missile Defense and National Missile Defense architectures. The MDBIC also supplies analysis needed by the Army Space Command to model space assets. The MDBIC is developing a Synthetic Battlefield Environment (SBE) for Theater Missile Defense to provide weapon developers, battle planners, and warfighting commanders an interactive way to simulate precise operational scenarios. The Distributed Interactive Simulation compliant Defense Simulation Internet SBE will be modular to permit replacement of a simulated element with the actual hardware, providing the capability for hardware-in-the-loop as well as human-in-the-loop testing. The MDBIC is working closely with the Army Training and Doctrine Command to develop ways to integrate its Battle Lab locations throughout the United States into a single, comprehensive battlefield simulation for the Force XXI campaign. Through the MDBIC, SSDC has and will be inserting missile defense capabilities into the activities of the Battle Labs, the Louisiana Maneuvers Program, Army Warfighting Experiments, and other Force XXI exercises. The MDBIC—in conjunction with the Army Theater Missile Defense Force Projection Tactical Operations Center (TOC)—provides the simulated battlefield environment needed to train and prepare TOC crews for the split-second decision-making necessary to defend against the ballistic missile threat. Together they create a force of "virtual combat veterans" who can, should the need arise, utilize the available technology, interpret the information, and make the decisions that will protect our allies and our forces and wage a winning theater missile defense battle.

The MDBIC consists of three major elements:

1. The Operations Directorate develops and implements four-pillar—active defense; passive defense; attack operations; and battle management/command, control, communications, computers and intelligence—TMD integration programs with related Army and Department of Defense efforts.

   — The Analysis Division uses various models and simulation tools to analyze the effectiveness of systems and concepts in combat scenarios.

   — The Engineering Division identifies and validates system requirements; assesses system vulnerability, technology, and threat; and provides engineering support throughout hardware integration and acquisition.

   — The Concept Demonstration Division coordinates field testing and demonstration of missile defense-related components, subsystems, and systems.

   — The Exercises and Training Division coordinates and executes MDBIC's involvement in Commander-in-Chief exercises and Army Warfighting Experiments by integrating four-pillar missile into the scenario and providing simulation stimulus to drive exercise play through the MDBIC's SBE.

   — The Force XXI Division coordinates integration missile defense technologies, capabilities, and simulations into the Force XXI campaign plan; interfaces with TRADOC Battle Labs regarding missile defense integration; and assists with integration of missile defense capabilities into warfighting experiments and exercises.

2. The Simulations Directorate provides required modeling and simulation hardware and software tools.

   — The Simulation Development Division develops and maintains models and simulation tools for analysis of TMD, NMD, and military space systems from the engineering to the system level, emphasizing benefits to the soldier in the field.

   — The Combat Environments Division provides a wide variety of expertise for the SBE, including reconfigurable software/hardware platforms in the Virtual Combat Testbed, geographical and spatial support from the Spatial

Weapons System Analysis Center, as well as threat modeling and scenario development.

— The Computer Resources Division provides mission critical computer/communication resources and technical engineering services for the space and missile defense community in the Advanced Research Center, the Simulation Center, and the Warfighting Analysis and Integration Center.

3. The Testbed Product Office develops and fields the Extended Air Defense Testbed and the Extended Air Defense Simulation and jointly develops the Israeli Testbed.

   — The Extended Air Defense Testbed (EADTB) forms the core of the SBE-TMD. The user-friendly, highly flexible EADTB affords a high-fidelity modeling capability to materiel developers and combat developers as well as operational commanders.

   — The Extended Air Defense Simulation (EADSIM), a low-to-medium level fidelity simulation, will continue to be used as a "first-cut" analysis tool. This simulation, widely used during Desert Storm operations by all four U.S. military services, currently has more than 200 subscriber sites worldwide.

   — The Israeli Testbed, a low-fidelity simulation with human-in-the-loop capability, was jointly developed to provide TMD simulation capability for the Israelis and is currently operational in Israel.

Future plans include developing the flexibility to use both the Extended Air Defense Simulation and Testbed in an interchangeable role within the SBE architecture. The SBE will participate in several Army field exercises.

Table D-3 shows the correlation between the MDBIC's technologies and the TRADOC Battlefield Dynamics, as well as the correlation to TMD/NMD. It also illustrates in general terms the capabilities of each technology.

Table D-3. MDBIC Capabilities

FUNCTION	BATTLEFIELD DYNAMICS: Early Entry, Lethality, & Survivability	Depth & Simultaneous Attack	Mounted Battle Space	Dismounted Battle Space	Battle Command	Combat Service Support	TMD	NMD	CAPABILITIES
• Pre-Launch Interdictions	●	●	O	●	O	O	●	O	• Real-time location & identification of targets • Rapid location & identification of passive targets • Defense against short range threats • Optimizes situational awareness • Preemptive & active defense measures • Image enhancement techniques and automatic target recognition algorithms used to extract targets with very high background clutter
• UAV/Attack Ops, Deep Strike BPI	●	●	O	O	O	O	●	O	• Sensor to shooter timeline enhanced • Reduction of threat launches against blue forces • Reduced stress on active defense • Significant reduction in AD interceptor expenditures for TMD • Effective at Corps and Theater levels • Extended range of TMD systems • Extended range of deep attack systems • Real-time location and identification of targets • Supports extension of battlefield penetration required for next century systems • Provides defense against boost phase, TBMs, TELs, GSEs, and Tanks
• Precision Kill-1 Concept	●	●	●	O	O	O	●	O	• Extends maneuver and forward area coverage • Shortens sensor to shooter timeline • Enhances the tactical mobility • Early & rapid deployable system • System available by turn of the century • Provides defense against TBMs, CMs, UAVs, ASMs, & ARMs • Highly mobile system • Early entry troops • Brigade level task forces • Minimum logistics modifications
•Simulation Capabilities SBE	●	●	●	O	O	O	●	O	• Examination of missile defense TTPs • Ability to provide real-time AAR capabilities • Examination of C4I structure • Examination of MD communication prodedures rqmts • Development of virtual prototype linkage with real C4I entities

● Provides Significant Capability O Provides Some Capability

Table D-3. MDBIC Capabilities (Continued)

FUNCTION	BATTLEFIELD DYNAMICS: Early Entry, Lethality, & Survivability	Depth & Simultaneous Attack	Mounted Battle Space	Dismounted Battle Space	Battle Command	Combat Service Support	TMD	NMD	CAPABILITIES
Survivability ***Systems*** • Antiradiation Missile (ARM) Countermeasures Evaluation (ACE) Hardware in-the-loop Facility	●	●	O	●	●	●	●	O	• Assessment of Radar Susceptibility • Improved Radar Survivability • Performance Enhancer for System • Improved Communication Survivability • Advanced Countermeasures for Multisensors ARMS
• Camouflage Concealment Deception Technologies	●	●	●	●	●	●	●	●	• Improved Low Observability • Improved Multispectral Decoys • Advanced RadarAbsorbtion Materials • Advanced Electrooptical Materials and Electronic Image Modification
• Armor Technology	●	●	●	●	●		●		• Applique Armors • Advanced Lightweight Armors • Advanced Electromagnetic Transparent Armors for Radars and Radomes • Rapid Fortification
• Geodesic Structures	O			●	●		●		• Rapidly Erectable Shaped Hardened Structure for Improved Conventional Munitions Survivability
• Integrated Electromagnetic Effects Requirements	●	●	●	●	●	●	●	●	• Fully Integrated balanced protection to HEMP, Lightening, HPM, ECCM, EMI, etc.
• Countermeasures for Adv. Threats	●	●	●	●	●	O	●	●	• Electronic Warfare Countermeasures • Laser / HPM Countermeasures • Special Forces Countermeasures • War Auxiliary Reserve Mode & Deception Survivability Enhancement Options
• Survivability / Operability Test Facilities							O	●	• Portable Optical Radiation/Redout Testbed for Seeker Hardening • Data / Guidelines for Interceptor Operating Rules • Communication Link Functionality

● Provides Significant Capability O Provides Some Capability

Table D-3. MDBIC Capabilities (Concluded)

FUNCTION	BATTLEFIELD DYNAMICS: Early Entry, Lethality, & Survivability	Depth & Simultaneous Attack	Mounted Battle Space	Dismounted Battle Space	Battle Command	Combat Service Support	TMD	NMD	CAPABILITIES
Survivability *System Upgrades*									
• MMIC Hardening	●	●	○	●	●	●	●	●	• Improved Survivability for Radar Transmit/Receive Modules to High Power Microwave Threats
• Nuclear hardening Technologies	●	●	○	●	●	○	●	●	• Improved Test Simulation Technology • Improved Environment/Effects Models • Integrated Balanced Protection
• Conventional Hardening Technologies	●	●	○	●	●	○	●		• Improved Test Simulation Technology • Improved Environment/Effects Models •Integrated Balanced Protection
• Electronic Data Guidelines for Element Survivability	●	●	●	●	●		●	●	• Automated Nuclear and Radio Frequency Hardening Technology Design Tool
• Radar Environmental Status Assessment Model	●	○	○	●			●	●	• Real-Time Estimator of Natural and Hostile Environments for Radar Signal Compensation
•Nuclear Corruptor							●	●	• Real-Time Corruption of recorded or synthetically derived THAAD Radar

● Provides Significant Capability ○ Provides Some Capability

C. Space Applications Technology Program (SATP)

The objectives of the SATP are to enhance warfighter capabilities and reduce casualties through the exploitation of space. Army-unique technologies are being developed and user demonstrations performed to exploit space to meet Army requirements. User endorsed capabilities will be gleaned to permit Army space requirements to be defined and submitted to platform developers. The program is highly leveraged with multi-agency participation. Refer to Volume I, Section III-Q of the ASTMP, for more information on Space Exploitation. The projects in the Space Exploitation technology area are as follows:

Laser Boresight (STO). This program will develop a solid-state laser calibration capability for Joint Tactical Ground Station (JTAGS) system. The laser calibrator will provide a known ground registration point for space-based sensors resulting in improved launch point predictions and impact area for Theater Ballistic Missiles (TBM). It will reduce the command and control timelines plus improve the overall responsiveness of the Joint Precision Strike and TMD forces by significantly reducing the TBM search box. The improved line-of-sight target accuracy will result in higher quality missile warning, alerting, and cueing information. This capability will be integrated into the JTAGS Pre-Planned Product Improvement (P3I). By FY97, demonstrate improved TBM launch point and trajectory parameters by using a compact, in-theater, tunable laser calibration system for the Defense Support Program satellite sensors. Extensive field testing with the theater warfighter in FY97 and transition to JTAGS PM in FY98.

POC: Dr. Richard Curtis, MDSTC; (205) 955-3802

Laser Satellite Communications (STO). A proof-of-concept demonstration will be conducted using ground-to-ground and ground-to-air systems for laser communications. This technology has the potential to increase the data capacity above that of existing communications, while decreasing the weight, size, and power requirements. The proof of concept will be developed into a technology demonstration and in the future transition into a dual use terminal or a tri-band to support the common ground station. Mountain top-to-mountain top experiments have been successfully completed. Feasibility studies are being done to assess the ground-to-ground and space-to-ground roles. More hardware is being built to perform ground-to-ground and ground-to-air experiments. Future experiments will put hardware on a satellite to perform space-to-air and space-to-ground experiments.

POC: Mr. Steve Hammonds, MDSTC; (205) 955-1843

Hyperspectral Imaging. The goal is to develop and demonstrate an Acousto-optic Tunable Filter (AOTF) to obtain hyperspectral imagery and polarization data in tactical scenes. This will enable discrimination of specific objects in a diffuse scene, to include searching for marijuana or looking for man-made objects.

The AOTF will also provide a significant improvement in space-based hyperspectral imaging processing capability. Hyperspectral images may be used to detect targets not detectable by other sensor types. The AOTF will provide the ability to select, in real-time, spectral bands to support individual mission requirements. Applications include target detection, weather/terrain, and mapping.

The approach is to develop the device and collect hyperspectral data to tactical interest on the ground, onboard an aircraft, and in space to demonstrate practical utility. (The airborne tests will serve to reduce the technical risks of the orbital flight.) The U.S. Army Topographic Engineering Center, U.S. Army Intelligence Center, and central MASINT office will use the data to build a signature data base, identify useful combinations of spectral bands, and identify strategies for reducing data processing requirements. This effort is jointly funded by the Army and the central MASINT office. Hardware completion and initiation of data gathering from a ground-based sensor was completed in FY95. An airborne flight capable system will be completed in FY97.

POC: Mr. Ben Kerstiens, MDSTC; (205) 955-1769

GPS Azimuth Determining System. The GPS Azimuth Determining System is a combat multiplier that provides pointing with survey quality accuracy using the principle of microwave interferometry to signals transmitted from NAVSTAR GPS to provide azimuth, position, elevation, and roll to an azimuth accuracy of 1.0 mil and elevation accuracy to 3.5 mils in 4 seconds. One objective is to transition the technology to PM MLRS, PM TRAILBLAZER, and PM AFAS. The azimuth determining system will be used to meet the pointing requirements of indirect fire weapons, radars, intelligence systems, communications tracking, and forward observers.

The approach is to enhance the GPS receiver to provide instantaneous survey-quality Azimuth, evaluate the system, and then transition to selected PMs.

POC: Mr. Jim Washington, USASSDC; (703) 607-1893

Battlefield Ordnance Awareness (BOA). The program is to demonstrate a near real-time ordnance reporting system using onboard processing with space sensors. This technology will improve battlefield visualization of friendly and enemy ordnance fires and cruise missile launches. It addresses the need to target ordnance delivery for counterfire purposes, a major battlefield deficiency. The BOA capability will identify the ordnance by type and provide position information for counter fire opportunities, as well as Battle Damage Assessment, blue forces ordnance inventory, information for dispatch for logistical and medical support, and search/rescue. Advanced processor technology will be used with state-of-the-art focal plane staring arrays to provide critical information to the commander. By FY97, acquire ordnance data by type and develop algorithms for near real-time processing. By FY98, demonstrate ordnance reporting with a BOA sensor/ processor package from a fixed platform. In FY99, develop a space-qualified BOA sensor package with onboard processing.

POC: Ms. Kaye Blankenship, MDSTC; (205) 955-3522

Automated Target Recognition–Semi-Automated Image Processing. This program consists of a series of efforts aimed at enhancing the ability of imagery analysts to exploit large amounts of wide area and point target imagery generated by sensors. The ASPO is currently engaged in two efforts to apply ART technologies to ASARS II imagery. The first of these is Rapid Focus, a hybrid optical-digital processor designed to provide real-time processing to perform initial target detection and location in search imagery and to identify target types in finer resolution imagery. The second approach, Streaker, uses a digital processor to detect and locate potential targets in search imagery in order to focus analyst attention. The ASPO is also participating in the ARPA SAIP Advanced Concept Technology Demonstration which will provide a suite of tools and applications that can be exported to DoD imagery exploitation systems that will allow the imagery analyst to accurately and completely search and analyze imagery, generate reports, and provide imagery products within operational timelines. A modest level of Army funding is required to assure availability of this technology for Force XXI.

POC: Mr. Eugene Lambert, ASPO; (703) 275-5988

Blue Force Tracking. Grenadier BRAT (Beyond line-of-site Reporting and Targeting) is a series of Army Space Program Office/Battle Command Battle technical tests and warfighting experiments to determine the capabilities and limitations of using national and theater systems to do Blue Force tracking, status reporting, and targeting. Grenadier BRAT has the potential to provide digitized situational awareness and status reporting with information injected directly into the existing Army architecture. Tracking can go deep into the enemy territory because it does not have ground-based line-of-sight limitations. Coverage and dissemination is near worldwide. Demonstrations of this capability occurred in June 1995 in the Grafenwoehr training area, Germany, in the September 1995 All Services Combat Identification Evaluation Team evaluation sponsored by the JROC and in the XVIII Airborne Corps' exercise Royal Dragon in May 1996. Currently, Grenadier BRAT is an approved initiative in TFXXI and is working with the SOF community in developing a CONOPS for use in the AWE. It is also pending approval to be evaluated in Division XXI. A modest level of Army funding is required to assure availability of this technology for Force XXI.

POC: Mr. Gregory Kesner, ASPO; (703) 275-5671

Tactical Direct Access Demonstration (DARPASAT). A tactical satellite launched by ARPA will be used to conduct a proof-of-concept technology demonstration with Army TENCAP systems to show the capability of satellite mission tasking direct from theater forces. The Joint Army/ARPA/NSA program will conduct the technology demonstration of this concept in support of Early Entry and Battle Command doctrine. Minimal funding for ground operation is required to conduct FY97 demonstrations.

POC: LTC Steven Leonard, ASPO; (703) 285-9035

Satellite Communications (SATCOM) on the Move. A NASA Advanced Communications Technology Satellite (ACTS) will be used to demonstrate communications on the move using EHFs. This will help define interservice requirements for future SATCOM developments, and will influence future capabilities for communications on the move.

The project will demonstrate the need for the technology and will also provide an EHF satellite communications-on-the-move capability to improve Army command and control for as long as the ACTS satellite is available. Demonstrations will show high data rates using a mechanically steered antenna, up to 1.544 Mbps, and a phase array antenna will be used to demonstrate data rates up to 9.6 kbps.

The Jet Propulsion Laboratory's (JPL's) ACTS Mobile Terminal (AMT), funded by the National Communications System, will be used to demonstrate proof-of-concept by installing AMT on a military vehicle (HMMWV) with a SINCGARS interface. The transition partners are Battle Command Battle Lab (BCBL), CECOM, and Global Grid. This is a dual-use technology since it uses the commercial bandwidth associated with the ACTS system and can be modified to operate with the MILSTAR waveform for future terminal modification.

D. U.S. Army Space Command (ARSPACE) Demonstrations

USARSPACE is a subordinate command of USASSDC and the Army component of the U.S. Space Command (USSPACECOM). USARSPACE provides USSPACECOM an Army perspective in planning for DoD space systems support to land forces and missile defense operations; ensures integration of Army requirements; responds to Commander-in-Chief U.S. Space Command (USCINCSPACE) directed taskings; commands assigned forces; and conducts planning for DoD space operations in support of Army strategic, operational, and tactical missions. The missions of USARSPACE include supporting USCINCSPACE as the Army component; commanding the Defense Satellite Communications System Operations Centers (DSCSOCs), and managing joint tactical use of the Defense Satellite Communications System (DSCS); conducting planning as the "user" of assigned Army Missile Defense forces; supporting the warfighter; and executing the Army Space Exploitation Demonstration Program (ASEDP).

USARSPACE executes the ASEDP by planning and conducting the selection process for technology, concept, and operational demonstrations. The demonstrations' classes are based upon the developmental maturity of the item or capability to be demonstrated. The purpose of the demonstrations is to match space capabilities with Army needs and to exploit and leverage DoD, Other Government Agencies (OGAs), and commercial space investments.

TRADOC Battle Labs, elements of USASSDC, and other Army organizations are major participants in this process. Actual execution of demonstrations may be accomplished by any of the participants with most operational demonstrations being executed by USARSPACE. Requirements derived from this process also drive the prioritization of technology demonstrations/efforts by MDSTC. These demonstrations have focused on integrating space capabilities into the Army to support more efficient, economical, and timely mission execution. As the program continues to evolve, it has become even more focused upon incorporating space-related capabilities as officially recognized elements of unit exercises and wargaming. Topical areas for demonstrations include position/navigation, communications, missile warning, environmental observation, and intelligence-related capabilities.

Through interaction with the TRADOC Battle Labs, the Louisiana Maneuver evaluations and exercises, and in the recently defined FORCE XXI programs, these demonstrations have obtained recognition as one method of determining operational requirements for objective systems. Also, use and evaluation of Commercial off-the-shelf

(COTS) equipment during contingency operations has led to many lessons learned which in turn have influenced the operational requirements driving science and technology plans. Because these demonstrations are highly dynamic in their structure and content, specific information about future demonstrations should be obtained from the Plans Division of USARSPACE (DSN 692-8720).

USARSPACE has also established the Advance Concepts/Technical Support Office to document and coordinate requirements for longer term technology development efforts. It will focus on technology and space-related capabilities that could be demonstrated in the 2- to 5-year or longer time frame and that should be included as technology demonstrations within the ASEDP. This new office will define requirements on which MDSTC space cell research and development efforts will be focused.

IV. SUPPORTING CAPABILITIES

The missile defense program makes significant investments in developing and maintaining support capabilities—most having potential applications for other Army technology development programs. These capabilities include special-purpose equipment and computers, simulation and modeling, assessment technology, test and evaluation technology, and facilities and ranges. They offer unique opportunities for enhancing the Army Technology Base with data and information derived from assessments, analyses, evaluations, experiments, demonstrations, and tests of both strategic and tactical systems.

A. Measurement Platforms

Airborne Surveillance Test Bed (AST). The AST is a BMD asset being used to validate Long Wavelength Infrared (LWIR) sensor functional performance and to collect infrared data on a wide variety of ballistic missile targets. The system's large field-of-view LWIR sensor is used to accurately measure target infrared signature and position. The AST is frequently used as a surrogate for sensor systems under development. By collecting data and demonstrating sensor performance, the system addresses critical NMD and TMD development issues. The AST consists of a large three-color, LWIR sensor mounted in an 86-foot-long cupola atop a modified Boeing 767 aircraft. In addition to the module housing the AST sensor, the cupola on top has a second module capable of accommodating another sensor. The main cabin houses the signal and data processing equipment, operator consoles, recording equipment, global positioning system processors, and other ancillary equipment. The AST completed system integration and testing at Boeing in January 1990. Since then, it has completed many data collection and performance demonstration missions. These missions have been conducted at a variety of test ranges, including Kwajalein Missile Range (KMR), Pacific Missile Range Facility, Eastern Test Range, White Sands Missile Range (WSMR), and Wallops Island. Missions have been conducted at other CONUS locations as well. The AST is based at the Military Flight Center, Boeing Field, Seattle, WA. Future missions will allow the AST to collect data against new and never-before-seen targets and to expand the demonstration of surveillance sensor functions to new areas. AST continues to provide critical data and demonstrations.

POC: Mr. Hank Holmes, MDSTC; (205) 955-2136; PMA A1155

High Altitude Observatory (HALO). The MDSTC manages the HALO program for BMDO. The HALO is an instrumented Gulfstream II-B optical data collection aircraft providing airborne collection of multispectral (spanning the ultraviolet through the longwave infrared), imaging (calibrated radiometric and photo documentary), optical signature data on targets of interest including reentry vehicles, missile plume phenomenology, and missile/target intercepts, and intercept debris characterization and kill assessment. The mobile test asset supports a variety of user organizations with sustaining funds provided by BMDO and augmented by user funds for specific missions activities.

POC: Mr. Sonny Anderson, MDSTC; (205) 955-2151; PMA A3360

Sea Lite Beam Director (SLBD). The SLBD is an USASSDC asset located at WSMR. Elements have been combined into an integrated system that can acquire and track targets at extended ranges, accept the full power of the Mid-Infrared Chemical Laser (MIRACL) beam, focus and aim this beam onto a moving target, and maintain the focused beam on the aimpoint long enough to destroy or disable the target.

The SLBD system performs its pointing and tracking with a stabilized line-of-sight controlled by an inertially stabilized reference mirror and low-power alignment lasers and optical sensors. This scheme provides for high bandwidth, low jitter, and precise pointing of the MIRACL beam.

In addition to pointing the high energy laser beam, the SLBD has been used very successfully to passively track and image aircraft and missiles in flight. The inherently high quality of the optical components, precise pointing of the device, and its ability to track very high speed targets make it an ideal platform for capturing in-flight imagery of

TMD launches and intercepts. Calibrated IR sensors in the SLBD's optical train collect high-speed, very high quality imagery of plume and hardbody signatures, and phenomenology, as well as recording point-of-intercept imagery.

POC: Mr. Tony Marrujo, USASSDC-HELSTF, (505) 679-5028

B. Testbeds/Ranges

Aero Optical Evaluation Center (AOEC). The AOEC facility is the world's largest and most capable shock tunnel. With its ultimate capability it will duplicate flight conditions for hypersonic interceptors. The facility has successfully isolated tunnel disturbances from vehicle measurements resulting in direct and correct measurements of aero-optical and aerodynamic conditions. The facility can quantify seeker performance, vehicle control, and aerodynamics. Multiband aero-optic and radiation effects can be quantified with the AOEC instrumentation suite. Jet interaction control effects, mixing, and combusting flows over seeker heads creating aero-optical effects that can be quantified at AOEC. Pressure and heating loads and force and moment measurements can be made during AOEC tests. This facility is unique to DoD in that it can test all BMDO interceptors at flight conditions, ultimately resulting in actual reduction in quantity of flights. The AOEC facility provides a path for flight test program cost reduction by providing a good understanding of flight test issues prior to flight.

POC: Dr. Harold Romero, MDSTC; (205) 955-3408; PMA A3360.01

Army Missile Optical Range (AMOR). AMOR is a contractor-operated compact laser radar range located at the U.S. Army Missile Command, Redstone Arsenal, Alabama. It serves primarily as an experiment facility supporting laser and LADAR measurements of selected materials and targets. It is currently utilized to support the USASSDC Imager Measurements Program, with the objective of exploring certain capabilities of active imaging systems. AMOR provides a cost-effective test bed for extensive data collection and for component/concept validation and verification.

AMOR utilizes reflective optics, which are essentially two 80-power telescopes, to optically construct the far field. A two-meter diameter primary mirror is the only common optical element between the transmitter telescope and the receiver telescope. Minimizing the number of common transmitter and receiver optical elements is essential to reduce stray light problems. The separate transmitter and receiver optical trains result in a 1 milliradian bi-static angle. The optics are mounted on a concrete platform which is vibrationally isolated from the building. The target mount is capable of translating and rotating targets.

AMOR performs large cross section (2 meter) measurements at 10.6, 1.06, and 0.53 micrometer wavelengths on tactical and strategic targets. In addition, range and Doppler resolved signature are obtained at AMOR. Current capability has been expanded to allow simultaneous active and passive sensor testing.

POC: Mr. Rodney Robertson, MDSTC; (205) 955-3795; PMA A1161/A3360

Extended Air Defense Test Bed (EADTB). The EADTB offers a breadth of scope from the fire-unit level up to theater level in a constructive simulation framework. An object-based simulation architecture supports this breadth of applicability by allowing the user to develop system models called specific system representations (SSRs). The user can then place numbers of these simulated systems on a host gameboard without a requirement for rewrite of other existing system models or modification of the supporting architecture. The EADTB supports a wide range of levels of detail in model development and offers the flexibility of simultaneous use of high- and low-detail SSRs in a single simulation exercise. This flexibility allows the analyst to apply a high-detail SSR to simulate a key system, such as a THAAD/PATRIOT enclave at a critical location, while simulating the surrounding theater context with a lower-detail and/or higher-aggregation representation. Thus, the EADTB can simultaneously assess both system performance and value added at a higher echelon, reducing the need for multiple simulations and the attendant requirement for model harmonization. The rule-set based EADTB SSR language will support growth beyond Extended Air Defense to explicitly model both surface warfare and NMD at a similarly wide range of levels of detail and aggregation. By placing model-development power in the hands of users, the EADTB has stimulated the ongoing development of a range of system models by system proponent agencies across all three Services. These proponent agencies will certify their EADTB models for a documented range of uses and contribute them to SSR library, which will be accessible to other EADTB users. The EADTB will thus become the first simulation to offer access to a library of system models contributed and certified by a diverse group of joint-service and, potentially, international sources.

The combination of an object-based framework, flexibility in level of model detail, promotion of the sharing of certified models, and Distributed Interactive Simulation (DIS) compliance will provide a number of benefits to EADTB users:

- Avoidance of duplication of development efforts
- Greater flexibility in scenario definition, especially for DIS exercises
- Reduction in the number of simulations required in broad-scope studies

- Simplification of the accreditation process
- Resultant time and cost savings

The EADTB is rapidly moving towards the assumption of these roles for the joint and international TMD community.

POC: LTC P. Macklin, USASSDC; (205) 955-4883; PMA A3352

Extended Air Defense Simulation (EADSIM). EADSIM is a workstation-hosted, system-level simulation which is used by combat developers, materiel developers, and operational commanders to assess the effectiveness of TMD and air defense systems against the full spectrum of extended air defense threats. EADSIM provides a many-on-many theater-level simulation of air and missile warfare, an integrated analysis tool to support joint and combined force operations, and a tool to augment maneuver force exercises at all echelons with realistic air defense training.

EADSIM is used by operational commanders, trainers, and analysts to model the performance and predict the effectiveness of ballistic missiles, surface-to-air missiles, aircraft, and cruise missiles in a variety of user-developed scenarios. EADSIM supports the four pillars of TMD in a full tactical context by modeling: (1) Active Defense [Surface-to-Air engagements, Air-to-Air engagements, Multi-tier engagements, and TBM engagements (boost, midcourse, terminal phases)]; (2) Passive Defense (IR and Radar signature); (3) Attack Operations (Surface-to-Surface attacks, Air-to-Surface attacks, Surveillance, and Intelligence collection); and (4) BM/C4I (Engagement logic, Command and Control structure, Communications networks, and Protocols).

EADSIM models fixed- and rotary-wind aircraft, tactical ballistic missiles, cruise missiles, infrared and radar sensors, satellites, command and control structures, sensor and communications jammers, communications networks and devices, and fire support in a dynamic environment which includes the effects of terrain and attrition on the outcome of the battle. EADSIM can easily be confederated with campaign-level models such as the Corps Battle Simulation and Vector-in-Commander, with high-fidelity models such as BRAWLER, and with virtual simulators such as the TI Reconfigurable Simulator configured as a Bradley Stinger Fighting Vehicle.

Automatic Target Recognition (ATR) Virtual Prototype. The MDBIC has initiated an effort to develop an ATR workstation, within a Silicon Graphics Computer, that emulates an ATR suite of equipment normally found at National-level agencies. The ATR emulation will consolidate both ATRs and decision aids into a Virtual Prototype within the Force Projection TOC or its equivalent Echelon Above Corps TOC. The purpose is to provide an imagery analysis and cruise missile detection/discrimination capability to a Corps or Division Commander by direct sensor to TOC down-links and thus expedite the BMC3 process. The ATR Virtual Prototype will be DIS compatible with the MDBIC synthetic battlefield environment and when operational will determine the optimum echelon placement of the capability to support TMD operations. The need for this capability arises from past experience where ground target imagery and target location was often too late to attack hostile targets. The ATR workstation will employ numerous ATR algorithms to extract multi-spectral CCD targets from their clutter background. The work station will also employ discriminants to rapidly identify cruise missiles, aircraft, and ballistic missiles from RSTA sensors that are either airborne (i.e., Aerostat) or ground-based such as the PATRIOT, THAAD, Corps SAM/MEADS, and GBS air defense radars. This effort is a coordinated effort with the Army Modeling and Simulation Office as a SIMTECH initiative.

POC: Mr. Rick Berg, USASSDC; (205) 955-3508

High Energy Laser Systems Test Facility (HELSTF). HELSTF has been managed by USASSDC since October 1990. It has a four-part mission: (1) support Army and DoD high energy laser Research, Development, Test, and Evaluation (RDT&E); (2) develop, integrate, and operate high energy lasers and related instrumentation, facilities, and support systems; (3) conduct and evaluate laser effects tests on materials, components, subsystems, systems, and weapons; and (4) provide a limited Anti-Satellite (ASAT) contingency capability, if called upon. HELSTF is a multi-service facility with representatives from the Navy and Air Force on site.

HELSTF became operational on 6 September 1985 when the Air Force conducted the first Lethality and Target Hardening program test for the BMDO. Since then, HELSTF has provided test support to DoD, NASA, industry, universities, and foreign governments under appropriate user agreements. The facility has a wide variety of test capabilities, including non-laser vacuum testing of space vehicles and high-speed, high-resolution IR tracking of missiles and target intercepts.

The Mid-Infrared Advanced Chemical Laser (MIRACL) is the workhorse laser for the site and is the only high energy laser operating in the free world. The associated Sea Lite Beam Director (SLBD) is the only laser beam director capable of transmitting a high energy laser beam. The SLBD provides extremely high pointing and tracking accuracies required for near earth orbit object tracking.

The Pulsed Laser Vulnerability Test System is a threat surrogate laser system for testing the vulnerability and susceptibility of U.S. systems to potential enemy directed energy systems. Two other chemical lasers, the Laser Development Device and the Low Power Chemical Laser, provide a wide spectrum of power levels and exposures for high energy laser customer research, development, test, and evaluation.

The instrumentation at the site is the most extensive in the United States. The Army Research Laboratory (ARL) supports the site with a full meteorological research and development station with numerous specialized instruments for laser propagation prediction and characterization. Laser diagnostics are on hand to measure and characterize the laser beam and its effects on the targets. Data processing is available for all data acquisition as well as post-test analysis.

HELSTF is ideally suited to explore concepts of directed energy weapons employment without the need to develop all new laser systems. The location at WSMR is the only instrumented laser range in the free world capable of engaging flying targets with high energy lasers. The WSMR support provides all of the assets of the range, which includes the most advanced optical and radar tracking systems available. Communications and data links with the Army Space Operations Center provide real time satellite communications and tracking for the customer. Command and control procedures may also be exercised over those links for end-to-end systems testing. The wide range of capabilities at HELSTF makes it able to support a broad range of DoD system applications related to optical systems, space environment, atmospheric propagation, KE and directed energy system concept demonstrations, and all ranges of laser operations and tests. Future expansion of HELSTF will include the addition of more advanced lasers now in development and further advances in laser beam propagation using atmospheric compensation systems.

A program to increase utilization of HELSTF is the High Energy Laser Light Opportunity (HELLO). It is a grouping of experiments from academia, industry, and OGAs. The first test, performed in September 1994, was conducted by California Institute of Technology, Phillips Petroleum, Sandia National Laboratory, and the Army Research Laboratory. In order to increase its flexibility and responsiveness to its customers, HELSTF expanded the HELLO program in August 1995 from one test to an ongoing series of tests. Instead of a specific date, HELLO will now be an open-ended invitation.

POC: Mr. Kenneth White, USASSDC; (505) 679-5538

Tools to Facilitate the Rapid Assembly of Missile Engagement Simulations (TFRAMES). Originally developed under the Kinetic Energy Weapon (KEW) Digital Emulation Center (KDEC), an analysis center supporting the evaluation of weapon technologies and interceptor performance, TFRAMES is a software development tool that minimizes the time and effort to go from missile model formulation to working simulations. Running on virtually any platform, TFRAMES has been used for a number of applications from a small fly-out tool, mini-rocket, which serves as a support tool for EADSIM, to use in development of BMDO's next standard threat generation model to be used by NASA in modeling the X-33.

POC: Mr. Jeff Randorf, USASSDC; (205) 955-3854

Lexington Discrimination System (LDS) Test Bed. The LDS test bed, located at MIT/Lincoln Laboratory in Lexington, MA, uses actual filed data to test discrimination algorithms and architectures in real time. This is the only such test bed available to the BMD community. Development began in FY85 and, after demonstrating the first real-time imaging of satellites at Kwajalein in FY87, emphasis shifted to development of a real-time radar algorithm test bed using staged data from the COBRA JUDY sensor. Algorithm development, testing, and evaluation produced the basis of today's advanced test bed. The LDS now allows automated real-time switching of a set of active or passive algorithms (forming a real-time algorithm architecture) to determine the identity of a single target from the threat train. The new LDS will also support sensor resource allocation studies. A study has indicated that the LDS could serve as an end-to-end element discrimination test bed, with elements testing their individual algorithms from subsystems connected directly to LDS. This idea is currently under consideration by BMDO.

POC: Mr. Patrick A. Tilley, MDSTC; (205) 955-3885; PMA A1155.03 & .13

Mosaic Optical Sensor Technology Test Bed (MOSTT). The MOSTT Program test facilities support the development, characterization, testing, and calibration of low background, IR surveillance sensors and interceptor seekers. These test facilities consist of the Portable Optical Sensor Testbed (POST) chamber and the Characterization of Advanced Low background Mosaics (CALM) chamber. The POST Chamber is a low background (20 degrees K, hard vacuum) IR sensor test chamber which has characterized/calibrated several important BMDO flight sensors including DOT, AOA/AST, and Queen Match. It is currently supporting the GBI program contractors and will be used to support the SMTS program in FY97. The CALM chamber is a low background (20 degrees K, hard vacuum) IR detector FPA test chamber. It is the only known FPA test chamber which can accurately scan a spot across an FPA at operational scan rates under low background conditions. It has served a critical role in the development of the high sensitivity Arsenic doped Silicon mosaic detector technology. These test facilities are government owned and contractor operated. In conjunction with the MOSTT contractor activities, the effort involves the U.S. Navy Naval Research and Development (NRaD) infrared and radiation test facilities in San Diego, CA. The NRaD activity focuses on performing optical characterization and radiometric measurements in a radiation environment on optical materials and full scale components.

POC: Mr. Clyde Elliott, MDSTC; (205) 955-3757; PMA A3360.01 &.11

Surveillance Test Bed (STB). The STB is a high-fidelity surveillance system simulation that generates performance assessment by modeling in detail the surveillance functions, radar and optical sensors, signal and data processing, targets, and environments. The STB is being developed at the Advanced Research Center (ARC) to conduct system demonstration/validation experiments to address MD/TMD surveillance issues, concerns, potential risks, and requirements definition. The surveillance functions included in the STB are detection, acquisition, track, association/correlation, bulk filtering, discrimination, data fusion, and sensor tasking. These functions are represented by algorithms called test articles (TAs). The STB consists of two major parts: the test environment and the TAs. The test environment generates the necessary information to exercise the TAs, provides for the necessary logging of data, and displays the desired measures of effectiveness and performance after test execution.

POC: Mr. Henry Hollman, MDSTC; (205) 955-5458

U.S. Army Kwajalein Atoll/Kwajalein Missile Range (USAKA/ KMR). Kwajalein Missile Range (KMR) is an element of the DoD Major Range and Test Facility base managed by the USASSDC under DoD Directive 3200.11. KMR supports missile defense research and technology programs for USASSDC and the BMDO as well as strategic offensive weapons system development and operational testing conducted by the U.S. Air Force and the U.S. Navy. KMR also assists in tracking and monitoring NASA space missions and provides deep-space surveillance and object identification for the USSPACECOM. Current testing emphasis is on theater ballistic missile discrimination in the radio, infrared and visual spectral frequencies, and on NMD C3 and interceptor seeker technology systems.

KMR is located on the U.S. Army Kwajalein Atoll in the Republic of the Marshall Islands in the Central Pacific, approximately 2100 nautical miles southwest of Hawaii. It is the home of some of the world's most sophisticated data gathering devices, offering a diverse mixture of radar, telemetry, and optical sensors to observe and record ballistic reentry vehicles, and to accumulate target signature data bases for BMD applications.

KMR is comprised of a group of data collection, command and control, and support instrumentation located on eight islands within the Atoll and a data reduction facility at Lexington, MA. KMR's general instrumentation is comprised of those assets found on most major ranges to include S-band telemetry, optics, C-band tracking radars (FPQ-19 and MPS-36), impact scoring, range safety, communications, and support functions such as calibration and photographic laboratories. In addition to the general instrumentation, KMR has one-of-a-kind video systems and high-powered radars. The latter, located at the Kiernan Reentry Measurements Site, consists of ALCOR, a 3 Mw, C-Band observables radar; ALTAIR, a 7 Mw, UHF/VHF radar; MMW, a 60 kw radar operating at Ka- and W-bands; and TRADEX, a 2 Mw radar operating at S- and L-bands. These radars are capable of independent or fully integrated operation via the Kwajalein Mission Control Center.

POC: Mr. Les Jones, USASSDC; (205) 955-1874

C. Other Supporting Capabilities

Advanced Research Center (ARC). The ARC is a contractor-operated computer facility located in Huntsville, Alabama. The ARC's mission is to provide a highly flexible, cost effective research and computational test bed to support missile defense programs to include TMD, NMD, BMC3, and other advanced technology simulations and experiments in support of MD. The ARC concept has evolved from over 20 years experience in test bed research, development, and use; first in support of the U.S. Army BMD program and more recently in support of the BMDO. The ARC facility contains a variety of Government owned hardware resources consisting of general purpose application development processors providing a wide range of architectures. Computer architectures consist of high speed vector and scalar uniprocessors, tightly coupled parallel processors, and graphic workstations. These resources can be configured to support a variety of experiments or developmental activities.

The ARC provides a distributed processing environment via a number of networking schemes. The ARC serves as a node of the BMDO's Joint National Test Bed and provides resources and support for distributed experimentation across the NTB network. A T3 link connects the ARC to the USASSDC Simulation Center. Other links exist from the ARC to development contractors' facilities.

The ARC has a sophisticated set of audio/visual capabilities. Video input from terminals and graphics consoles can be displayed on large screen displays providing recording and display capability for conferences and demonstrations. The Experiment Control Center is an example of how this capability can be used to support commanders and battle staffs in the execution of real-time experiments. This provides USASSDC with a distributed multi-processor test bed through interfaces to simulated battle management functions providing insight into critical human-in-control issues, algorithm performance, and experimentation analysis.

The ARC supports a small laboratory facility for evaluation and integration of advances in computing. Current areas of research include Virtual Reality and Parallel Programming schemes that use Artificial Intelligence (AI) techniques such as genetic algorithms and neural networks for processor scheduling.

Activities currently supported at the ARC include:

- BMC3 Architecture Development and Evaluation
- Real-Time Algorithm Design and Development
- Prototype Processing Hardware Evaluation
- Software Engineering Methodology and Tool Development
- TMD and NMD Technology Evaluations
- Man-Machine Interface Development
- Integrated Hardware/Software Experimentation and Demonstration
- Missile Defense Scientific and Technical Information Center (MDSC)
- TMD and NMD Weapon and Sensor Development and Evaluation
- EADTB and TMD Interoperability
- ARC Advanced Technology Evaluation and Integration Lab

Numerous government organizations, represented by over 60 contractors, use ARC resources for problem analysis and resolution. The ARC serves 800 different customers worldwide. A hardware and software engineering staff provide design and implementation support for unique user requirements.

POC: Mr. Paro Perrett, MDBIC; (205) 955-3921; PMA A3352.02/12

Missile Defense Data Center (MDDC). The MDDC is managed and operated under the control of the Sensors Directorate. The MDDC's main computer facility is located at Teledyne Brown Engineering. The mission of the MDDC is to provide the BMDO approved scientific and academic community with access to information collected by BMDO measurement programs, to provide multi-mission, multi-sensor data fusion capability, and to provide storage and dissemination of past, present, and future data relevant to the missile defense activities of the United States and allied nations. It is chartered to serve as a centralized repository for these programs and to maintain state-of-the-art facilities for the community and the programs.

The Center is responsible for: mission support; maintaining the document library; development, installation, operation, and maintenance of the science data bases; data distribution; user training; and overall technical support for the missions.

The MDDC offers a number of unique services for its users and customers. Included among these services are: (1) Real time digitization and storage of video data (3200 continuous frames); (2) Telemetry processing for Pulse Code Modulation and Pulse Amplitude Modulation encoded analog data; (3) Special security processing capabilities; (4) Automated data ingestion for mission support; and (5) Support for very large, online database applications.

BMDO continually reevaluates its experimental requirements, thereby adding and deleting programs assigned to the MDDC. Currently, BMDO has assigned the data management activities for 120 programs to MDDC, including STORM, Corps SAM/MEADS, PATRIOT PAC-3, THAAD, MSX, GBI, AST, HALO, and many others.

The MDDC has extensive experience in data management. Mission support teams interface with measurement programs to assist in establishing requirements and procedures for capturing supporting data, developing data reduction strategies, verifying data integrity, archiving data products, and distributing data products and documents. The MDDC's Data Management staff has working agreements and relationships with more than 120 national ranges, test facilities, supporting platforms, and orbiting resources.

The MDDC has an in-house software development team dedicated to meeting the needs of the user community as well as the day-to-day operations of the data center. The MDDC is known nationally for the development of the integrated software system for the ingestion of mission data—DADS (Digital Automated Data System). This system has enhanced the data management process by automating the generation, population, and access to mission databases. DADS organized the structure, definitions, and information on all data delivered from an experiment and stores the information in a centralized database that is used as an interactive tool to generate on-line databases.

POC: Ms. Barbara Rogers, MDSTC; (205) 955-1518; PMA A1155

Optical Discrimination Algorithms (ODA) Development Center. The ODA Development Center is a multi-contractor facility housing a wide array of networked Silicon Graphics computer hardware. Numerous simulation, modeling, and analysis tools are resident at the Center to facilitate robust and rapid analysis and algorithm development activity. The majority of the ODA Program's work is performed at the ODA Development Center.

The ODA Program objectives are to analyze optical data and to develop discrimination algorithms. The analysis of optical data is performed in order to understand the physics and phenomenology of objects likely to be encountered in missile defense or theater defense scenarios. The data collected on domestic flights is analyzed in order to determine how objects (representing warheads, decoys, associated objects, etc.), behave in terms of radiometrics (optical thermal behavior) and metrics (dynamic behavior). The fundamental goal of data analysis is to determine what the sensor "saw" and why the objects appeared to the sensor as they did. The understanding of this optical data is critical to the development of discrimination algorithms that can discern between lethal and non-lethal objects in a real defense scenario. ODA frequently produces pre-flight signature predictions for domestic flights in order to assist in mission planning (e.g., determine optimal placement of sensor platforms), to determine potential mission anomalies before actual flight, and to determine how the optical data "should" appear when it is collected.

ODA also analyzes data collected on foreign targets. The purpose of this analysis is to characterize the threat systems that may eventually be encountered in a theater or missile defense scenario. The knowledge gained in characterizing these objects is applied to allow defense systems to properly identify and designate lethal objects.

ODA develops and evaluates discrimination algorithms, which are the signal processing elements that allow a defense element or system to differentiate between lethal and non-lethal objects. The discrimination process is essential to a defense system because it prevents the waste of expensive interceptors on non-lethal objects and provides a high degree of confidence that all lethal objects will be intercepted. Discrimination algorithms are the cornerstone to the discrimination process. The ODA program uses the knowledge gained through the analysis of data, both foreign and domestic, to identify discriminants and to develop discrimination techniques that are applied in discrimination algorithms.

The ODA program makes its work available to the defense community through several products, including (1) The Discrimination Algorithm Catalog, a five-volume compendium of available discrimination algorithms and discrimination technology; (2) The Optical Data Analysis Journal, a bi-annual publication that documents current and relevant results of ODA's optical data analysis activity; (3) The Target Signatures Handbook, describing the validated computer construction (simulation) of targets of interest to the community; and (4) ODA Conferences, semi-annual three-day conferences in which ODA and related discrimination and data analyses are presented to the defense community.

POC: Mr. Mike Lash, MDSTC; (205) 955-3872; PMA A1155

Simulation Center (SC). The Simulation Center was established in 1981 to provide USASSDC access to high-speed computers. Since its inception, the SC has worked to provide stable and reliable computer support to the entire range of BMDO scientists and engineers. The SC is a contractor-operated facility located in the USASSDC building in Huntsville, AL. Unclassified and classified processing activities are accommodated utilizing many connectivity methods. The SC is staffed to provide expert help for users with its operating systems, optimization techniques, communications, and debugging code problems. The SC computations resources are available to BMDO and its contractors for program development, testing, and production. The type of code being produced by users at the SC include Computation Fluid Dynamics, Aero-Optical Quality, Jet Interaction Performance, and Impact Dynamics.

There are currently three Cray UNICOS computers operations within the SC, along with unclassified computer platforms that share a common file system. The Cray and AXP processors, along with several UNIX workstations, provide a wide range of hardware and software capabilities to support a broad spectrum of USASSDC and BMDO activities. Some of these programs include PAC-3, THAAD, Arrow, and NMD.

The SC Scientific Visualization Suite (SVS) is a multi-purpose facility available to all users for code development, training sessions, and demonstrations. The SVS is supported by four Silicon Graphics workstations, two Sun workstations, two electrohome large screen projectors, and an audio system. The SVS is connected to all other SC resources to provide a flexible system that can be configured to special requirements.

The SC has unclassified and classified connectivity to the Advanced Research Center. The SC is also connected to the Interim Defense Research and Engineering

Network for unclassified processing. Future plans include a classified connection to IDREN.

POC: Ms. Claudette Owens, MDBIC; (205) 955-4538; PMA A3352.02/12

Spatial Weapons System Analysis (SWSA) Center. The SWSA Center is an automated tool using geographic information system technology to proactively support OSD, BMDO, USASSDC, and contracts with military applications disciplines during all phases of the weapon system acquisition process. The SWSA Center supports requests from OSD, BMDO, USASSDC, and other government organizations for spatial weapons system analysis. Also, satellite imagery processing and aerial photograph processing is promoted. These efforts result in the prevention of weapon system breakage which occurred previously due to not considering all the real Earth constraints and opportunities. The SWSA Center uses the two major data types (vector and raster) in geographic information systems technology. This gives SWSA a wider range of data sources, and a broader scope for analysis. Most of the data used is already in digital form, which gives SWSA the advantage of quicker processing. The Center also has the technology and capability to acquire and process data not already in digital form. An extensive library of databases covering the world, plus trained analysts with security clearances, completes the SWSA Center's capabilities to provide rapid response to requirements.

POC: Mr. Robert Baker, MDBIC; (205) 955-3327

V. TECHNOLOGY TRANSFER

A. Introduction

One of the more notable benefits of technology development at the USASSDC is technology transfer. The command defines Technology Transfer (T2) as the application of scientific and technological capabilities to fields of endeavor other than those for which they were developed. USASSDC is committed to transferring and facilitating access of USASSDC-developed technology to enhance our nation's defense, economy, and competitiveness. USASSDC is required by law to establish an Office of Research and Technology Application for acting as contacts for T2 and executing a T2 program as an R&D activity. The ORTA for USASSDC is located in the Program Analysis & Integration Directorate at MDSTC.

Legal Mechanisms used to accomplish the T2 process include Cooperative Research and Development Agreements (CRDAs), Patent Licensing Agreements (PLAs), spinoff technologies from the Small Business Innovative Research (SBIR) program, and Memorandums of Understanding (MOUs). In relation to the SBIR program, there is a new two-year pilot program called Fast Track. The intent of this program is to support, by early award of a phase II contract, those companies which, during the high risk phase I effort, attract independent third-party private sector funding. T2 tools used to facilitate the T2 process include the Automated Technology Catalog, Patent and Dual-Use Catalogs, T2 brochures, workshops, and newsletters.

B. USASSDC's Technology Transfer Functions

USASSDC's T2 program has several tools in place in order to effectively transfer technology to other government agencies, academia, and industry. They create a proactive environment for both networking and developing new avenues for technology transfer. **Figure D-2** depicts the elements that USASSDC incorporates into its technology transfer program.

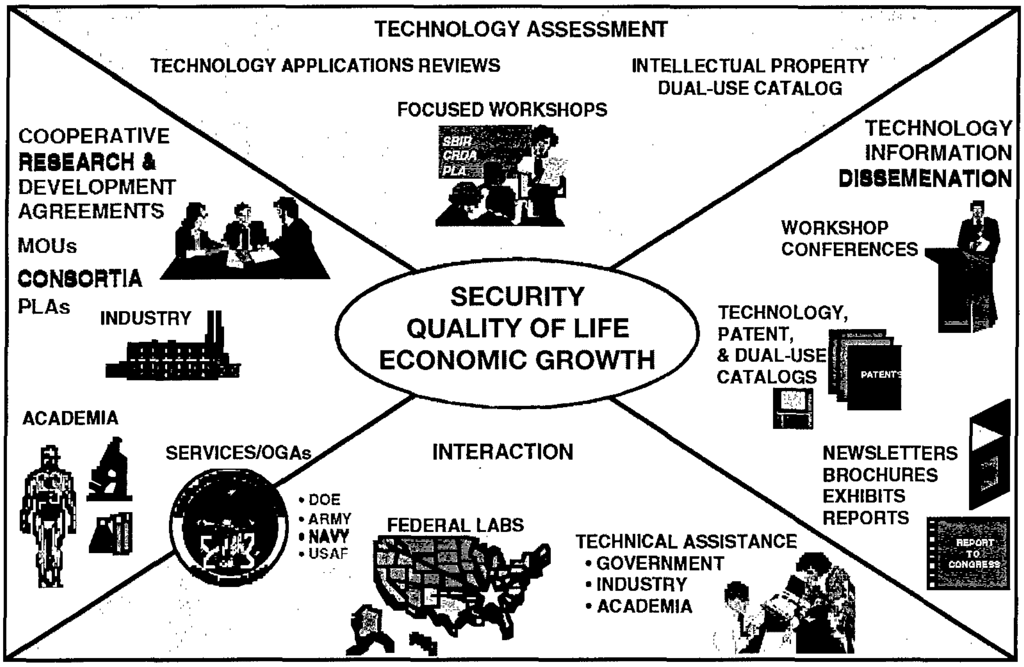


Figure D-2. USASSDC Technology Transfer Program

Below are the T2 functions of USASSDC's plan and how those functions are supported:

(1) *Assess Specific USASSDC Technologies for Transfer.* Accomplishing this function includes reviewing ongoing efforts through the Automated

Technology Catalog (ATC); determining possible applications of technologies by interacting with technical personnel, participating in technical reviews, reviewing the Dual-Use Catalog, and determining the technology needs.

(2) *Disseminate Information on USASSDC Technologies.* USASSDC has a wide range of communications media used for disseminating information and data to technology users. This is conducted through T2 workshops, technical presentations (Army Science Conference, T2 Society Conference, other professional society conferences, and public media), publications (ATC, Dual-Use and Patent Catalogs, brochures, newsletters, and technical papers), and multimedia presentations. Various T2 tools help to facilitate the T2 process. The ATC contains comprehensive and detailed technology information and data to include descriptions, points of contact, objectives, schedules, and applications. The Dual-Use Catalog contains information on technologies that have both commercial and defense applications. The Patent Catalog offers complete narrative information on patents available for licensing. The Technology Network outlines ongoing technology transfer events and technologies that have matured into commercial products.

(3) *Networking and Interaction with Other Government Agencies, Academia, and Private Industry.* Within the federal government, there is networking with the Departments of Transportation and Energy, the Federal Laboratory Consortium (FLC), National Technology Transfer Center, and NASA. Within the state and local government, there is networking with the Chambers of Commerce and Small Business Development Centers. Through the Huntsville/Madison County Chamber of Commerce, USASSDC provides technical consultation and assistance to local industry. Thus far, the Command has responded to over 40 industry problem statements and requests. Interactions with Academia are conducted through Co-Op Programs, adjunct facilities, and cooperative research. Private industry has communication links with USASSDC through Cooperative Research and Development Agreements (CRDAs), Memorandums of Understanding (MOUs), licensing agreements, and the Technology Transfer Society.

(4) *Use T2 Mechanisms to Pursue Opportunities for Cooperative Agreements.* One tool used to identify opportunities for cooperative agreements is by reviewing the Small Business Innovative Research (SBIR) Program. These programs are an important source since commercial potential is a consideration during award of SBIR contracts. USASSDC is currently managing nearly 200 SBIR contracts consisting of a broad spectrum of technologies. Examples of successful transfers from the SBIR program are described in the spinoff section. The most common mechanisms used by USASSDC include CRDAs, MOUs, and Patent and Licensing Agreements (PLAs). A CRDA is an agreement between one or more federal laboratories and one or more non-

federal parties in which both participants can provide personnel, services, facilities, or equipment for the conduct of specified research and development. Although the non-federal party may also provide funding, the federal laboratory cannot provide direct funding. USASSDC has several partnering agreements, including the Alliance for Optical Technology, Huntsville Incubator Program, Disaster Preparedness, and CRDAs with industry and academia.

C. Spinoffs

"Spin-off technology" is the term used for those technologies already developed for defense purposes which also demonstrate non-defense, commercial applications. The USASSDC is very actively involved in the transfer of technologies to other federal agencies, industry, and academia. The following write-ups present a summary of several of these transfers and ongoing activities and agreements.

Neural Net for Cancer Screen. Representing a milestone in automated image processing, a neural network can now help discover cervical cancers once routinely missed. Related to technology developed for BMDO through USASSDC by HNC Software, Inc., the network is the basis of the PAPNET Testing System. The PAPNET System is a product of Neuromedical Systems, Inc., and represents the culmination of an eight-year effort to improve the existing Pap test. Powerful and fast neural network algorithms help to quickly identify the signs of malignancy in cell clusters. With the PAPNET test, cytology labs can increase the total detection of abnormalities by up to 30 percent. The system was cleared for use by the FDA in November 1995 and is being used in more than 40 U.S. clinics and 15 countries.

HNC developed neural network technology for BMDO through USASSDC. Neuromedical Systems, which acquired its neural network developer from HNC, holds a patent for the application of neural networks.

Acousto Optic Tunable Filters (AOTFs). The Acousto Optic Tunable Filter (AOTF) is a dual use technology evolving with BMDO SBIR programs with Ciencia, Inc., of Hartford, Connecticut. Military applications for the AOTF include target interrogation sensors for the detection and use of target discriminants defined by intensity, contrast, and polarization.

Ciencia's AOTF technologies include: an AOTF-controlled flow cytometer for the Biological Integrated Detection System (BIDS) to detect, analyze, and classify battlefield chemical and biological agents (The BIDS is a U.S. Army Chemical and Biological

Defense Agency program prompted by Operation Desert Storm); an AOTF-based spectrofluorometer for NASA and NIH cell culture devices; an AOTF-based lightweight digital x-ray imager (an Army program); and an AOTF-based on-line process controller (a DOE program). Ciencia's AOTF is being used by FMC Corporation for on-line processing of chemicals and by Sunkist Growers, Inc., for detecting mold on citrus fruit. New Cienica business will supply Beckman Instruments with an AOTF for clinical analyzers and CREO Products, a Canadian-based business, with a specialized AO modulator. Ciencia is pursuing markets to provide environmental monitoring and waste management devices.

In addition to the technology developed at Ciencia, Brimrose Corp. of America, based in Baltimore, has created an AOTF-based, non-invasive sensor that can measure blood sugar levels. The work at Brimrose was based on research originally sponsored by BMDO. They have also developed an AOTF-based spectrometer that can read changes in the body's calcium levels to help predict heart attacks and strokes. The device also has potential for environmental monitoring.

Electronics Technology (A/D Converter). The Sensors Directorate at the MDSTC is developing high performance 10 and 12 bit analog-to-digital converters (ADCs) to meet strategic system requirements for analog signal processing. The commercial world is benefiting from this research by the devices being incorporated into applications ranging from high speed modems, film scanners, medical ultrasound, and x-ray, plus pro video cameras.

Analog Devices, the contractor for this technology, has released for commercial sales three ADC mega sample per second (MSPS) device designs: the AD773 (10 bit, 18/20MSPS); AD872 (12 bit, 10 MSPS); and AD973 (10 bit, 18 MSPS) ADCs. Customers include Alcatel Network Systems, Texas Instruments, Eastman Kodak, Hewlett Packard, Elscint Ltd., AeroJet Electrical Systems, Harris Corp., Loral Fairchild Corp., and Westinghouse.

Non-strategic military applications using these ADCs include F-16 radar upgrade, cameras, and communications. The ADCs are also used in the Comanche Helicopter FLIR systems. Potential is high for other defense systems to implement these devices. Analog Devices receives on a steady basis inquiries for technical data and engineering samples.

A new product released is a 16-bit digital-to-analog converter (DAC) that will support the proposed information Superhighway. This low power, log glitch device will provide the ability to transmit television video across the telephone lines.

Electronics Technology (Stacked Chip). Under a Phase I and Phase II SBIR, Irvine Sensors Corporation (ISC) developed an integrated chip-stacking technology for infrared on focal plane arrays (FPA). Further developments under the Weapons Directorate led to applications in interceptor technology. The technology, cubing, is a way of building three-dimensional, monolithic semiconductor devices called "cubes". The technology is also referred to as a full stack because it incorporates up to 100 chips bonded together like a slice of bread. Cubes offer a higher level of integration, faster processing speeds, and lower power requirements than current chip technology.

ISC's primary business is the development of infrared devices and high-density packages for computer electronics intended to have broad applications in military and electronics systems. The technology developed under the SBIR will be further developed through a joint manufacturing and license agreement between ISC and IBM. The initial agreement focused on the full stack technology. Since the initial agreement, Irvine has introduced the first commercial version of the 3D Memory Short Stack for use in applications with limited vertical space. Short stacks contain up to ten chips mounted like a stack of pancakes, and serves as a virtual memory chip because of its dramatic improvement in capacity over similar sized single-chip packages. The success of the short stacks, which offer the same performance benefits as the full stacks, prompted the expansion of the IBM agreement to include the short stacks. The joint development work will take place at both facilities and involve technical employees from the two companies. The unique strengths of the two companies will further enhance the technologies for more compact, powerful, and rugged computing systems. In a separate application of the chip-stacking technology, Irvine has signed a $5.2 million BMDO contract to develop a neural network sensor intended to mimic some of the recognition capabilities of the human eye and brain. This is the first phase of a planned development that will eventually lead to modules with the interconnect densities and speeds of the human brain.

After the technology was successfully demonstrated, the Advanced Research Project Agency (ARPA) provided funding to ISC to apply the technology to memory chips. The technology was successfully demonstrated and IBM formed a partnership with ISC to develop, produce, and manufacture more compact, powerful, and rugged computing systems. Under the terms of the Full Stack agreement, both IBM and Irvine can develop products and sell them externally. Under the Short Stack agreement, IBM has agreed to use the Short Stack technology for internal purposes only, and will also serve as a manufacturer of the devices for Irvine Sensors.

The Extended Air Defense Simulation (EADSIM). The arena of theater and tactical C3I has become enormously complex in recent years. With that complexity has come increasing difficulty in analyzing C3I and air defense system effectiveness, determining system impact on combat operations, and assessing the priority of emerging operational concepts. EADSIM helps both developers and potential users of new C3I and extended air defense systems to quickly, accurately, and inexpensively determine how well the design or specific employment of a system will fulfill operational requirements. Basic applications include that of assessing TMD Architectures, aircraft/cruise missile defenses, force analyses, operational effectiveness analyses, and mission area analyses. EADSIM, a government-owned model, was developed in a joint effort between USASSDC and the U.S. Army Missile Command (MICOM) as a low-cost, interim analysis capability to evaluate Extended Air Defense concepts until the EADTB could be fielded.

The EADSIM Model has been demonstrated in the commercial sector for use in applications such as drug interdiction strategies, air traffic control planning, and highway patrol communications systems. EADSIM has played an important role in systems and operational analysis by many government agencies and support contractors and has over 100 registered users. These users include: U.S. Army Air Defense Artillery School; PEO, AMD; 32nd Army Air Defense Command; BMDO; JCS, J8; USAF Studies and Analysis Agency; USAF Joint Electronic Warfare Command; USAF Tactical Air Warfare Center; Naval Strike Warfare Command; and NavAir. In addition, international users include; the United Kingdom Director, Science (BMD); SHAPE Technical Center in the Hague, Netherlands; Federal Republic of Germany Ministry of Defense, Armaments Directorate; and Israeli Ministry of Defense.

HELSTF HELLO Program. In an innovative approach to technology transfer, USASSDC made the most powerful laser in the United States located at the High Energy Laser Systems Test Facility (HELSTF) available to industry, laboratories, and academic institutions in September 1994. The program, called the High Energy Laser Light Opportunity (HELLO), was conducted at White Sands Missile Range, N.M. Twenty-three experiments were conducted in an assembly-line manner and provided with standard diagnostics, making continuous megawatt-class laser light available and affordable for the first time ever to most researchers. The laser, known as the Mid-infrared Advanced Chemical Laser (MIRACL), was originally developed by the U.S. Navy to demonstrate that ships can use laser to defend themselves against cruise missiles.

The twenty-three experiments were conducted by Phillips Petroleum, California Institute of Technology, Sandia National Laboratory, and the Army Research Laboratory (ARL). The HELLO generated two CRDAs with Phillips Petroleum and California Institute of Technology and additional experiments by Sandia and ARL. Potential spinoffs from the experiments include future manufacturing processes for hardening surface properties by changing crystal structures with high power lasers. This technology may improve the manufacturing of hardened machine parts. Another spinoff potential is the use of lasers for oil exploration. This concept has tremendous potential for increasing future oil and gas reserves by allowing for significant improvements in oil exploration techniques and drilling processes.

In order to increase its flexibility and responsiveness to its customers, HELSTF expanded the HELLO program in August 1995 from one test to an ongoing series of tests. Instead of a specific date, HELLO will now be an open-ended invitation.

Rapid Manufacturing Of Carbon/Carbon Composites. Carbon-carbon composites are materials that maintain high strength at elevated temperatures and have high thermal conductivities. These properties make this material ideal for use in aircraft brakes. Based on the number of kilograms of carbon-carbon material sold, this application represents over 90% of the market. Previous processing methods were expensive and required long periods of time to achieve a desired structure.

Under a Phase II BMDO SBIR contract managed by the USASSDC, Sioux Manufacturing Corporation is developing a process for manufacturing carbon-carbon composites. The objective of this effort is to reduce both fabrication time and cost. A preform of carbon fibers is placed in contact with the ferrofluid catalyst and set in a furnace at elevated temperatures. The methane reacts to form additional carbon depositions on the surface of the carbon fibers. Phase I experiments demonstrated that the rate of mass gain was enhanced by at least an order of magnitude on small laboratory-scale samples. As a result of the increased rate of reaction, more parts can be produced in a given time using fewer production furnaces, which results in lower capital costs.

The Phase II effort scales the processing technique to a pilot plant level for the fabrication of aircraft brake components. This effort is accomplished with BFGoodrich Supertemp as the primary commercialization partner. If the scale-up of this process is successful, i.e., the desired strength and thermal properties are achieved in less time than current fabrication techniques, then a license agreement will be negotiated to transfer this technology to BFGoodrich.

This is an excellent example of a dual-use technology with synergistic applications. Defense applications include missile nose tips, exhaust exit nozzles, and improved brakes (good friction characteristics at reduced manufacturing cost) for military aircraft. Commercial applications are targeted toward airlines and replacement brakes for standard commercial aircraft. In addition, an emerging use is for thermal doublers on circuit boards to hold high density electronic equipment.

D. Dual-Use Technologies

Dual-use technologies are those which have commercially viable applications for both defense and non-defense purposes. The USASSDC has developed a Dual-Use Catalog that lists USASSDC technologies that have identified potential applications in both the defense and commercial industries. Each record contains a description of the technology and potential technology transfer applications. For more information on this or other T2 tools available at the Command, contact Mr. Russell Alexander, USASSDC MDSTC at (205) 955-4763.

VI. ACRONYM LIST

A/D	Analog to Digital
AAR	After Action Review
ABM	Antiballistic Missile
ABO	Agents of Biological Origin
ABT	Air Breathing Threat
ACAT	Acquisition Catagory
ACTD	Advanced Concept Technology Demonstration
ACTS	Advanced Communications Technology Satellite
ADA	Air Defense Artillery
ADC	Analog-to-digital Converter
ADLT	Advanced Discriminating LADAR Technology
ADTOC	Air Defense Tactical Operations Center
AFAS	Advanced Field Artillery System
AI	Artificial Intelligence
AIT	Atmospheric Interception Technology
ALCOR	ARPA Lincoln C-Band Observables Radar

ALTAIR	ARPA Long Range Tracking and Instrumentation Radar
AMOR	Army Missile Optical Range
AMT	ACTS Mobile Terminal
AO	Acousto-Optical
AOEC	Aero Optical Evaluation Center
AOTF	Acousto-Optic Tunable Filter
ARC	Advanced Research Center
ARL	Army Research Laboratory
ARM	Anti-Radiation Missile
ARPA	Advanced Research Project Agency
ARSPACE	U.S. Army Space Command
ASARS	Advanced Synthetic Aperature Radar System
ASAT	Anti-Satellite
ASCO	Advanced Systems Concept Office
ASEDP	Army Space Exploitation Demonstration Program
ASM	Air-to-Surface Missile
ASPO	Army Space Program Office
AST	Airborne Surveillance Testbed
ASTMP	Army Science and Technology Master Plan
ASTP	Advanced Sensor Technology Program
ATC	Automated Technical Catalog
ATD	Advanced Technology Directorate
ATMD	Army Theater Missile Defense
ATR	Automatic Target Recognition
BIDS	Biological Integrated Detection System
BMC3I	Battle Management Command, Control, Communications, and Intelligence
BMC4I	Battle Management Command, Control, Communications, Computers, and Intelligence
BMD	Ballistic Missile Defense
BMDO	Ballistic Missile Defense Organization
BOA	Battlefield Ordnance Awareness
BRAT	Beyond Line of Site Reporting and Tracking

C	Centigrade
C3I	Command, Control, Communications, and Intelligence
C4I	Command, Control, Communications, Computers, and Intelligence
CALM	Characterization of Advanced LWIR Mosaic
CCD	Camouflage, Concealment, and Deception
CECOM	Communications and Electronics Command
CINC	Commander-in-Chief
CM	Cruise Missile
CONUS	Continental United States
Corps SAM/MEADS	Corps Surface-to-Air Missile/Medium Extended Air Defense System
COTS	Commercial-off-the-shelf
CRDA	Cooperative Research and Development
DAC	Digital-to-Analog Converter
DADS	Digital Automated Data System
DAGGR	Depressed Altitude Guided Gun Round
DEM/VAL	Demonstration Validation
DIS	Distributed Interactive Simulation
DITP	Discriminating Interceptor Technology Program
DoD	Department of Defense
DoE	Department of Energy
DOT	Designating Optical Tracker
DSCS	Defense Satellite Communications System
DSCSOCs	Defense Satellite Communications Systems Ops Centers
EADSIM	Extended Air Defense Simulation
EADTB	Extended Air Defense Test Bed
ECCM	Electronic Counter Countermeasure
ECM	Electronic Countermeasure
ECS	Engagement Control System
EHF	Extremely High Frequency
EKV	Exoatmospheric Kill Vehicle
EMI	Electromagnetic Interference

F	Fahrenheit
FAAD	Forward Area Air Defense
FCR	Fire Control Radar
FDA	Food and Drug Administration
FEL	Free Electron Laser
FLC	Federal Laboratory Consortium
FPA	Focal Plane Arrays
FY	Fiscal Year
GBI	Ground-Based Interceptor
GBR	Ground-Based Radar
GBR-P	Ground-Based Interceptor—Prototype
GBS	Ground-Based Sensor
GPS	Global Positioning System
GSE	Ground Support Equipment
HALO	High Altitude Observatory
HE	High Explosive
HELLO	High Energy Laser Light Opportunity
HELSTF	High Energy Laser Systems Test Facility
HEMP	High Altitude Electromagnetic Pulse
HMMWV	High Mobility, Multipurpose Wheeled Vehicle
HPM	High Powered Microwave
HTK	Hit-to-Kill
HVL	Hypervelocity Launcher
Hz	Hertz
IBM	International Business Machines
ICBM	Intercontinental Ballistic Missile
InSb	Indium Antimonide
IR	Infrared
ISC	Irvine Sensors Corporation
JCS	Joint Chiefs of Staff
JTAGS	Joint Tactical Ground Station

K	Degrees Kelvin
kb	Kilobits
kbps	Kilobits per Second
KDEC	Kinetic Energy Weapon Digital Emulation Center
KE	Kinetic Energy
KE ASAT	Kinetic Energy Anti-Satellite
KEW	Kinetic Energy Weapon
km	Kilometer
KMR	Kwajalein Missile Range
LADAR	Laser Radar
LDS	Lexington Discrimination System
LEAP	Lightweight Exoatmospheric Projectile
LWIR	Long Wavelength Infrared
MADCAP	Mosaic Array Data Compression and Processing
Mbps	Million Bits per Second
MD	Missile Defense
MDBIC	Missile Defense Battel Integration Center
MDDC	Missile Data Center
MDSTC	Missile Defense & Space Technology Center
MFL	Multiple Folded Ladar
MICOM	U.S. Army Missile Command
MIRACL	Mid-Infrared Advanced Chemical Laser
MIT	Massachusetts Institute of Technology
MLRS	Multiple Launch Rocket System
mm	Millimeter
MMIC	Monolithic Microwave Integrated Circuit
MMW	Millimeter Wave
MNS	Mission Need Statement
MOSTT	Mosaic Optical Sensor Technology Test Bed
MOU	Memorandum of Understanding
MSPS	Mega Sample Per Second

MSX	Midcourse Space Experiment
NASA	National Aeronautics and Space Administration
NAVSTAR	Navigational Satellite
NIH	National Institute of Health
nm	nanometer
NMD	National Missile Defense
NSA	National Security Agency
NTB	National Test Bed
ODA	Optical Discrimination Algorithms
OGA	Other Government Agencies
ORD	Operational Requirements Document
ORTA	Office of Research and Technology Application
OSC	Optical Signatures Code
OSD	Office of the Secretary of Defense
P3I	Pre-Planned Product Improvement
PA&ID	Program Analysis and Integration Directorate
PAC-3	PATRIOT Advanced Capability—3
PATRIOT	Phased Array Tracking to Intercept of Target
PEO	Program Executive Office
PEO AMD	Program Executive Officer for Air and Missile Defense
PET	Pilot-line Experiment Technology
PLA	Patent License Agreement
PM	Program Manager/Project Manager
PMA	Program Management Agreement
PMRF	Pacific Missile Range Facility
POC	Point of Contact
POP	Proof-of-Principle
POST	Portable Optical Sensor Tester
PtSi	Platinum Silicide
R&D	Research and Development
RadHard	Radiation Hardened

RADOT	Recording Automatic Digital Optical Tracker
RAM	Random Access Memory
RDT&E	Research, Development, Test & Engineering
RF	Radio Frequency
ROBS	Rapid Optical Beam Steering
RSTA	Reconnaissance, Surveillance, and Target Acquisition
RV	Reentry Vehicle
S/O	Survivability/Operability
S/SU/AC	System/System Upgrade/Advanced Concept
SAIP	Semi-Automated Imagery Processing
SATCOM	Satellite Communications
SATP	Space Applications Technology Program
SBE	Synthetic Battlefield Environment
SBIR	Small Business Innovative Research
SC	Simulation Center
SEO	Survivability Enhancement Option
SHAPE	Supreme Headquarters Allied Powers Europe
SiC	Silicon Carbide
SLBD	Sea Lite Beam Director
SMTS	Space and Missile Tracking System
SRAM	Static Random Access Memories
SSDC	Space & Strategic Defense Command
SSR	Specific System Representations
STARS	Strategic Target System
STB	Surveillance Test Bed
STO	Science & Technology Objective
STOW	Synthetic Theater of War
STRV	Space Technology Research Vehicle
STTR	Small Business Technology Transfer
SVS	Scientific Visualization Suite
SWSA	Spatial Weapons System Analysis

T,T&E	Targets, Test and Evaluation
T2	Technology Transfer
TA	Test Articles
TBM	Tactical Ballistic Missile
TCMP	Theater Missile Defense Critical Measurements Program
TENCAP	Tactical Exploitation of National Capabilities
TFRAMES	Tools to Facilitate the Rapid Assembly of Missile Engagement Simulations
THAAD	Theater High Altitude Area Defense
THEL	Tactical High Energy Laser
TMD	Theater Missile Defense
TOC	Tactical Operations Center
TRADEX	Target Resolution and Discrimination Experiment
TRADOC	Training and Doctrine Command
TTP	Tactics, Techniques, and Procedures
UAV	Unmanned Aerial Vehicle
UHF	Ultra High Frequency
ULSIC	Ultra Large Scale Integrated Circuit
UOES	User Operational Evaluation System
USAF	U.S. Air Force
USAKA	U.S. Army Kwajalein Atoll
USARSPACE	U.S. Army Space Command
USASSDC	U.S. Army Space and Strategic Defense Command
USCINCSPACE	United States Commander-in-Chief Space
USMC	U.S. Marine Corps
USSPACECOM	United States Space Command
VHF	Very High Frequency
VLSI	Very Large-Scale Integration
W	Watts
WSMR	White Sands Missile Range

Annex E

INTERNATIONAL ARMAMENTS STRATEGY AND NEAR-TERM FOREIGN OPPORTUNITIES

TABLE OF CONTENTS

FIGURES

TABLES

INTERNATIONAL ARMAMENTS STRATEGY

I. STRATEGIC OVERVIEW

A. Background

The Department of Defense must operate and plan for a future characterized by rapid proliferation of technological threats, uncertainty in the world order, and strong domestic pressures for significant reductions in defense spending. Deep cuts in defense spending will almost certainly continue, not only for the United States, but for our allies also. The Army faces the daunting challenge of maintaining and modernizing forces that will assure the dominance and security of U.S. ground forces in this environment. We will rely more heavily on cooperative action with our allies to meet this challenge. International armaments cooperation—consistent with the Army's technology leveraging strategy, as described in Chapter VII, Technology Transfer—has become an increasingly important part of our national strategy.

B. Vision

International military-industrial partnerships contribute to warfighting capabilities of our soldiers and our allies by maintaining a truly "world-class" technology and industrial base, built on a global-minded workforce and the best available industrial capabilities and services. As shown in Figure E-1, our International Armaments Cooperative Strategy (IACS) is a comprehensive effort to focus our diverse goals to—

Maintain a global awareness of the best technological developments and develop leveraging strategies considering the potential contributions of industry, universities, other government agencies, and international sources;

Focus data and personnel exchanges and participation in international forums to optimize benefit to the U.S. Army; and

To develop and represent in the ASTMP, senior-level guidance based on well-thought out leveraging strategies.

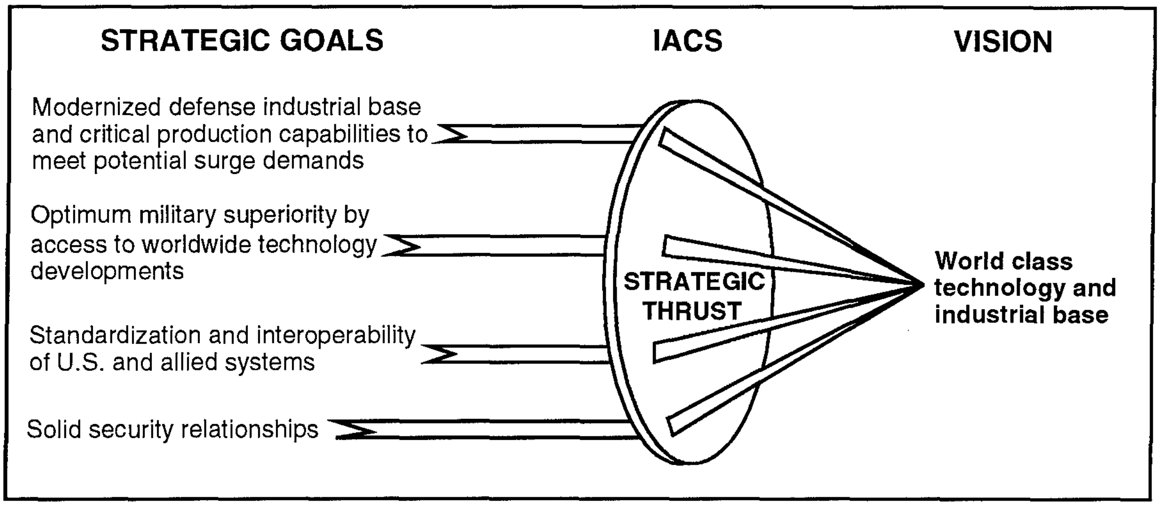


Figure E-1. The International Armaments Cooperation Strategy (IACS) Focus

C. Overview and Trends

To implement our International cooperative strategy effectively, we must be prepared to take advantage of existing capabilities and exchange mechanisms to access world-leading or potentially world-leading capabilities in other countries. At the same time we need to improve our awareness of new opportunities and significant trends in the state-of-the-art in other countries. With the spread of Internet and other modern communications links, we have unprecedented access to data from other countries. We now are evolving the tools needed to collect, evaluate, and synthesize that data in an efficient and effective way.

The following tables highlight a number of areas (also reflected in Table E-1 of the International Cooperative Opportunities in Chapter VII of the ASTMP) where significant potential for cooperation exists. Table E.I-1 highlights some of the stronger prospects selected from Section E.II, which discusses potential opportunities of other countries to contribute within the next three-to-six years to the near-to-mid-term milestones identified in Chapter IV of the ASTMP. Table E.I-2 highlights basic research areas where capabilities abroad may provide a basis for longer-term cooperation.

Table E.I-1. Highlighted Near/Mid-Term Opportunities

TECHNOLOGY (Ref. to E.II)	UNITED KINGDOM	FRANCE	GERMANY	OTHER COUNTRIES	JAPAN	PACIFIC RIM	FSU
B. Aerospace Propulsion and Power	Gas turbine engines, High performance transmission	High temperature structures, Bearingless rotor hub	Bearingless rotor hub, Composite and high-strength shafting				
C. Air and Space Systems	Composite structures, FADEC, Rotor systems	Adaptive controls, Fly-by-light, Crash survivability	Smart structures, Fatigue		Ceramics, Composite materials and structures		
D. Nuclear, Biological and Chemical Defense	Chemical agent sensors	CBW agent sensors, Vehicle systems, Electronic decontamination	Detection systems	**Canada** Detection systems	Detection systems		
E. Individual Survivability and Sustainability	Soldier systems (physiological and psychological)	Soldier systems (ballistic protection)	Soldier systems	**Canada** Soldier systems (microclimate control)	Electric power for manportable systems	**AU** Soldier systems (carriage)	
F. Command, Control and Communications	Battlefield interoperability, Natural language processing, Intelligent systems	Battlefield interoperability, Distributed real-time communications, Switching systems, Machine translation, C2 simulation, Mission Planning	Communication networks, Battlefield interoperability, Machine translation, Natural language processing	**Netherlands** Natural language processing, Knowledgebase and database science	Fuzzy logic, High-speed communications		
G. Computing and Software	Massively parallel processing, Optical switching, Visually-coupled interfaces	Optical processing, Fiberoptic networks, Visually-coupled interfaces	Massively parallel processing, Neural networks, Visually-coupled interfaces	**Canada** Visually-coupled interfaces, Large data set representation	Neural networks, Optical switching and networks, Visually-coupled interfaces		
H. Conventional Weapons	Overall strength, ETC gun	Overall strength	Overall strength, ETC gun	**Israel** ETC gun, BMD missile			**Russia** Overall strength
I. Electronic Devices		IR focal plane arrays, MMIC components, Compound semiconductors, Batteries	MMIC compounds, Compound semiconductors, Small engines		All aspects		**Russia** Molecular electronics, Power switching, Rechargeable batteries
J. Electronic Warfare and Directed Energy Weapons	Low energy lasers	Laser materials			High and low energy lasers		**Russia** High power microwaves, High energy lasers, **Ukraine** High power microwaves
K. Civil Engineering and Environmental Quality	Environmental protection, Bioremediation, Lightweight bridging	Environmental protection, Bioremediation, Demilitarization of energetic materials	Environmental protection, Bioremediation	**Nordic Group** Environmental protection, Bioremediation	Environmental protection, Bioremediation		
L. Battlespace Environment	Overall capability	Overall capability, Remote sensors	Overall capability	**Israel** Atmospheric effects **Canada** Atmospheric dispersion	Remote sensing, Robotics		
M. Human System Interfaces	VR interfaces, Performance models	Displays, Ergonomics, Performance models	Soldier system interfaces, Performance models	**Canada** VCR displays	Displays, VR, Robotics		

(Continued)

Table E.I-1. Highlighted Near/Mid-Term Opportunities (Continued)

TECHNOLOGY (Ref. to E.II)	UNITED KINGDOM	FRANCE	GERMANY	OTHER COUNTRIES	JAPAN	PACIFIC RIM	FSU
N. Manpower, Personnel and Training	Good overall capabilities, Dynamic training and simulation	Good overall capabilities, Dynamic training and simulation	Good overall capabilities	**Canada** Simulation and displays	Ceramics, Composites, Polymer processing		
O. Materials, Processes and Structures	Welding and joining, Alloys and composites, Lightweight structures, Smart structures	Alloys and composites, Energy-absorbing structures, Smart structures	Alloys and composites, Engineering structures, Smart structures				
P. Medical and Biomedical	Infectious diseases, Biological defense, Operational medicine, Combat casualty care	Infectious diseases, Biological defense, Operational medicine, Combat casualty care	Infectious diseases, Biological defense, Operational medicine, Combat casualty care		Medical imaging		
Q. Sensors	Automatic target recognition, Seismic sensors, Vehicle integration	IR focal plane arrays, Laser sensors, Multidomain sensors, Signal processing, Multisensor integration	Combat ID sensors, Vehicle integration	**Israel** Acoustic sensors, Target recognition	Electronic components, Photonic devices		**Russia, Ukraine** High power microwaves
R. Ground Vehicles	Good overall capabilities, Gas turbines	Good overall capabilities, Secondary batteries	Good overall capabilities, Structural design, Vehicle survivability, Autonomous control, Diesel engines, Integrated electronics	**Israel** RPVs, Teleoperation **Austria** Diesel engines	Ceramic engines, Electric drive		**Russia** Electric drive, Batteries, Switches
S. Manufacturing Science and Technology	Bioprocess engineering, CASE tools, Industrial robotics	Bioprocess engineering, CASE tools, Industrial robotics	Bioprocess engineering, CASE tools, Industrial robotics	**Israel, Canada, Netherlands** Bioprocess engineering	Fuzzy logic, Bioprocess engineering, Industrial robotics		
T. Modeling and Simulation	Strong capabilities in all aspects	Strong capabilities in all aspects	Storing capabilities in all aspects	**Canada** VR 3-D visualization	VR, Distributed industrial enterprises	Distributed interactive simulation	

Table E.I-2. Highlighted Long-Term Opportunities

TECHNOLOGY (Ref. to E.III)	UNITED KINGDOM	FRANCE	GERMANY	OTHER COUNTRIES	JAPAN	PACIFIC RIM	FSU
B. Mathematical Sciences	Fluid dynamics, Linear algebra	Levy processes, Dynamic systems, Boltzman's equations, Control theory, Computer vision, Finite elements, Nonsmooth optimization	Finite elements, interactive methods	**Canada** Analytic geometry **Israel** Computational physics	General capabilities	**India** **China**	**Russia** Numerical methods
C. Computer and Information Systems	Database sciences, Natural language processing	Natural language processing	Natural language processing	**Netherlands** **Sweden**	Software prototyping		
D. Physics	Optical switching, Sensors, Signature reduction, Lasers	Optical switching, Sensors, Signature reduction, Lasers	Sub-micron research, Optical switching, Sensors	**Canada** **Sweden** **Israel**	Sub-micron research, Optical switching, Sensors, Fiberoptic gyros, Lasers		**Russia** Glonass, Optical sensors, Non-linear optics
E. Chemistry	Polymer composites, Surface resistance to wear and corrosion, Chem/biol defense, Soldier power, Demil. restor., and pollution prevention	Chem/biol defense, Soldier power	Polymer composites, Surface resistance to wear and corrosion, Chem/biol defense, Soldier power, Explosives/ propellants	**Israel** **Netherlands** **Sweden** **Finland** Chem/biol defense **Israel** **Sweden** **Canada** Explosives/ propellants	Polymer composites, Surface resistance to wear and corrosion, Explosives/ propellants, Chem/biol defense	**S. Korea** **China** Surface resistance	
F. Materials Science	Welding and joining, Armor/antiarmor, Coatings, Ion implant	Ceramic matrix composites, Armor	Ceramics, Coatings	**Israel** Armor, Personnel armor, Diamond deposition	Composites, Superconductors, Coatings	**S. Korea** Tungsten alloy penetrators	**Russia** Armor, Anti-armor, Superalloys **Ukraine** Welding and joining
G. Electronics	JESSI/MEDEA research, C3, Networking, Switching	JESSI/MEDEA research, Battlefield communications	JESSI/MEDEA research, Networking, Switching		Solid-state devices, Networking, Switching, MMIC, Low-power devices		
H. Mechanical Sciences	Smart/active structures, Fluid dynamics, Gas turbine engines, Solid/liquid gun	Smart/active structures, Fluid dynamics, Gas turbine engines, Solid gun	Smart/active structures, reciprocating engines, solid gun	**Italy** Smart/active structures **Canada** Fluid dynamics, Solid gun, Gas turbines	Smart/active structures, Fluid dynamics, Reciprocating engines		**Russia** **Ukraine** Naval gun propulsion, Experimental-theoretical fluid dynamics
I. Atmospheric and Terrestrial Sciences	Atmospheric backscatter, Global and regional weather prediction, Cold weather prediction	Atmospheric electricity-aircraft interactions, IR physics of the atmosphere	Low-level weather prediction	**Canada** Ice flow and weather prediction, Atmospheric dispersion **Denmark** Ionosphere interactions, Atmospheric turbulance **Netherlands** IR background **Brazil** Ionosphere experiments	Ionosphere and troposphere interactions, Tropical cyclones		**Russia** Solar flare prediction, Atmosphere spectral transmissivity, Low-level weather prediction
J. Medical	Infectious diseases, Combat casualty care, Operational medicine, Biological defense	Infectious diseases, Combat casualty care, Operational medicine, Biological defense	Infectious diseases, Combat casualty care, Operational medicine, Biological defense	**Switzerland** **Israel** **Netherlands** **Sweden** Infectious diseases, Combat casualty, Operational medicine, Biological defense	Infectious diseases, Combat casualty care, Operational medicine, Biological defense	**China** Infectious diseases, Combat casualty care	**Russia** Combat casualty care, Biological defense

(Continued)

Table E.I-2. Highlighted Long-Term Opportunities (Continued)

TECHNOLOGY (Ref. to E.III)	UNITED KINGDOM	FRANCE	GERMANY	OTHER COUNTRIES	JAPAN	PACIFIC RIM	FSU
K. Biological Sciences	Combinatorial chemistry, Genome project, Receptor characterization, NMR, Microbial products for nutrition, Bioremediation, Nutritional additives, Protein stabilizers, PHB plasticizer, Energy transduction, Biomaterials for tensile strength	Genome project, Receptor characterization, Nutrient additives, Bioremediation, Stress resistance, Protein stabilizers, Energy transduction, Biomaterials for tensile strength	Combinatorial chemistry, Genome project, Nutrient additives, Bioremediation, Protein stabilizers, Energy transduction, Biomaterials for tensile strength	**Israel** Wide range of entries **Netherlands** Wide range of entries **Switzerland** Wide range of entries	Genome project, Receptor characterization, NMR, Visual sensing, Metabolic products, Bioremediation, Protein stabilizers, Biomaterials for tensile strength	**Australia** Wide range of entries	
L. Behavioral, Cognitive and Neural Sciences	Cognitive, Noncognitive, Perceptual processes	Cognitive, Noncognitive, Perceptual processes	Cognitive, Noncognitive, Perceptual processes	**Netherlands** **Israel** **Sweden** Cognitive, Noncognitive, Perceptual processes, Leadership	Cognitive, Noncognitive Perceptual processes		

D. Summary

There is growing emphasis on coalitions to provide military force in support of international policy. This fact, coupled with decreasing resources for defense, and the global dissemination and rapid advance of technology, increase the potential pay-off and importance of having a long-term strategic plan for international cooperation.

This revision to the ASTMP--which for the first time, explicitly addresses potential cooperative opportunities in basic research topics--represents the next step in an evolution. The changes in format and structure respond to fundamental changes in the environment in which international programs are conducted. One of the key changes has been the streamlining of the process for implementing international agreements. At the same time, the need for identifying programs that will build sustainable ties has become evident. As a result, emphasis is shifting from attention to specific MOUs and DEAs, towards a strategy that will ultimately provide both technical detail and broad assessments of significant trends.

Better understanding of trends is key to an effective strategy. Technology is advancing rapidly, and some opportunities may be time-sensitive. The arrows in the summary charts reflect a general assessment of country capabilities, and their rate of advance relative to field at large, as follows:

- ▲ The country is considered to have world class capabilities in one or more key aspects of the subtechnology identified. Based on current and projected levels of research and expenditures, the level is likely to continue to define or remain near the global state of the art.
- ➤ The country is considered to have world class capabilities in one or more key aspects of the subtechnology identified. Based on current and projected levels of research and expenditures, the level will no longer define the state of the art, although it should remain near world class capabilities.
- ▼ The country presently has world class capabilities, however, current research activities are unlikely to keep them at this level.
- △ The country is not yet considered a world class actor in this field. The country has promising capabilities or an accelerated, coordinated research and development effort underway, in selected areas of technology, which could contribute to making it among the world leaders or enable it to help define the global state of the art in the future.
- ➢ The country has capabilities in selected areas which are not considered world class, nor are likely to achieve that level in the near future. The capabilities still could contribute beneficially to US Army research and development activities.

∀ The country has capabilities which could contribute in the short-term to US Army research and development requirements, but are likely to be overcome or rendered irrelevant by future advances elsewhere.

Again, the trends tables address specific technological and research opportunities tied to specific subtechnologies and topics identified in Chapters IV and V of the ASTMP Volume I. The lack of an entry does not necessarily indicate the absence of cooperative opportunities. In some cases, work by a single researcher in a foreign university may prove important.

II. NEAR- AND MID-TERM INTERNATIONAL COOPERATIVE OPPORTUNITIES

A. Opportunity Assessment Overview

The 1997 ASTMP Annex E represents the latest step in an evolutionary process to identify, refine, and focus efforts to implement our international cooperative strategy. The process brings together a variety of technology and intelligence assessments to identify broad areas where the capabilities and trends in the state-of-the-art among potential partners offer significant promise for contributing to US Army objectives. Within these broad areas, designated technology area points of contact for Chapter IV highlighted specific needs, in the process identifying existing or near-term pending agreements. The results of the process have now been revisited and refined through several successive iterations of the ASTMP and Annex. The resulting collection of capabilities and near-term opportunities described in the following Annex and summarized in Chapter IV, illustrate the breadth and diversity of opportunity offered by international cooperation.

Our European allies, notably the **United Kingdom, France**, and **Germany**, are technologically advanced and we have long-standing exchange programs in most areas of military technology. There are niches of particular excellence, and strong European Community cooperative programs in information systems technology, semiconductor manufacture, materials, and manufacturing science and technology should increase the indigenous capability of our allies. Except for specific niches of excellence, these capabilities are more likely to parallel those of the United States and provide complementary opportunities as opposed to revolutionary breakthroughs in new areas. However, cooperation has other objectives and benefits in terms of effective cost and risk sharing and improved interoperability. Cooperative programs with countries having current excellence and an upward trend in development offer sound prospects for contributing to these objectives. Future interoperability objectives for coalition forces stress the ability to exchange information across allied forces seamlessly to support preemptive planning and mission rehearsal, integrated force management, and effective employment of precision forces. This, in turn, will provide an impetus for international development of standards and models to support battlespace digitization and Army Digitization Office objectives.

In a few instances, most notably within the FSU, the opportunities identified may prove somewhat perishable as technologies advance and economic conditions erode the base of support for research. Such time-sensitive opportunities may be found in piezoelectric crystal growth, certain aspects of gas turbine engines and ramjet propulsion, and pulsed power. Other areas of strong capability, less time-sensitive, may be found in mathematical science where, for a variety of social and cultural reasons, **Russia** and the other countries of the FSU have been traditionally strong.

Japan offers the widest range of technological capabilities. The Ministry of International Trade and Industry (MITI) oversees and coordinates a wide range of research and development in electronics, structural materials including ceramics, and manufacturing science and technology. Applications of these technologies to military uses are not widely advertised, but there is clear evidence of growing capability and activity in this direction. The Army has initiated several programs with **Japan**, for example, in ramjet propulsion and in applications of fuzzy logic to helicopter flight control, and their technological capabilities offer numerous other opportunities. However, indications are that patience and a concerted long-term commitment are necessary prerequisites to successful negotiation of cooperative agreements with **Japan**.

Those countries that we think of as traditionally strong in technology are rapidly being joined by other countries as global dissemination and internationalization of high technology industries increases. Countries such as **Israel** and **Korea** have growing capabilities in a wide range of military-industrial technologies, including microelectronics and electronic systems, aerospace, ground vehicles, and sensors (primarily Israel) that already offer selected cooperative opportunities. India has a broad base of expertise for software development capable of supporting advances in a number of technology areas. **Singapore**, under the auspices of the National University, has launched a strong and diversified world-class program in biotechnology. **Malaysia** and **Indonesia**, in large part based on technology transfer from European Aerospace firms, are developing a helicopter and small air transport design and manufacturing base. In the future, other niches of capability, backed by solid basic industrial infrastructures, are likely to develop in these and other countries, particularly in biotechnology and environmental sciences which are becoming pervasive worldwide areas of research and development.

The following subsections provide a brief overview of the international state-of-the-art and key technological capabilities which have potential to contribute to objectives and milestones identified in each of the 19 areas of technology addressed in Chapter IV. Within each technology we also identify one or more near-term opportunities to address specific needs. Each specific opportunity includes a brief description, and justification highlighting potential benefits of the international effort envisioned. Benefits are defined in terms of the potential to address specific ASTMP and/or DOD technology milestones and objectives. Appropriate AMC and international points of contact and/or project officers (PO's) for each of the technologies and agreements cited are also provided.

B. Aerospace Propulsion and Power

Advances in aeropropulsion technologies are needed to support Army objectives for improved rotorcraft and transport performance, and for other services, attack and fighter aircraft, and unmanned air vehicles.

Technology subareas include rotorcraft propulsion (encompassing small gas turbine engines and rotorcraft drive systems) and fuels and lubricants. Table E.II-1 below provides a summary of key capabilities and trends. The importance of gas turbine propulsion in civilian aircraft markets has led to the development of world-wide capabilities for their development and production, with over 40 producers in 11 countries listed as suppliers in recent global surveys. Many other countries have production technologies for repair and overhaul. Market figures indicate that the U.S. has continued to capture a growing share in a declining market, largely through exports. A growing number of companies look to international joint venturing as a strategy for dealing with this market.

International cooperative R&D in gas turbine technologies and products may, in addition to providing access to state-of-the-art technology, also provide access to an increasingly competitive international market.

Table E.II-1. Aerospace Propulsion and Power

B. AEROSPACE PROPULSION AND POWER	UNITED KINGDOM	FRANCE	GERMANY	OTHER COUNTRIES	JAPAN	PACIFIC RIM	FSU
SMALL TURBINE ENGINES	➤	⋀ High temperature structures ➤ Rotorcraft propulsion	➤ High temperature gas turbines Rotorcraft propulsion	➢ **Israel, Canada** Small gas turbines	➢		▼ **Russia** Wind tunnel test facilities
ROTORCRAFT POWER TRANSFER SYSTEMS	➤ High-performance transmission	⋀ Bearingless rotor hub	⋀ Bearingless rotor hub Composite and high-strength alloy shafting				
FUELS AND LUBRICANTS		➤ High-temperature lubricants	➤ High-temperature lubricants		➤		

France, **Germany**, and the **U.K.** are at, or nearly on a par with the U.S. in many aspects. Key areas of capability with leveraging potential include materials and coatings, and related structures and aerodynamic design and modeling. **Russia**, **Canada**, **Israel**, and **Japan** have substantial infrastructures and niches of excellence (e.g., Japanese ceramics; **Canada**, small gas turboprops).

The following summary highlights one area where an existing or near-term pending agreement offers significant opportunities for advances in aeropropulsion. Advances in materials, structures, and coatings (see Subsections II.O and III.F) should also support improved efficiency and performance in ground vehicle propulsion systems.

1. Ceramic Materials for Gas Turbine Engines (France)

Description: The application of ceramic material technologies to the development of gas turbine engine components will provide significant enhancements over currently fielded systems. Particular interest is in the development of lightweight, fuel efficient engines which offer greatly increased power-to-weight ratios, and are capable of operation at high temperatures. The **United States**, **Germany**, **Japan**, and **France** are world leaders in ceramic technologies.

Justification: **France** is a recognized world leader in ceramic/carbon carbon composites. The application of ceramics to engine components should contribute to several ASTMP goals and objectives, specifically to milestones for reduction in fuel consumption and an increase in the power-to-weight ratio for helicopter engines. This technology is common and will also contribute to advances in gas turbine propulsion for land vehicles.

Implementation: An umbrella agreement exists with **France,** and is a potential vehicle for establishing a Project Agreement (PA) covering this technology.

AMC POC:	Dr. Rodney Smith Army Materiel Command AMXIP-OB 5001 Eisenhower Blvd Alexandria, VA 22333-0001 e-mail: icpa@hqamc.army.mil
IPOC:	Mr. Tom Devereux U.S. Army ATCOM St. Louis, MO 63120-1798 e-mail: None provided

C. Air and Space Vehicles

Rotorcraft are of particular interest to the Army. They are, and will remain, essential for a variety of critical scout, transport, and combat missions. The operational flexibility afforded by VTOL capabilities has created growing civil and military markets, particularly in third world nations. As a result, the helicopter industry has become highly internationalized and interdependent. In addition to the capabilities in the US/Canadian industrial base, **Germany, France, the UK, Russia** and **Italy** are all capable of designing and producing state-of-the-art military rotorcraft. **Japan, Maylasia, India, South Africa**, and the **PRC** all have substantial capabilities for rotorcraft production. **India** and **South Africa** have indigenous military helicopter development programs.

Competition for international military sales is intense, and marketing rights and export prospects have affected a number of development decisions, particularly in international programs. Such market forces continue to push world-wide developments. Foreign capabilities may offer opportunities to reduce the cost of improving each of the key technology subareas: aeromechanics, flight control, structures (including survivability and as a major consideration signature reduction), and subsystems. Table E.II-2 below summarizes potential prospects.

Table E.II-2. Air and Space Vehicles

C. AIR AND SPACE VEHICLES	UNITED KINGDOM	FRANCE	GERMANY	OTHER COUNTRIES	JAPAN	PACIFIC RIM	FSU
AERODYNAMICS	➤ Rotorcraft design	➤ Rotorcraft CFD	➤ Rotorcraft	▷ **Italy** **Israel** **Sweden** Aeromechanical design	▷ CFD Hypervelocity		▼ **Russia** Wind tunnel test facilities
FLIGHT CONTROLS	➤ Active harmonic control	▲ adaptive controls; Fly-by-light	➤ Control theory	▷ **Sweden** Adaptive controls			
STRUCTURES	▲ Composites Smart structures ➤	▲ Crash survivability C-C matrix ceramic Smart structures ➤	▲ Smart structures Fatigue	▲ **Canada** Fracture/fatigue analysis ▷ **Italy** Rotorcraft structures	▲ Ceramics Composite materials and structures	▷ **Malaysia** **China** rotorcraft	➤ **Russia** Rotorcraft structures; Ti and steel alloy structures
SUBSYSTEMS	▲ FADEC Rotor systems	➤	➤ Advanced cockpit systems	▷ **Israel** Advanced cockpit systems	▷ Avionics cockpit systems	▷	▷

The proliferation of low-cost high-performance computing systems has lead to a growing worldwide interest in CFD. Advanced composite structures and fly-by-wire/light are becoming common in international aircraft. Technologies for military systems reside principally in the few countries that produce military helicopters. Predominant among these are **France, Germany**, the **U.K.**, and **Italy**.

Areas of foreign research include advanced rotor design (**U.K., France**, and **Germany**) incorporating features like bearingless hub design with reduced observables and improved reliability and ballistic survivability. French capabilities in carbon ceramic and crash survivable structures are considered world class. **UK** work in rotor blades, harmonic controls, and full authority digital engine control (FADEC) are also significant. The following highlights specific areas where existing or near-term pending agreements offer significant opportunities for advances in each of these areas. Access to **Russia**'s extensive wind tunnel and aerodynamic testing facilities may offer near-term potential benefits. Longer term advances in so-called digital wind tunnel technology may educe the need for extensive wind tunnel testing. **Russia** has also fielded some of the most capable military rotorcraft in terms of aerodynamic performance (speed and lift capability).

1. Aeromechanics (France, Germany, Israel)

Description: A near-term objective of the ASTMP is rotorcraft design by computational fluid dynamics (CFD). A significant portion of this process is the design of helicopter rotors and blades. Use of CFD for design of rotors can enhance helicopter speed, maneuverability, and lift capabilities, while reducing acoustic signature and structural vibration.

Justification: While the **United States** is the world leader in CFD and related techniques, **France, Germany**, and **Israel** have complementary world-leading efforts to improve and develop analytical techniques and generate experimental data bases that may contribute to meeting ASTMP goals of 50 percent increase in maneuverability; 35 percent increase in air vehicle speed; and a 30 percent increase in rotor efficiency.

Implementation: There are MOAs that provide mechanisms for cooperative development to meet these ASTMP milestones.

AMC POC: Dr. Rodney Smith
Army Materiel Command
AMXIP-OB
5001 Eisenhower Blvd
Alexandria, VA 22333-0001
e-mail: icpa@hqamc.army.mil

IPOC: Mr. Tom Devereux
U.S. Army ATCOM
St. Louis, MO 63120-1798
e-mail: None provided

2. Handling Qualities Research (Germany)

Description: With the development of more capable helicopters and requirements to perform more demanding tasks in extreme atmospheric and visibility conditions, a requirement exists to define and produce aeronautical design specifications and standards to support the research, development, and acquisition communities. Ground-based and in-flight simulation studies are targeted to relate longitudinal, lateral, and directional response to control inputs and disturbances. Specific areas of concern are the investigation of cross-coupling requirements, gust rejection for rate response systems, and the response time delay limits for high bandwidth response systems.

Justification: The recently developed Airworthiness Design Standard (ADS 33) significantly addressed this requirement; however, gaps still exist in the data base which need to be filled to verify the defined criteria and new data are required for the extension of the elements. Current research cannot be adequately accomplished using national assets alone. Significant prior work utilizing **Germany**'s in-flight simulator and correlated **U.S.** ground-based simulators has produced a viable data base to build upon even when a **U.S.** system becomes available. This work directly supports JTR, RAH-Comanche, AH-64 Enhanced Apache, and the construction and evaluation of simulation modeling tools.

Implementation: Handling Qualities Research is a task outlined under a current U.S.-GE Aeromechanics MOU with specific schedule and goals.

AMC POC: Dr. Rodney Smith
Army Materiel Command
AMXIP-OB
5001 Eisenhower Blvd
Alexandria, VA 22333-0001
e-mail: icpa@hqamc.army.mil

IPOC: Mr. Tom Devereux
U.S. Army ATCOM
St. Louis, MO 63120-1798
e-mail: None provided

3. Stability and Control Analysis (Germany)

Description: There are two different identification techniques used for flight test data in stability and control analysis: a frequency-domain method (predominantly used in the **United States**) and a time-domain technique (predominantly used in **Germany**). Results obtained clearly demonstrate that each of these techniques has its inherent advantages and disadvantages. Stability and control analysis directly impacts on modeling, simulation, flight control system design, and implementation of higher harmonic studies. The fidelity and accuracy of all rotorcraft modeling and simulation is directly related to the state of the art regarding stability and control analysis.

Justification: A coordinated approach combining the strengths of both techniques yields the most promising path to successfully detailing complete and accurate portrayal of flight control system design parameters and subsequent performance. This provides a critical technology link bridging theoretical design techniques, prediction, simulation, and test analysis. This work directly supports JTR, RAH-66 Comanche, AH-64 Enhanced Apache, and the construction and evaluation of simulation modeling tools.

Implementation: Stability and Control Analysis is a task outlined under a current U.S.-GE MOU with specific schedule and goals.

AMC POC: Dr. Rodney Smith
Army Materiel Command
AMXIP-OB
5001 Eisenhower Blvd
Alexandria, VA 22333-0001
e-mail: icpa@hqamc.army.mil

IPOC: Mr. Tom Devereux
U.S. Army ATCOM
St. Louis, MO 63120-1798
e-mail: None provided

4. Rotor Data Correlation (Germany)

Description: Validation of wind tunnel data obtained from model and full-scale rotor systems continues to present challenges in the design and prediction of new rotor systems. The use of wind tunnel tests plays a key role, together with analysis prediction and flight test evaluation, in the development of new rotor systems. Such tests are typically performed using a range of rotor systems sizes and wind tunnel facilities. Key is accounting for scaling effects and the influence of the test environment. A second objective is to validate analyses for predicted rotor performance, loads, and stability. Prior joint work has produced an extensive high quality data base of experimental data. Comparisons between **U.S**. and **German** theoretical predictions with test results will identify key modeling requirements and areas requiring new analytical technology development.

Justification: Cooperative research in the past few years has significantly impacted the understanding of this technology area. Comparison of national data, codes, and methodologies significantly contributes to continued advances. **German** and **U.S.** prediction codes should continue to be compared and optimized, combining the experience of both laboratories. Additionally, a technology development program is warranted to increase the understanding of hingeless rotor performance and dynamics. This technology will improve the design methodology to build better, more efficient rotor systems with improved control characteristics. MBB's production experience on hingeless rotor system, the **GE** 0.4-scale model of a BO 105 rotor system, the **U.S.** full-scale model, and the **GE** in-flight BO 105 simulator contribute significantly to this technology area. These efforts will identify requirements for modeling development in support of emerging rotor systems.

Implementation: Rotor Data Correlation Research is a task outlined under a current U.S.-GE Aeromechanics MOU with specific schedule and goals.

AMC POC: Dr. Rodney Smith
Army Materiel Command
AMXIP-OB
5001 Eisenhower Blvd
Alexandria, VA 22333-0001
e-mail: icpa@hqamc.army.mil

IPOC: Mr. Tom Devereux
U.S. Army ATCOM
St. Louis, MO 63120-1798
e-mail: None provided

5. Helicopter Crash Survivability (France)

Description: The application of advanced engineering technology (specifically computer modeling and simulation) to the design of aircraft structures, components, and weapon systems offers an opportunity to enhance aircraft crash survivability. Survivability depends upon a number of factors including equipment performance. Equipment performance may be enhanced by more efficient design and testing of aircraft structures and systems. The purpose of such design and testing is to develop equipment which will retain the shape and integrity necessary to protect humans in crash situations while continuing basic functions. The **French** are a peer of the **United States** in crashworthiness design and testing, and may contribute to related areas of structural design and survivability (particularly helicopters).

Justification: Of particular interest is the testing of advanced structural concepts and manufacturing processes for composite performance and thermoplastic materials for primary helicopter airframe structures. These could contribute directly to meeting the milestones for improvements in aerodynamic performance and survivability of Army rotorcraft.

Implementation: An existing DEA may provide a vehicle for pursuing further opportunities. Further, a blanket agreement on Technology Research and Development Projects (TRDP) exists with France, which may serve as another tool for exchange of this technology via the establishment of a Project Agreement (PA)

AMC POC:	Dr. Rodney Smith Army Materiel Command AMXIP-OB 5001 Eisenhower Blvd Alexandria, VA 22333-0001 e-mail: icpa@hqamc.army.mil
IPOC:	Mr. Tom Devereux U.S. Army ATCOM St. Louis, MO 63120-1798 e-mail: None provided

6. Cockpit Integration Technologies (Germany)

Description: Man/machine integration goals by FY99 are to develop and demonstrate through simulation and flight test a cooperative man/machine system that synergistically integrates revolutionary mission equipment package technologies. These include high speed data fusion processing, cognitive decision aiding knowledge-based systems, and an advanced pilotage sensor and display to achieve maximum mission effectiveness and survivability. Milestones are a demonstration simulation by 2Q97 and flight testing by 3Q98.

Justification: **Germany** is a recognized world leader in cognitive decision aiding knowledge-based system and high speed data fusion. At the Bundeswehr University in Munich a research program currently has a functioning cognitive decision aided knowledge-based vehicle driving system. Continuing research promises technology breakthroughs directly applicable to specific human systems defense technology objectives and the U.S. Rotorcraft Pilots Associate program as well as related crew station research programs.

Implementation: Data exchange could be initiated under a DEA. Cooperative efforts are possible under the umbrella agreement.

AMC POC: Dr. Rodney Smith
Army Materiel Command
AMXIP-OB
5001 Eisenhower Blvd
Alexandria, VA 22333-0001
e-mail: icpa@hqamc.army.mil

IPOC: Mr. Tom Devereux
U.S. Army ATCOM
St. Louis, MO 63120-1798
e-mail: None provided

D. Nuclear, Biological, and Chemical Defense

Contamination avoidance is the highest priority of the DOD chemical and biological (CB) defense program. The program also includes force protection (individual and collective) medical (see Subsection II.P of this Annex) and decontamination. The past two years have been marked by growing interest in, and rapid advances in and proliferation of biosensing technology for environmental, industrial, and medical applications. While these technologies are dual-use in nature, the growing threat of CB weapons of mass destruction has focused continued attention on development of operational sensors to meet military requirements. Table E.II-3 below indicates areas of capability and trends. The **UK**, **France**, **Germany**, and **Japan,** all have strong capabilities in sensors, with France having particular strengths in remote sensing. **Germany** and **Israel** have strengths in individual and collective protection with **Germany** identified as particularly capable in collective protection for military vehicles.

Reliable detection of BW agents is particularly difficult, due to the high background and diversity of naturally occurring organisms. **Canada**, the **U.K.**, and the **U.S.** participate in ITF24 which oversees cooperation in this area. Other countries, including **Israel**, the **Netherlands**, **Sweden**, **Switzerland**, and **Russia**, have significant work in various methods of biodetection. **Singapore** has, in recent years, made a significant national investment in a world class facility, and may offer future capabilities in sensors and materials for personnel protection and decontamination.

Modeling and simulation capabilities relate to, and parallel, capabilities in meteorology and prediction of atmospheric transport effects, and sensor performance modeling.

Remote and real-time point detection of CB agents are prominently identified in the Joint Warfighting S&T Plan (JWSTP), as are models and simulations to support processing and dissemination of real-time warning and reporting data. The ASTMP Chapter IV.E includes milestones for these, and identifies additional requirements for individual and collective protection and decontamination. The table below summarizes potential prospects.

Table E.II-3. Nuclear, Biological, and Chemical Defense

D. NUCLEAR, BIOLOGICAL AND CHEMICAL DEFENSE	UNITED KINGDOM	FRANCE	GERMANY	OTHER COUNTRIES	JAPAN	PACIFIC RIM	FSU
ELECTROMAGNETIC (EME) ENVIRONMENT SURVIVABILITY	➤ Propagation and EMP effects	➤ Propagation and EMP effects	➤ Propagation and EMP effects	▷ **Israel** Propagation ▷ **Canada** HEMP ▷ **India** Propagation and HEMP			➤ **Russia** EMP effects
RADIATION, BLAST, AND THERMAL PROTECTION	➤ All aspects	➤ Blast and Thermal	➤ All Aspects	▷ **Israel** All aspects	▷ TREE		➤ **Russia**
DETECTION	▲ Chemical agent point sensors	▲ CBW agent point and remote sensing	▲ Detection systems	▲ **Canada** Detection systems **Israel,** ▷ **Sweden, Netherlands, Switzerland** Detection sensors	▲	▲ **Singapore**	➤ **Russia** BW detection sensors
INDIVIDUAL PROTECTION	➤	➤	➤	➤ **Israel**	▷		➤ **Russia**
COLLECTIVE PROTECTION		▲ Vehicle systems		➤ **Israel**	➤		➤ **Russia**
DECONTAMINATION		▲ Electronics decontamin-ation			➤		
MODELING AND SIMULATION	▷	▷	▷	▷ **Canada** **Israel** Atmospheric transport effects			

The following highlight specific areas where existing or near-term pending agreements offer significant opportunities for advances in each of these areas.

1. Laser Sensors for Remote Detection of Chemical/Biological Warfare (CBW) Agents (France)

Description: Remote detection of CBW agents is done using laser light scattering and reflected analysis techniques. Systems using remote detection offer obvious advantages over point source detectors which must be in local contact with the CBW agent. The **United States** and **France** are world leaders in laser technology and in CBW-related technologies, and have exchanged much information in CBW research and testing.

Justification: **French** research and development may contribute to development of standoff biological agent detection and identification capability using laser light scattering techniques.

Implementation: There are existing agreements in this technology area with **France** which could potentially expedite implementation of a specific program agreement to address this opportunity.

AMC POC: Dr. Rodney Smith
Army Materiel Command
AMXIP-OB
5001 Eisenhower Blvd
Alexandria, VA 22333-0001
e-mail: icpa@hqamc.army.mil

IPOC: Dr. George R. Famini/Ms. Juanita M. Keesee
U.S. Army Edgewood RD&E Center
ATTN: SCBRD-ASI
Aberdeen Proving Ground, MD 21010-5423
e-mail: grfamini@cbdcom.apgea.army.mil
e-mail: jmkeesee@cbdcom.apgea.army.mil

2. Mass Spectrometric Technologies Cooperative Project (Germany)

Description: Point detection and identification of chemical and biological agents using mass spectrometric technologies. The goal is to develop technologies which result in significant improvements to the chemical and biological agent detection/identification capability of fieldable mass spectrometers. This includes technologic means to increase the sensitivity, speed of response, selectivity, and specificity.

Justification: Leverages Germany's past developmental experience with the development, integration, and testing of mass spectrometers in such systems as the NBCRS, Fuchs.

Implementation: There is an existing agreement in this technology area with Germany which could potentially expedite implementation of a specific program agreement to address this opportunity.

AMC POC:	Dr. Rodney Smith Army Materiel Command AMXIP-OB 5001 Eisenhower Blvd Alexandria, VA 22333-0001 e-mail: icpa@hqamc.army.mil
IPOC:	Dr. George R. Famini/Ms. Juanita M. Keesee U.S. Army Edgewood RD&E Center ATTN: SCBRD-ASI Aberdeen Proving Ground, MD 21010-5423 e-mail: grfamini@cbdcom.apgea.army.mil e-mail: jmkeesee@cbdcom.apgea.army.mil

3. Biological Detector (BD) Formerly All Agent Biological Chemical Detector (Canada, United Kingdom)

Description: A 6.2 exploratory development program for the Biological Detector (BD) has been completed successfully in cooperation with the **United Kingdom** (UK) and **Canada** (CA). A follow-on 6.3b development is being conducted with the UK and CA. The focus of cooperative development has shifted from hardware elements to antibodies and reagents, with increased emphasis on joint test and evaluation. The results of this cooperative project will contribute to the upgrade of the interim U.S. Biological Integrated Detection System (BIDS).

Justification: The BD will be a component of the BIDS, providing an automatic detection and identification capability. The objective is to develop and field an automated antibody-based BD which will be incorporated into the detector suite of the BIDS. Cooperative efforts are focused on development of the agents at target concentrations, as well as the test and evaluation of these antibodies in various prototype detection systems.

Implementation: There are existing agreements in this technology area with the UK and CA which could potentially expedite implementation of a specific program agreement to address this opportunity.

AMC POC: Dr. Rodney Smith
Army Materiel Command
AMXIP-OB
5001 Eisenhower Blvd
Alexandria, VA 22333-0001
e-mail: icpa@hqamc.army.mil

IPOC: Dr. George R. Famini/Ms. Juanita M. Keesee
U.S. Army Edgewood RD&E Center
ATTN: SCBRD-ASI
Aberdeen Proving Ground, MD 21010-5423
e-mail: grfamini@cbdcom.apgea.army.mil
e-mail: jmkeesee@cbdcom.apgea.army.mil

4. Regenerable Collective Protection Filtration Techniques for Combat Vehicles (Germany)

Description: Current collective protection filters for combat vehicles impose a significant logistic burden in their requirement for replacement after a finite number of attacks or after extended attack-free service. Technologies are under investigation to create filters which have a nearly indefinite service life and offer exceedingly broad spectrum protection. The primary candidate at the moment is pressure swing absorption technology. The **United States** has pursued a research and exploratory development program to model the performance of such systems and to do some confirmatory testing. **Germany** initiated a companion program last year and had planned on beginning to obtain test data but experienced non-technical difficulties getting started in the laboratory. Technical experts on both sides have met and data collection is scheduled to begin later in the year.

Justification: The **United States** has extensive experience with prototype systems which could reduce **German** development costs very significantly, while still providing an extensive prototype data base. **German** research and development may contribute additional experimental data for validation of the **U.S.** computational models, thereby reducing U.S. development costs while increasing reliability.

Implementation: There are existing agreements in this technology area with **Germany** which could potentially expedite implementation of a specific program agreement to address this opportunity.

AMC POC: Dr. Rodney Smith
Army Materiel Command
AMXIP-OB
5001 Eisenhower Blvd
Alexandria, VA 22333-0001
e-mail: icpa@hqamc.army.mil

IPOC: Dr. George R. Famini/Ms. Juanita M. Keesee
U.S. Army Edgewood RD&E Center
ATTN: SCBRD-ASI
Aberdeen Proving Ground, MD 21010-5423
e-mail: grfamini@cbdcom.apgea.army.mil
e-mail: jmkeesee@cbdcom.apgea.army.mil

5. Decontamination of Sensitive Electronic Equipment (Germany)

Description: At present there are no methods available for the decontamination of sensitive equipment such as avionics, electronics, detectors, computers, communication equipment, etc. In the late 80's and early 90's, the **United States** was pursuing the development of a system to satisfy this requirement and **Germany** was beginning a companion study. Both efforts were terminated since the technology used an ozone-depleting substance. Steeply declining defense budgets over the next few years and higher priorities forced the United States to all but abandon the search for a technical solution. Germany, however, continued to pursue the issue as part of the Haupt Entgiftungs Platz-90 (HEP-90) development and has exploratory development studies underway.

Justification: The CB defense program is now managed as a fully integrated Joint Service Program; this has resulted in the resurfacing of this requirement and work on decontamination needs is currently scheduled to begin again, albeit at modest levels, beginning in FY97. This is reflected in the Defense Technology Objective CB-09-12-D, Decontamination for Global Reach. On-going German research and development may contribute to the development of equipment capable of decontaminating sensitive pieces of military hardware without damaging them irreversibly. Of the concepts currently being explored, one utilizing new aqueous surfactant and decontaminant formulations appears to be the most promising.

Implementation: here are existing agreements in this technology area with Germany which could potentially expedite implementation of a specific program agreement to address this opportunity.

AMC POC: Dr. Rodney Smith
Army Materiel Command
AMXIP-OB
5001 Eisenhower Blvd
Alexandria, VA 22333-0001
e-mail: icpa@hqamc.army.mil

IPOC: Dr. George R. Famini/Ms. Juanita M. Keesee
U.S. Army Edgewood RD&E Center
ATTN: SCBRD-ASI
Aberdeen Proving Ground, MD 21010-5423
e-mail: grfamini@cbdcom.apgea.army.mil
e-mail: jmkeesee@cbdcom.apgea.army.mil

6. Bioprocesses for Remediation (Germany)

Description: Bioprocesses (specifically biodegradation/bioremediation) provide methods for decontamination of waste sites and the demilitarization of energetic materials. These processes are accomplished through the use of biological organisms including fungi, bacteria, and algae. **Japan**, the **United Kingdom**, **Germany**, **France**, **Israel**, and the **Nordic Group (Norway, Sweden, and Denmark**) have significant capabilities in segments of this area, with France being particularly strong in developing bioprocessing techniques for disposing of energetic materials (explosives and propellants). Biotechnology is highly internationalized and strongly centralized within the EC. Because of the open nature of exchange in this area, agreements with one nation may serve as a vehicle for accessing EC technology at large.

Justification: Specific ASTMP objectives include the effective remediation of contaminated waste sites and the destruction (using environmentally safe practices) of chemical agents and energetic materials.

Implementation: There is an existing agreement in this technology area with Germany which could potentially expedite implementation of a specific program agreement to address this opportunity.

AMC POC:	Dr. Rodney Smith Army Materiel Command AMXIP-OB 5001 Eisenhower Blvd Alexandria, VA 22333-0001 e-mail: icpa@hqamc.army.mil
IPOC:	Dr. George R. Famini/Ms. Juanita M. Keesee U.S. Army Edgewood RD&E Center ATTN: SCBRD-ASI Aberdeen Proving Ground, MD 21010-5423 e-mail: grfamini@cbdcom.apgea.army.mil e-mail: jmkeesee@cbdcom.apgea.army.mil

7. Modeling and Simulation in Distributed Interactive Simulation (TTCP: Canada, United Kingdom, Australia, and New Zealand)

Description: Distributed interactive simulation (DIS) is an effort underway to develop training and materiel development simulation systems interconnected via high speed networks. Current efforts include the inclusion of chemical, biological, and smoke effects into the DIS network, both for the purposes of training in a CB environment and for materiel acquisition support. DIS has the potential to account for environment and equipment effects; can operate in virtual, constructive, or live modes; and will utilize high fidelity phenomenology and component models. Further, this will provide a value-added process for materiel evaluations.

Justification: The United States has extensive expertise in the development of DIS networks. The other TTCP member countries could take advantage of this network and tie in at a much reduced cost. Further, by initiating DIS nodes in the member countries reflecting their equipment, it will be possible to develop doctrine and training better suited to coalition forces.

Implementation: There is an existing agreement in this technology area with the **United Kingdom, Canada, Australia**, and **New Zealand** which could potentially expedite implementation of a specific program agreement to address this opportunity.

AMC POC:
Dr. Rodney Smith
Army Materiel Command
AMXIP-OB
5001 Eisenhower Blvd
Alexandria, VA 22333-0001
e-mail: icpa@hqamc.army.mil

IPOC:
Dr. George R. Famini/Ms. Juanita M. Keesee
U.S. Army Edgewood RD&E Center
ATTN: SCBRD-ASI
Aberdeen Proving Ground, MD 21010-5423
e-mail: grfamini@cbdcom.apgea.army.mil
e-mail: jmkeesee@cbdcom.apgea.army.mil

E. Individual Survivability and Sustainability

Survivability and sustainability of individual soldiers and small operational groups for the future battlefield and for operations other than war (OOTW) will require advances across a wide spectrum of capabilities. These include ballistic protection, CBW protection, signature reduction, as well as enhanced capabilities for delivering provisions and electrical power for the so-called soldier system. The suite of underlying technologies is comparably diverse, ranging from textiles (with a special case being biotechnologically derived materials such as spider silk or bioceramics for body armor) to advanced fuel cells and batteries. Requirements for electrical power for individual soldier equipment vary with primary (disposable) cells being of interest for actual battle, and rechargeables (such as nickel-metal hydride) having a key role in training, currently a major consumer of batteries.

Table E.II-4 below summarizes key capabilities and trends. Cooperative opportunities in soldier systems and electrical power sources are most likely to be found with **France,** the **UK**, and **Germany**. **Canada** also has a program and niche capabilities in soldier systems. **Japan** has significant capabilities in biomaterials and in electrical power sources. **Russia** is also a world leader in certain types of batteries. A niche capability in individual microclimate control has been identified with **Australia**.

Table E.II-4. Individual Survivability and Sustainability

D. NUCLEAR, BIOLOGICAL AND CHEMICAL DEFENSE	UNITED KINGDOM	FRANCE	GERMANY	OTHER COUNTRIES	JAPAN	PACIFIC RIM	FSU
ELECTROMAGNETIC (EME) ENVIRONMENT SURVIVABILITY	➤ Propagation and EMP effects	➤ Propagation and EMP effects	➤ Propagation and EMP effects	▷ **Israel** Propagation ▷ **Canada** HEMP ▷ **India** Propagation and HEMP			➤ **Russia** EMP effects
RADIATION, BLAST, AND THERMAL PROTECTION	➤ All aspects	➤ Blast and Thermal	➤ All Aspects	▷ **Israel** All aspects	▷ TREE		➤ **Russia**
DETECTION	▲ Chemical agent point sensors	▲ CBW agent point and remote sensing	▲ Detection systems	▲ **Canada** Detection systems **Israel,** ▷ **Sweden, Netherlands, Switzerland** Detection sensors	▲	▲ **Singapore**	➤ **Russia** BW detection sensors
INDIVIDUAL PROTECTION	➤	➤	➤	➤ **Israel**	▷		➤ **Russia**
COLLECTIVE PROTECTION		▲ Vehicle systems		➤ **Israel**	➤		➤ **Russia**
DECONTAMINATION		▲ Electronics decontamination			➤		
MODELING AND SIMULATION	▷	▷	▷	▷ **Canada** **Israel** Atmospheric transport effects			

A key area for soldier systems will continue to be man-portable electrical power. Here **Japan** is a world leader in secondary batteries, fuel cells, and small gasoline engines followed closely by **France** and **Russia** in selected aspects of secondary batteries. **Germany** is also identified as having world class capability in miniature fossil fuel engines for portable electrical power.

The ASTMP Chapter IV.F includes milestones for achieving 20% reductions in the weight of individual protective suits, and for reducing the thermal signature of individual soldiers. There also is a continuing requirement for more efficient sources of portable electrical power.

The following highlight specific areas where existing or near-term pending agreements offer significant opportunities for advances in individual soldier systems and batteries and fuel cells for electrical portable power.

1. Soldier System Technology (Australia, Canada, France, Germany, United Kingdom)

Description: The soldier system concept seeks to achieve the enhancement of soldier combat performance through the integration of advanced technologies. The soldier system focuses on enhancing soldier capabilities in the areas of lethality, command and control, survivability, sustainability and mobility, and encompasses everything the individual soldier wears, carries, and consumes in a tactical environment. The **United States, Australia, Canada, United Kingdom**, and **France** all have efforts underway to modernize the soldier and employ the soldier system concept.

Justification: This work contributes to the ASTMP goals for the Force XXI Land Warrior program. **Australia, Canada, United Kingdom, France**, and **Germany** all have various levels of expertise in the five basic capability areas for soldier systems and each of these countries has initiated a soldier modernization program. Cooperation, coordination of programs, and leveraging of resources among these nations is critical to the achievement of multi-national coalition operations and force compatibility.

Implementation: Joint efforts on soldier modernization are currently underway in various fora. Under TTCP, an Ad Hoc Study Group on Soldier System (TLG-8) has been formed; under NATO Panel III a Working Group of Experts on Soldier Modernization has been active for a number of years. Active Umbrella MOU/MOA Agreements currently exist with each of these countries. The United States and Canada are currently finalizing a Terms of Reference (TOR) for a Soldier System Technology Working Group (SSTWG), a US/FR TOR is in process, and specific US/UK project arrangements (PA) are being drafted.

AMC POC:
Dr. Rodney Smith
Army Materiel Command
AMXIP-OB
5001 Eisenhower Blvd
Alexandria, VA 22333-0001
e-mail: icpa@hqamc.army.mil

TOR POC:	Ms. Robin St. Pere (SSCNC-AN) U.S. Army Solider Systems Command (PROV) U.S. Army Natick RDE Center Comm: (508) 651-5840 DSN: 256-5840
IPOC:	Ms. Jan Lanza US Army Soldier Systems Command US Army Natick RDE Center ATTN: SSCNC-AN Natick, MA 01760-5015 e-mail: jlanza@natick-amed02.army.mil

2. Lithium and Ni-M-H Batteries and Fuel Cells (France)

Description: Future manportable weapons and sensors, communications, and other electronics equipment will require power sources with increasingly higher energy densities and operating life.

Current lithium primary batteries are not cost effective in meeting manportable power requirements and exceed weight requirements for individual soldier systems. Advanced lithium and nickel metal hydride (Ni-M-H) batteries will meet very near term manportable power requirements, but, beyond that, development of more powerful batteries will be necessary. The development of compact, high-energy fuel cells may also address power requirements of individual soldier systems for personal cooling/heating and CBW protection.

Justification: Significant requirements for low cost, long life power sources across a wide spectrum of military applications, including manportable equipment and future individual soldier systems. Training requirements will continue to consume a large number of these resources

Implementation: World leaders in the development of lithium and Ni-M-H batteries and fuel cells include the **United States**, the **United Kingdom**, **PACRIM**, **France**, and **Russia**. The DEA with France has potential for contributions to ASTMP goals and objectives. Additionally, an umbrella agreement concerning Technology Research and Development Projects (TRDP) exists with France, and might serve as an additional exchange mechanism, via the establishment of a Project Agreement (PA) covering this technology.

AMC POC: Dr. Rodney Smith
Army Materiel Command
AMXIP-OB
5001 Eisenhower Blvd
Alexandria, VA 22333-0001
e-mail: icpa@hqamc.army.mil

MSC POC: Ms. Annette Chomsky
US Army CECOM
ATTN: AMSEL-RD-AS-TI
Ft. Monmouth, NJ 07703
e-mail: chomsky@doim6.monmouth.army.mil

F. Command, Control, and Communication

C^3 technology encompasses capability to acquire, process, and disseminate information across force elements (including international coalition forces). The functions must be reliable, provide secure multi-level access, and be protected from enemy attacks. This will require advances not only in computing hardware and software (discussed in Section E.II.G) but in the interconnection fabric of communications. As delineated in the JWSTP, the goal is seamless and effective integration of capabilities for planning and preemption, integrated force management, and effective employment of sensor-to-shooter "systems-of-systems." Table E.II-5 below summarizes trends in capabilities to meet milestones in seamless communications, information distribution and management, and decision-making addressed in Chapter IV of the ASTMP Volume I.

Table II.E-5. Command, Control, and Communications

F. COMMAND, CONTROL, AND COMMUNICATIONS	UNITED KINGDOM	FRANCE	GERMANY	OTHER COUNTRIES	JAPAN	PACIFIC RIM	FSU
SEAMLESS COMMUNICATION	Battlefield interoperability	Battlefield interoperability	Comm. networks Battlefield interoperability International interoperability	**Canada** tactical interoperability	Fuzzy logic, High-speed comm.		
INFORMATION DISTRIBUTION AND MANAGEMENT	Natural language processing	Real-time distributed comm. Switch systems Machine translation C^2 simulation	Machine translation Natural language processing	**Canada** advanced data display **Netherlands** natural language processing Knowledgebase/ database science			
DECISION MAKING	Intelligent systems	Mission planning		**Israel** battle management	Fuzzy logic		

Digitization of the battlefield—as reflected in the Army C4I technical architecture and the inter-operability objectives of the Army Digitization Office—is expected to rely largely on the effective use of commercial off-the-shelf (COTS). While these may provide many of the building blocks, integration, demonstration of the technology in the field remains a significant challenge. Widespread mass market availability of low-cost computers of unprecedented power and global connectivity over the Internet has lead to rapid expansion and proliferation of information systems technologies.

There are several key areas where international developments are likely to provide continuing opportunities for cooperation. These include:

High-speed digital switching and networking techniques supporting seamless communications and robust interoperable systems.

Machine translation software products, and intelligent agents for data acquisition and retrieval.

Intelligent systems technologies for real-time decision support.

The opportunities highlighted in the following paragraphs support defense technology objectives for achieving information superiority and operational dominance in the battlespace of the future. The breadth, diversity, and number of the areas highlighted reflect the nature of the global information infrastructure, and identify a number of areas where existing or near-term pending agreements offer significant opportunities for cooperation.

1. Real-time Distributed AI-based Data Fusion (France)

Description: Exploratory investigations of applications of distributed, intelligent systems to real-time data fusion and combat battle management.

Justification: A major thrust of the ASTMP is enhancement of operational capabilities by incorporating AI into large synthetic computing environments in which networking and process management are handled automatically and are transparent to the user. **France** has extensive experience and a sound information technology infrastructure, combined with strong capabilities in battlefield communications to support research in this area.

Implementation: An umbrella agreement concerning Technology Research and Development Projects (TRDP) exists with France, and is a potential vehicle for establishing a Project Agreement (PA) covering this technology. Use of the TRDP and PAs will speed up development of new technologies.

There are also two active DEAs with France, the scope of which encompasses this work and which could also be used to develop this opportunity.

AMC POC: Dr. Rodney Smith
Army Materiel Command
AMXIP-OB
5001 Eisenhower Blvd
Alexandria, VA 22333-0001
e-mail: icpa@hqamc.army.mil

MSC POC: Ms. Annette Chomsky
US Army CECOM
ATTN: AMSEL-RD-AS-TI
Ft. Monmouth, NJ 07703
e-mail: chomsky@doim6.monmouth.army.mil

2. Air/Land Enhanced Reconnaissance Targeting (ALERT)

Description: Develop a multi-function laser to support the on the move algorithm requirements of the Air/Land Enhanced Reconnaissance and Targeting program (ALERT). The laser must have the functionality to provide eye safe range, range mapping, target profiling, non-eye safe range and target designation at tactical ranges and speeds for the Comanche.

Justification: Currently, the Comanche multi-mode laser provides only non-eye safe target range and target designation as well as eye safe range. What is needed to achieve the potential of aided on-the move performance is multi-function laser. The laser must have an increased pulse rate of 10x above the current Comanche laser as well as scan/target profiling capability.

Implementation: Potential foreign suppliers of the technology are known to exist.

Inquiries regarding cooperative projects and arrangements in this area should be directed to the AMC POCs identified below:

AMC POC:	Dr. Rodney Smith Army Materiel Command AMXIP-OB 5001 Eisenhower Blvd Alexandria, VA 22333-0001 e-mail: icpa@hqamc.army.mil
IPOC:	Bob Both US Army CECOM ATTN: AMSEL-RD-AS-TI Fort Monmouth, NJ 07703 e-mail: both@doim6.monmouth.army.mil

3. Battlespace Command and Control (BC2) ATD

Description: Establish seamless information transfer in command and control to include collaborative planning, intelligence, logistics and weather.

Justification: As US forces increasingly partner with a diverse roster of nations in global missions there is an acute need for systems level interoperability and integration. Consistent Battlespace Understanding (Command and Control, Intelligence, Targeting, Logistics, Weather, and other information) must be shared seamlessly, as though destination and source were part of a unified system. This need transcends echelon and spans the full spectrum of warfighter operations.

This will provide: a consistent battlespace understanding that will result in more rapid, effective decisions leading to reduced casualties and fratricide of the combined force; More thorough and swift sharing of tactical information, providing improved force synchronization, broadened force versatility, and mission achievement consistent with commander's intent/objectives; Interoperable C4I systems provide a proactive means for collaborative planning, course of action analysis, forecasting and mission rehearsal resulting in improved force performance and more effective allocation of resources; An established combined force Systems Architecture provides flexibility to the CJTF and facilitates combined operations.

Implementation: Through existing agreements continue discussions with allies to identify "niche" areas with a potential for collaboration.

Keep allies apprised of our efforts so they will adopt compatible programs with potential to utilize same standards and underlying architectures. This will increase potential for collaboration in the future.

Inquiries regarding cooperative projects and arrangements in this area should be directed to the AMC POCs identified below:

AMC POC: Dr. Rodney Smith
Army Materiel Command
AMXIP-OB
5001 Eisenhower Blvd
Alexandria, VA 22333-0001
e-mail: icpa@hqamc.army.mil

MSC POC: Bob Both
US Army CECOM
ATTN: AMSEL-RD-AS-TI
Fort Monmouth, NJ 07703
e-mail: both@doim6.monmouth.army.mil

4. Vehicle Mounted Mine Detector (VMMD)

Description: There is an urgent need for a teleoperated, vehicle mounted mine detection and marking system. This capability does not currently exist in the U.S. inventory and a vehicle mounted mine detector has top priority. The top priority in obtaining this capability is the development of the Ground Standoff Minefield Detection System (GSTAMIDS). GSTAMIDS, as envisioned, will use multiple integrated sensors to detect and locate individual mines/minefields and mark individual mines or clear lanes.

Justification: The U.S. Army Engineer School has a draft Operational Requirements Document (ORD) entitled Ground Standoff Minefield Detection System (GSTAMIDS).

GSTAMIDS shall be a vehicle-mounted system without an integral power source. GSTAMIDS shall detect and mark surface or buried, metallic and/or nonmetallic, antitank (AT) mines.

This vehicle mounted mine detection program, currently scheduled for an Advanced Technology Demonstration (ATD), would gain the lessons learned by the other participating countries' vehicle mounted detector programs, mine detection expertise and experience, contrasting test facility capabilities/environments from joint tests and improve our overall vehicle mine detection technology approach. In addition, the **U.S.** would obtain technical data on sensor performance for sensor types that we are not pursuing in our VMMD program.. There would be cost associated with joint/international tests here in the U.S. and with our allies. Current VMMD program costs for travel and testing would have to be augmented by this program to include our allies VMMD equipment and schedules.

Several countries are pursuing mine detection technologies that are of interest to the **U.S.** These programs are known to address nuclear, radar, and IR technologies for mine detection using vehicular platforms.

Implementation: Existing approach/platform is the Technical Cooperation Program (TTCP) which has a Terms of Reference (TOR) already in place between the following countries: **Australia, Canada, New Zealand, United Kingdom** and **United States** in the area of countermine and humanitarian demining. The specific TTCP Subgroup is W and their is a special Technical Liaison Group #5 (TLG-5) dealing specifically with countermine and humanitarian demining technologies. NATO AC243/RSG1 Panel on mine detection technologies is another forum for the discussion of these technologies.

Inquiries regarding cooperative projects and arrangements in this area should be directed to the AMC POCs identified below:

AMC POC: Dr. Rodney Smith
Army Materiel Command
AMXIP-OB
5001 Eisenhower Blvd
Alexandria, VA 22333-0001
e-mail: icpa@hqamc.army.mil

MSC POC:

Bob Both
US Army CECOM
ATTN: AMSEL-RD-AS-TI
Fort Monmouth, NJ 07703
e-mail: both@doim6.monmouth.army.mil

5. Command Post Communications (Germany)

Description: Broadband communications networks for corps, division, and brigade command posts.

Justification: The **German** Army is developing a wideband, wireless command post communications network that will be capable of providing voice, digital data, and video connectivity among the elements of a dispersed command post. This system is similar to the system being investigated in the **U.S.** Army's Survivable Adaptive System (SAS) ATD. There is real potential for data exchanges and an interoperability effort between these two programs. A key German technology includes ultrafast 40 GHz optical switching developed by the Heinrich Hertz Institute.

Implementation: The umbrella agreement concerning Technical Research and Development Projects with Germany could be used to set up an interoperability program between BIGSTAF and SAS. It is possible that data could be exchanged between these two programs.

AMC POC: Dr. Rodney Smith
Army Materiel Command
AMXIP-OB
5001 Eisenhower Blvd
Alexandria, VA 22333-0001
e-mail: icpa@hqamc.army.mil

MSC POC: Ms. Annette Chomsky
US Army CECOM
ATTN: AMSEL-RD-AS-TI
Ft. Monmouth, NJ 07703
e-mail: chomsky@doim6.monmouth.army.mil

6. Machine Translation (Germany)

Description: Machine translation technology can be used in the C3 area for information exchange between U.S. and allied forces in combined operations.

Justification: There is a significant amount of research and development in the area of machine translation being done in **Germany**. The German Army has developed a prototype translation system consisting of a 16-channel recorder, a server, two workstations, and an electronic military lexicon. The Germans are interested in cooperation in the further development of this capability, particularly in the areas of language identification, speaker identification, and automatic translation. Additionally, there is world class research in machine translation being done in Germany at Siemens and the University of Karlsruhe.

Implementation: The umbrella agreement concerning Technical Research and Development Projects with Germany could be used to set up a Project Agreement (PA) covering this technology.

AMC POC: Dr. Rodney Smith
Army Materiel Command
AMXIP-OB
5001 Eisenhower Blvd
Alexandria, VA 22333-0001
e-mail: icpa@hqamc.army.mil

MSC POC: Ms. Annette Chomsky
US Army CECOM
ATTN: AMSEL-RD-AS-TI
Ft. Monmouth, NJ 07703
e-mail: chomsky@doim6.monmouth.army.mil

7. Next Generation Tactical Switches (France)

Description: This project concerns R&D of advanced switch systems technology to further the performance of information flow to and from the land forces (Army) commander. Advanced switch technology, specifically Asynchronous Transfer Mode (ATM) switching, promises to offer many advantages to a next-generation information infrastructure, for commercial as well as military tactical and strategic applications. This project will serve for exchange of technology that will be developed in the parties' respective R&D technology base programs.

Justification: The growing information explosion integrating voice, data, and imagery will be affecting all military services and the Army tactical commander has a growing, long-term need to send and receive voluminous amounts of information in many and various forms. This project will serve to advance the tactical switch system technology and lay the basis for the next generation of Army tactical switches that will transport information in a global, seamless manner.

Implementation: There is an existing agreement in this technology area with France.

AMC POC:
Dr. Rodney Smith
Army Materiel Command
AMXIP-OB
5001 Eisenhower Blvd
Alexandria, VA 22333-0001
e-mail: icpa@hqamc.army.mil

IPOC:
Mr. Robert Both
U.S. Army CECOM
AMSEL-RD-AS-TI
Fort Monmouth, NJ 07703
e-mail: both@doim6.monmouth.army.mil

8. Battlefield Interoperability Project (France)

Description: This project will extend U.S. Digitization of the Battlefield concepts and techniques to **France**. This will be a stand alone effort which will leverage existing efforts ongoing with **Germany** in relationship to a follow-on to the Combat Vehicle Command and Control System MOU Amendment A. The objective of the proposed effort is to establish a capability necessary for the conduct of joint research and development efforts needed to implement, evaluate, and validate improved interoperability between the tactical (regiments/ battalion and companies) command and control systems of the respective nations. The **U.S**. approach to demonstrating interoperability is the implementation of an intelligent translation gateway box which will receive variable message format (VMF) messages from a Command Post (CP) on the U.S. side and convert them in real time to French common ADatP3 message format for transmission to a French CP and vice versa.

Justification: The completion of these tasks will lead to the development of equipment and software suitable for providing technical, functional, and operational interoperability between the systems of the two countries. The necessary procedural, operational, and technical translations will be effected to achieve the required interoperability. A series of laboratory experiments utilizing both U.S. and French facilities will be performed leading to a field demonstration of the developed capability.

Implementation: There is an existing agreement in this technology area with France which could potentially expedite implementation of a specific program agreement to address this opportunity.

AMC POC:	Dr. Rodney Smith Army Materiel Command AMXIP-OB 5001 Eisenhower Blvd Alexandria, VA 22333-0001 e-mail: icpa@hqamc.army.mil
IPOC:	Mr. Robert Both U.S. Army CECOM AMSEL-RD-AS-TI Fort Monmouth, NJ 07703 e-mail: both@doim6.monmouth.army.mil

9. International Command and Control Systems Interoperability Project (IC2-SIP) (Germany)

Description: This project, which is part of the Army's strategy for International Digitization, will establish the framework to create a joint testbed facility to conduct research and demonstration efforts needed to implement, evaluate, and validate improved interoperability between the **U.S.** and **German** Command and Control (C2) forces. This program will leverage off previous bilateral Combat Vehicle Command and Control (CVC2) and current ongoing Combined Arms Command and Control (CAC2) efforts The initial interoperability research and demonstration to be undertaken will primarily address Brigade-Battalion echelon C2 Systems interface between U.S. and German Forces.

Justification: To provide a mechanism for U.S. and GE C2 forces to demonstrate and evaluate interoperability and implement new procedures and functions required for a digitized battlefield. It is envisioned that once the testbed is designed, integrated, tested, and fully operational, it will accommodate joint testing between U.S. and other multi-national forces.

DoD Directive 4630.5 states that "forces for combined operations must be supported with compatible, interoperable and integrated Command, Control, Communications and Information (C3I) System." In response to the 1994-99 Defense Planning Guidance, a Mission Need Statement (MNS) was developed for the Horizontal Integration of the Digitized Battle Command. The MNS document delineates the various alternatives to achieve maximum combat power and effectiveness and stipulates that Interoperability and Standardization (I&S) should be accomplished with at least U.S.-NATO and U.S.-ABCA nations.

Implementation: An Amendment to an existing agreement with Germany was used to implement the cooperative program.

AMC POC: Dr. Rodney Smith
Army Materiel Command
AMXIP-OB
5001 Eisenhower Blvd
Alexandria, VA 22333-0001
e-mail: icpa@hqamc.army.mil

IPOC: Mr. Robert Both
U.S. Army CECOM
AMSEL-RD-AS-TI
Fort Monmouth, NJ 07703
e-mail: both@doim6.monmouth.army.mil

10. French-English Machine Translation of C2 Messages (France)

Description: A new 4-year development effort is planned which is designed to produce a multi-directional French-English Interlingual based Machine Translation (MT) system capable of high quality translation of complex sentences in the domain of military free text messages as defined by corpus material from USA CECOM and from STSIE (formerly SEFT) DGA, **France**. The development will produce advanced development software models with best commercial practice documentation containing semantic lexicons of both French and English each having 1000-3000 root word form entries, Graphical User Interface (GUI) tools for augmenting and maintaining the lexicons, and wide coverage grammar parsers and generators.

Justification: A current U.S.-French treaty in force requires multi-national fire support from command and control centers of either nation. In addition, fire support battalions of either nation may be mission assigned to brigades of the other nation. This requires translation of requests for fire and other C2 messages in locations where human translators are unavailable. In addition, the Dessert Storm after action report, the Federated Labs BAA initiative, and command and control STOs mentioning multi-national operations support this requirement.

Implementation: Meetings have been held with the French under various agreements. The exchanges of information in these DEAs may lead to a potential cooperative effort.

AMC POC: Dr. Rodney Smith
Army Materiel Command
AMXIP-OB
5001 Eisenhower Blvd
Alexandria, VA 22333-0001
e-mail: icpa@hqamc.army.mil

PA POC: Mr. Robert Both
U.S. Army CECOM
AMSEL-RD-AS-TI
Fort Monmouth, NJ 07703
e-mail: both@doim6.monmouth.army.mil

11. Intelligent Command Aids (UK)

Description: Project agreement is to investigate potential payoff associated with incorporating emerging fuzzy logic techniques into a large scale battlefield decision making simulation.

Justification: Armies throughout the world continue to expend considerable resources in the pursuit of developing intelligent command aids, particularly in the area of simulation and computer generated forces. A common problem is that of representing the command and control process. It is far too expensive to have human controllers "command" the computer generated forces. Current approaches have usually used large rule-based systems to construct "command agents" that attempt to model individual decision making entities. However, the deterministic behavior introduced by the rule set and inference engine does not realistically reflect the need to act or vague (or fuzzy) knowledge characteristics of a real-world command and control problem. Fuzzy logic techniques and fuzzy inference engines are an approach that enhance current intelligent command aids by overcoming this problem and may also provide proven methodologies for the construction of more realistic and effective future systems.

Implementation: The GeKnoFlexE system developed by the **UK** (Ft. Halstead), which simulates battlefield decision making, will be used as the testbed system. The current conventional rule-based inference structure will be "fuzzified" by augmenting and/or replacing it with fuzzy rules and a fuzzy inference mechanism. Since the current GeKnoFlexE system is completely non-fuzzy, direct comparisons of complexity, behavior, and other performance parameters will be possible.

AMC POC: Dr. Rodney Smith
Army Materiel Command
AMXIP-OB
5001 Eisenhower Blvd
Alexandria, VA 22333-0001
e-mail: icpa@hqamc.army.mil

IPOC: Mr. Stephen Cohn
Army Research Laboratory
AMSTL-TT-IP
2800 Powder Mill Road
Adelphi, MD 20783-1197
e-mail: scohn@arl.army.mil

12. Tactical Level Allied/Coalition Force C2 Simulation (France)

Description: Project objective is to provide a tactical level C2 exercise for a US/FR allied task force utilizing DIS protocols in a JANUS environment. The effort will begin to evolve a plausible doctrine, tactics, and training procedure, with the concomitant military language, symbology, and rank structure, and provide the architecture for an integration of military equipment and systems (interoperation) in order to form a unified C2 structure where politically acceptable. This will be broken down into acceptable "bite-sized" objectives to try various allied/coalition C2 techniques and combinations at the tactical level.

Justification: The key to victory in a combined allied/coalition operation is the unity of purpose and effort. This has been accomplished in past allied/coalition operations by coordinated planning and liaison officer exchanges, establishment of trust through plain and objective communications and personal contact, and unity of command only where it was politically acceptable. This project will lay a sound framework against which future evolution of technologies, tactics, and procedures to enhance interoperability of coalition forces can be better evaluated.

Implementation: Using the FY95 JANUS DIS exercise, recently concluded with the French Centre d'Analyse de Defense (CAD) as a framework, establish a notional US/FR allied task force utilizing the same or similar SWA scenario. Establish a common US/FR lexicon, determine feasibility of language translation, establish operating procedures, and lay out radio net architectures. The task force proceeds to a common objective utilizing FR and U.S. C2 in alternative exercises, giving each side the ability to identify targets, call for fire or close air support, and report across allied lines as well as vertically within each national structure.

AMC POC:	Dr. Rodney Smith Army Materiel Command AMXIP-OB 5001 Eisenhower Blvd Alexandria, VA 22333-0001 e-mail: icpa@hqamc.army.mil
IPOC:	Mr. Stephen Cohn Army Research Laboratory AMSTL-TT-IP 2800 Powder Mill Road Adelphi, MD 20783-1197 e-mail: scohn@arl.army.mil

13. Fuzzy Logic in Mission Planning and Decision Making (France)

Description: Project is to provide a theoretical and empirical foundation for using fuzzy information in planning and decision making environments, with an eye toward future extension into other larger systems (such as battlefield simulations). Fuzzy logic techniques will be used to allow the manipulation of vague data to increase realism of simulation and, ultimately, effectiveness of decision making.

Justification: Automated mission planning systems require evaluation of potential paths based upon a perception of the current true situation. Automated decision making aids consider relevant courses of action in a similar manner. In virtually every case, the current situation is perceived based on vague or uncertain data; for example, data on enemy positions, weapon ranges, reaction time, efficiency, and so on. Most systems for planning and decision making use or assume precise data. When only vague information is available, some "rounding off" must occur, either manually or automatically, before presenting the data to the system. Such a process not only introduces added complexity, but also may adversely affect the reliability of subsequent plans or decisions based on the altered data. Fuzzy logic information will improve the capability of mission planning and decision making aids.

Implementation: The work already begun by individuals at MATRA will be used as a basis from which to build. Methodologies for integrating fuzzy information into the mission planning process will be investigated and applied to existing and/or new automated aids. Fuzzy logic approaches for data collection, aggregation, and potentially deaggregation will be evaluated and applied to decision making systems.

AMC POC: Dr. Rodney Smith
Army Materiel Command
AMXIP-OB
5001 Eisenhower Blvd
Alexandria, VA 22333-0001
e-mail: icpa@hqamc.army.mil

IPOC: Mr. Stephen Cohn
Army Research Laboratory
AMSTL-TT-IP
2800 Powder Mill Road
Adelphi, MD 20783-1197
e-mail: scohn@arl.army.mil

G. Computing and Software

While military applications will increasingly rely on COTS, there remain unique requirements for which technological advances in basic computing hardware and software will be required. These fall into the realm of so-called "grand challenge", which will require Tera (10^{15}) Operations/second. Several different approaches are being considered, each of which--if ultimately realized--is likely to offer certain inherent advantages for different applications. High-performance computing and scalable parallel systems are of particular importance. Optical processing techniques combine elements of both and are being pursued as a means of increasing inherent parallelism and computation throughput. Software advances are seen as a way to allow aggregation of very large numbers of computing elements. Both of these approaches lend themselves to solutions to complex deterministic problems (i.e., problems for which a sequence of calculations to reach a specific solution can be defined). By contrast neural networks provide a better way of attacking less determinate problems.

Table E.II-6 below highlights significant capabilities and trends in key areas of computing and software. High performance computing is an area of international research and development. In addition to France, which is recognized as a world leader in photonics, Japan, and Russia have had strong programs in optical computing; Germany has a growing interest, and has strong capabilities in production of photodynamically active bacteriorhodopsin films which may prove to be an enabling technology for future optical/molecular computers. Israel has a small, but sound and growing electrooptics infrastructure as well. The growth of the Internet and multi-media are producing growing demand for development and global implementation of very high-speed digital networks. Development of these is an international activity, with cooperation among major telecommunications firms. One example is the Japanese Real-World Computing program which includes a number of other countries as participants.

Table E.II-6. Computing and Software

G. COMPUTING AND SOFTWARE	UNITED KINGDOM	FRANCE	GERMANY	OTHER COUNTRIES	JAPAN
HIGH PERFORMANCE COMPUTING AND SCALABLE PARALLEL SYSTEMS	➤ MPP	➤ Optical processing	➤ MPP Artificial neural networks		➤ Artificial neural networks
NETWORKING	➤ Optical switching	➤ Tactical fiber optic systems	➤ Fiber optic systems	➤ **Canada** optical switching and networks **China** Fiber optics	➤ Optical switching and networks
SOFTWARE ENGINEERING	➤	➤	➤ Software for MPP and neural networks	A **India** **Israel** CASE and applications	
ARTIFICIAL INTELLIGENCE	➤	➤	➤	➤ **Many**	➤
HUMAN COMPUTER INTERFACE	➤ Visually-coupled systems	➤ Visually-coupled systems	➤ Visually-coupled systems	A **Canada** Visually-coupled systems Large data-set representation A **Italy** Haptic/tactile sensors	➤ Visually-coupled interfaces

International software developments are enabled by widespread availability of very powerful microprocessor-based symmetrical multi-processing systems. A number of countries, including **Israel, India**, and **Russia** are actively engaged in commercial cooperative software developments. Increasing processing capability has also led to a growing level of international interest and work in intelligent systems and human composite interfaces.

The following subsections identify specific opportunities where existing or near-term pending agreements offer significant potential benefits.

1. Photonic Devices for Optical Computing (France)

Description: Data throughput processing requirements of real-time imagery and signal processing exceed the capabilities of digital electronic processors. Optical processing techniques are well suited for analysis of data generated by these high volume throughput applications. The development of photonic devices necessary for optical computing are of significant interest to the U.S. Army and have numerous military applications. World leaders in photonics/electro-optics include the **United States** and **Japan**, followed by **France**, the **United Kingdom**, and **Germany**.

Justification: ASTMP goals include demonstration of a 2-D optical processor capable of running real-time Automatic Target Recognition (ATR) and signal processing algorithms on data from imaging sensors such as the Synthetic Aperture Radar (SAR) or electro-optical (E-O) systems. Near-term ASTMP milestones include the development of optical interconnections for computers; photonic and electronic devices integrated on the same chip; image-forming light modulators; and an order of magnitude improvement in spatial light modulation dynamic range.

Implementation: Active agreements cover this area.

AMC POC:

Dr. Rodney Smith
Army Materiel Command
AMXIP-OB
5001 Eisenhower Blvd
Alexandria, VA 22333-0001
e-mail: icpa@hqamc.army.mil

CECOM IPOC:

Ms. Annette Chomsky
US Army CECOM
ATTN: AMSEL-RD-AS-TI
Ft. Monmouth, NJ 07703
e-mail: chomsky@doim6.monmouth.army.mil

ARL IPOC:

Mr. Stephen Cohn
Army Research Laboratory
AMSTL-TT-IP
2800 Powder Mill Road
Adelphi, MD 20783-1197
e-mail: scohn@arl.army.mil

2. MPP and Neural Network Programming (Germany)

Description: Massively Parallel Processing (MPP) and neural network programming could be applied to numerous applications covered by ASTMP milestones and objectives in each of the 10 science and technology areas. Simulation and modeling are examples of applications requiring the computing speed and power (data crunching capacity) offered by MPP techniques, while neural network programming may be more useful in the development of decision aids. Only a few countries pose the supporting infrastructure necessary for major research and development in these technologies. World leaders include the **United States, Japan, Germany**, and to a lesser extent the **United Kingdom** and **France**.

Justification: MPP and neural network programming are important aspects of the Army's electronic battlefield (EBF) concept. MPP will contribute significantly to simulation and virtual reality components of the EBF.

Implementation: An active DEA exists with Germany.

AMC POC:
Dr. Rodney Smith
Army Materiel Command
AMXIP-OB
5001 Eisenhower Blvd
Alexandria, VA 22333-0001
e-mail: icpa@hqamc.army.mil

IPOC:
Mr. Stephen Cohn
Army Research Laboratory
AMSTL-TT-IP
2800 Powder Mill Road
Adelphi, MD 20783-1197
e-mail: scohn@arl.army.mil

3. Algorithms for Massively Parallel Processing (MPP) [NATO Groups]

Description: A key to advanced simulation and modeling is the implementation of advanced algorithms, specifically for MPP. Currently only a few countries possess the supporting infrastructure necessary for major research and development in this area. World leaders include the **United States, Japan, Germany**, and to a lesser extent the **United Kingdom** and **France**.

Justification: MPP is an important aspect of the Army's electronic battlefield (EBF) concept, and will contribute significantly to simulation and modeling and virtual reality applications. [This opportunity is closely related to another opportunity (Techniques for MPP and Neural Network Programming).]

Implementation: There is an active DEA that has the potential to contribute to ASTMP goals. Other existing mechanisms exist which also have potential for contribution.

AMC POC:	Dr. Rodney Smith Army Materiel Command AMXIP-OB 5001 Eisenhower Blvd Alexandria, VA 22333-0001 e-mail: icpa@hqamc.army.mil
IPOC:	Mr. Stephen Cohn Army Research Laboratory AMSTL-TT-IP 2800 Powder Mill Road Adelphi, MD 20783-1197 e-mail: scohn@arl.army.mil

H. Conventional Weapons

Conventional weapons objectives are directed towards a variety of technologies for increasing the lethality and mission effectiveness of guided and unguided weapons and mines. Opportunities are to be found in a variety of subareas identified in Chapter IV of the ASTMP, volume I as illustrated in the Table E.II-7 below.

Table E.II-7. Conventional Weapons

H. CONVENTIONAL WEAPONS	UNITED KINGDOM	FRANCE	GERMANY	OTHER COUNTRIES	JAPAN	PACIFIC RIM	FSU
FUZING, SAFING AND ARMING	OVERALL	OVERALL	OVERALL	Israel Italy	Components		
GUIDANCE AND CONTROL	OVERALL	OVERALL	OVERALL		Components	ROK	
GUNS, CONVENTIONAL AND ELECTRIC	ETC gun	OVERALL	ETC gun	Israel ETC gun		Australia Rail-guns	Russia OVERALL
MINES AND COUNTERMINES	OVERALL	OVERALL	OVERALL				Russia OVERALL
WARHEADS EXPLOSIVES AND ROCKET/MISSILE PROPULSION	OVERALL	OVERALL Hypervelocity propulsion	Vehicle integration	Israel BMD missile Sweden Switzerland	Hypervelocity propulsion		
WEAPON LETHALITY AND VULNERABILITY							

Russia, France, Germany, and the **U.K.** are major developers of conventional weapons followed closely in capability by **Italy, Sweden**, and **Israel**. **Japan**, which is prohibited by its national legislation from exporting weapons, has significant indigenous capabilities as well as strong capabilities in certain lay component technologies such as gallium arsenide microwave components and neural net and fuzzy logic pattern recognition, and hypervelocity propulsion. Army objectives for improvements in tungsten alloy penetrators may be furthered by cooperation with other countries, including the **U.K.** and **France**. **France** has strong capabilities in explosives and propulsion systems; including air-breathing hypervelocity propulsion systems. **Japan** has also taken steps to improve its technological capabilities in aerospace materials and aerodynamic design for hypersonic propulsion systems. Both of these could contribute to development of long-range hypervelocity systems for the Army.

The ASTMP Chapter IV.H includes milestones for extending the range and lethality of conventional artillery and anti-armor rounds. The growing global concern about increased proliferation of mines and countermine capabilities point to the need for international development and adoption of new design standards and mine clearing capabilities. The following highlight specific areas where existing or near-term pending agreements offer significant opportunities for advances in hypervelocity missile propulsion, electrothermal gun propulsion, and guidance and control.

1. Hypervelocity Vehicle Propulsion (Japan, Germany)

Description: The development of hypervelocity vehicles depends greatly upon advanced rocket propulsion techniques, as well as advances in airframe design, and guidance and control. Advances in propulsion technology (specifically air-breathing propulsion) are necessary to support near term objectives of U.S. Army missile development programs.

Justification: Advances in hypersonic/hypervelocity (Mach 6-8), shortening engagement cycle times, and increasing system lethality threat handling capabilities will enhance close combat and short range air defense missions. **Japan** and **Germany** have significant experience in the design, manufacture, and testing of air-breathing rocket motors and components. **Japan** has initiated a broad-based initiative to develop materials and structural/aerodynamic design techniques for hypervelocity transport , the results of which could contribute to this effort. The focus of efforts is towards a multi-mission kinetic energy missile capable of being launched from multiple light platforms, and hitting a target with 3-5 times the kinetic energy of tank cannons.

Implementation: Inquiries regarding potential cooperative projects and arrangements in this area should be directed to the POCs identified below.

AMC POC:

Dr. Rodney Smith
Army Materiel Command
AMXIP-OB
5001 Eisenhower Blvd
Alexandria, VA 22333-0001
e-mail: icpa@hqamc.army.mil

IPOC:

Mr. Thomas K. Lambert
Scty Asst Mgt Dir
U.S. Army Missile Command
Redstone Arsenal, AL 35898-5210
e-mail: tlambert@redstone.army.mil

2. Electrothermal-Chemical Propulsion Technology (United Kingdom, Israel)

Description: Electrothermal-Chemical Propulsion (ETC) is a collection of propulsion concepts which offer the potential for near-term substantial increases in projectile kinetic energy (up to 25 percent) while utilizing conventional solid propellant gun tube and projectile technology.

Justification: If successful, this program will provide the **U.S**. Army with propulsion technology which will increase projectile kinetic energy (up to 25 percent) and overall gun performance by up to 50 percent with corresponding increases in lethality and range. At the present time, the **United States** has the lead in this technology, but, over the next several years, the **United Kingdom** is devoting substantially more resources than the **United States** in the exploration of several novel ETC approaches which could benefit U.S. programs. Israeli research has already demonstrated an 18 percent increase in velocity, using electrical energy to augment and control the conventional propellant's burn.

Implementation: The effort with the **United Kingdom** falls under TTCP and will address advanced propellant development, modeling and simulation, and plasma/propellant interaction required to obtain weapons-level performance enhancement and repeatability. Another source for potential contributions is a classified MOU with **Israel**.

Israel

AMC POC:	Dr. Rodney Smith Army Materiel Command AMXIP-OB 5001 Eisenhower Blvd Alexandria, VA 22333-0001 e-mail: icpa@hqamc.army.mil
IPOC:	Mr. Stephen Cohn Army Research Laboratory AMSTL-TT-IP 2800 Powder Mill Road Adelphi, MD 20783-1197 e-mail: scohn@arl.army.mil

I. Electronic Devices

The **US** and **Japan** generally share a commanding world lead in most aspects of electronic componentry and packaging, with the **UK, France, Germany**, and **Russia** having strong capabilities in the subareas identified in Chapter IV of the ASTMP, Volume I and summarized in Table E.II-8 below.

Table E.II-8. Electronic Devices

I. ELECTRONIC DEVICES	UNITED KINGDOM	FRANCE	GERMANY	OTHER COUNTRIES	JAPAN	PACIFIC RIM	FSU
ELECTROOPTICS	Photonics signal processing	IR FPA	Photonics signal processing	**Israel** **Italy**	All aspects		
MILLIMETER WAVE COMPONENTS	MMIC	MMIC, compound semiconductors	MMIC, compound semiconductors	**Israel**	MMIC, acoustic wave devices, compound semiconductors		
NANOELECTRONICS	Microscopy	Molecular chemistry	Submicron devices		All aspects		**Russia** molecular electronics
PORTABLE ELECTRICAL POWER		Batteries	Small engines	**Switzerland**	All aspects		**Russia** rechargeable batteries, power switching

France has a strong capability in photonics and microwave tubes, and is doing innovative work in optical switching and distribution of microwaves that may lend itself to conformal phased array radar and smart-skin applications. **France, Germany**, and **Japan** all have strong capabilities in millimeter waves, and in the underlying compound semiconductor processing required. An area of interest is German exploration of the potential use of indium phosphide as an alternative to GaAs. The promise of indium compounds has yet to be realized in production devices, a breakthrough in processing, leading to more economical production of MIMIC/MMICs would be significant. In nanoelectronics, the countries listed have had strong efforts in molecular electronics, and in areas of biotechnology that should support advances in the kind of self-assembling nanostructures that are now envisioned for nanoelectronics. The **FSU** had developed a well organized infrastructure in molecular electronics, potentially applicable to a variety of nanoelectronic devices. While the effect of the break-up of the **FSU** is difficult to estimate, significant residual capability in this area may still exist. Recent advances in biotechnology and advanced microscopy are also likely to increase the general worldwide level of activity and capability in this area.

In portable power, **Japan** is a world leader in virtually all aspects, with strength in batteries, fuel cells, power control and switching components. **France** is strong in batteries, and **Russia** has strengths in certain types of rechargeable batteries and in power switching components, **Switzerland** is a leader in capacitive storage, and **German** and **Japanese** work on small fossil-fueled rotating engines for power generation may ultimately provide a practical solution to soldier power and sustainability (See also E-II.E.)

The following subsections identify specific opportunities where existing or near-term pending agreements offer significant potential benefits.

1. IR Focal Plane Array Fabrication and Packaging (France)

Description: New developments in Focal Plane Array (FPA) technology may provide significant enhancements over currently fielded systems. Of particular interest is the design, fabrication, and packaging of smart FPAs into a single (monolithic) structure. France is a world leader in several aspects of IR technologies, and has both the experience and supporting infrastructure necessary for research and development in this field.

A major barrier in implementing the monolithic structure of a smart FPA is the growth of Cadmium Zinc Telluride (CdZnTe) and Mercury Cadmium Telluride (HgCdTe) on Silicon (Si). Currently, a French Scientist is at Fort Belvoir working with ARL and NVESD scientists to overcome this obstacle.

Justification: The purpose of the Smart Focal Plane Arrays ASTMP STO is the development of a new generation of high density, two-dimension arrays to meet target acquisition requirements of future weapon systems. These arrays will combine varying wavelength regions into a single monolithic structure with on-chip processing. A specific ASTMP goal is to develop and demonstrate a full-up FPA with integrated readouts and imaging processing capability.

Implementation: An active DEA exists with France covering new developments in IR. Another DEA with France may also contribute to ASTMP goals and objectives. Additionally, an umbrella agreement concerning Technology Research and Development Projects (TRDP) exists with France, and might serve as an additional exchange mechanism via the establishment of a Project Agreement (PA) covering this technology.

AMC POC:	Dr. Rodney Smith Army Materiel Command AMXIP-OB 5001 Eisenhower Blvd Alexandria, VA 22333-0001 e-mail: icpa@hqamc.army.mil
CECOM IPOC:	Mr. Richard Pei US Army CECOM ATTN: AMSEL-RD-AS-TI Fort Monmouth, NJ 07703 e-mail: peir@doim6.monmouth.army.mil
ARL IPOC:	Mr. Stephen Cohn Army Research Laboratory AMSTL-TT-IP 2800 Powder Mill Road Adelphi, MD 20783-1197 e-mail: scohn@arl.army.mil

2. Development of Indium Compounds for MMIC/MIMIC (Germany)

Description: Future electronic systems demand increasingly smaller, faster, and cheaper microelectronic devices. Devices based upon silicon technology (such as VHSIC—Very High Speed Integrated Circuits) have reached a point at which components cannot be manufactured at significantly smaller sizes.

Justification: The use of MIMIC technology will contribute directly to the development of powerful multi-purpose single monolithic chips for sensors, processors, and millimeter wave phased array antennas. To meet future requirements, compound semiconductors are necessary. While **Japan, France**, and **Germany** are world leaders in compound semiconductors, **Germany** has developed a specific niche in Indium compounds. German contributions to microwave and photonic devices could be significant if initial projections can be realized in production devices.

Implementation: An active DEA exists with Germany and could serve as a vehicle for the exchange of information to support ASTMP objectives.

AMC POC:

Dr. Rodney Smith
Army Materiel Command
AMXIP-OB
5001 Eisenhower Blvd
Alexandria, VA 22333-0001
e-mail: icpa@hqamc.army.mil

IPOC:

Ms. Annette Chomsky
US Army CECOM
ATTN: AMSEL-RD-AS-TI
Ft. Monmouth, NJ. 07703
e-mail: chomsky@doim6.monmouth.army.mil

J. Electronic Warfare/Directed Energy Weapons

Design of EW and directed energy systems often demands detailed intelligence regarding the characteristics of the system being attacked. To the extent that this requires disclosure of threat intelligence, international cooperation is impeded. There are, however, several areas of technology of a more general dual use nature, including high power microwave tubes (in which **France** and the **UK** have significant capabilities) and lasers, where the **France** and **Germany** have strong capabilities. Table E.II-9 provides a summary of potential opportunities for each technology subarea.

Table E.II-9. Electronic Warfare and Directed Energy Weapons

J. ELECTRONIC WARFARE AND DIRECTED ENERGY WEAPONS	UNITED KINGDOM	FRANCE	GERMANY	OTHER COUNTRIES	JAPAN	PACIFIC RIM	FSU
ELECTRONIC ATTACK							
ELECTRONIC SUPPORT	**Research in these areas may require sharing of sensitive threat information and is handled on a case-by-case basis**						
ELECTRONIC PROTECTION							
RF DEWs	HPM	HPM					**Russia, Ukraine** HPM
LASERS	Low energy lasers	Laser materials			High energy lasers Low energy lasers		**Russia** High energy lasers Low energy lasers

The following subsections identify specific opportunities where existing or near-term pending agreements offer significant potential benefits.

1. Advanced Materials for Visible Solid-State Lasers (France)

Description: Optical countermeasure systems for the visible spectral region need, for some applications, substantially higher efficiencies than are likely to be achieved by frequency shifting from existing lasers. Diode pumped solid-state lasers operating directly at visible wavelengths hold the potential to solve this problem, but improved materials (gain media) are required.

Justification: The ASTMP identifies milestones for development of a high efficiency laser source operating in the visible spectral band. This may be achieved by using a diode array pumped solid-state crystalline laser medium. Such lasers could be used for optical pumping for Laser IR Countermeasures Systems, as well as in other applications demanding efficient generation of laser energy for communications, photonic computing, etc. Two foreign groups are among the world leaders in the development of such materials: the group at Universite' de Lyon in **France** and the group at Universitat Hamburg in **Germany**. Both groups, together with their research collaborators, have the expertise and infrastructure to make valuable progress in the identification and development of the needed materials.

Implementation: Existing interactions in the international arena under existing agreements provide a particularly strong opportunity to learn from expertise on laser materials and on different mechanisms for diode pumping of visible lasers.

AMC POC: Dr. Rodney Smith
Army Materiel Command
AMXIP-OB
5001 Eisenhower Blvd
Alexandria, VA 22333-0001
e-mail: icpa@hqamc.army.mil

MSC POC: Ms. Annette Chomsky
US Army CECOM
ATTN: AMSEL-RD-AS-TI
Ft. Monmouth, NJ 07703
e-mail: chomsky@doim6.monmouth.army.mil

K. Environmental Quality and Civil Engineering

The problems of meeting national and international environmental standards, and of engineering affordable and sustainable facilities and infrastructures in a climate of reduced funding are common to all of our potential partners. Remediation of environmental pollution and maintenance of infrastructure are areas of considerable importance to the civil sector as well, and most industrialized nations have active programs in techniques, materials, and in modeling and simulation to support requirements analysis and design.

Table E.II-10 highlights significant environmental and civil engineering capabilities. Among notable highlights, the **U.K.** has been a leading force in the development of international standards for environmental management systems. Much of the current draft ISO Standard is patterned after existing British standards. **Japan,** the **U.K.**, **Germany, France, Israel**, and the **Nordic Group** all have significant effort in bioremediation (the use of biological organisms or their products (enzymes) to breakdown or neutralize a wide range of contaminants). The French in particular have had a long-standing interest and strong effort in biodegradation and demilitarization of energetic materials. Internationally there is growing concern for clean-up of organophosphate insecticide-contaminated sites. An effective enzymatic treatment for this purpose might also be adopted for decontamination of nerve agents. We can anticipate that growing awareness of environmental effects as regional and global issues, and the emergence of international standards for their effective management, will lead to opportunities for increased cooperation to improve pollution prevention, environmental protection, techniques for monitoring and compliance, and remediation particularly with EC countries and Japan who are moving rapidly towards adoption of the ISO 14000 standard.

While no highlighted opportunities have been identified in this area. Germany is a world leader, and other industrialized nations have substantial programs and capabilities which are appropriate areas for cooperative work.

Table E.II-10. Civil Engineering and Environmental Quality

K. CIVIL ENGINEERING AND ENVIRONMENTAL QUALITY	UNITED KINGDOM	FRANCE	GERMANY	OTHER COUNTRIES	JAPAN	PACIFIC RIM	FSU
ENVIRONMENTAL QUALITY	▲ Environmental protection; Bioremediation; Regulatory compliance	▲ Environmental protection; Bioremediation; Demil of energetic materials	▲ Environmental protection; Bioremediation	▲ **Nordic Group** **Israel** Environmental protection; Bioremediation	▲ Environmental protection; Bioremediation	▲ **Singapore** Bioremediation	
CIVIL ENGINEERING	▲ Light-weight bridging	➤ Survivable structures	➤				

Nordic Group = Finland, Norway, Sweden

L. Battlespace Environment

An understanding of battlefield environments and effects are essential in all aspects of a military system's life cycle, from modeling and simulation for design, through mission planning and rehearsal, to actual configuration and programming of sensors and weapons in execution. Here cooperative international programs are needed to ensure that coalition forces can interoperate effectively with a common and consistent understanding of the battlespace, and with an ability to receive and process environmental information required to execute the battle.

The technologies and capabilities addressed in this section are critical to realizing the JCS long term strategy for information superiority and dominant battlespace knowledge. Table E.II-11 highlights specific areas identified in Chapter IV of the ASTMP.

Table E.II-11. Battlespace Environment

L. BATTLESPACE ENVIRONMENT	UNITED KINGDOM	FRANCE	GERMANY	OTHER COUNTRIES	JAPAN	PACIFIC RIM	FSU
COLD REGIONS				➤ Norway			➤ Russia
TOPOGRAPHY	➤	➤	➤	➤ Many	➤		
COMBAT ENVIRONMENT	➤	▲ Remote sensing;			▲ Remote sensing; Robotics		
BATTLESCALE METEOROLOGY	➤ EC Nations and Canada share overall capability in weather prediction				➤		➤ Russia Weather prediction
ATMOSPHERIC EFFECTS	➤ EC Nations have capabilities in various areas			▲ Israel Atmospheric effects Canada 3D data display Atmospheric dispersion			

The availability of global satellite data, coupled with more powerful low-cost information systems to manage large quantities of data, has fostered growing international dissemination and standardization of topographical data. Technology for application of the data to military uses (real-time generation and prediction of terrain signatures from stored or measured geographic/topographic data; mission planning and targeting, etc.) will be found predominately in the **U.K.**, **France**, and **Germany**. However, significant niche capabilities may be found elsewhere. Similarly we observe growing international exchanges in weather prediction and in research related to predication of long-term environmental and climatic conditions. Specific expertise in short-term, high-resolution battlescale weather predictions, and in real-time prediction of atmospheric effects on battlefield sensors is presently limited to the EC nations (notably **Germany** and the **U.K.**) and **Canada**. In addition, within the US/Canadian infrastructure, **Canada** has notable capabilities in weather prediction, and in techniques for visualization and presentation of large three dimensional data sets.

The following identifies a specific opportunity where an existing agreement offers significant potential benefits.

1. Atmospheric Effects (Israel)

Description: Weather always has a significant impact on battlefield operations, and accurate prediction of weather offers a primary tactical advantage. Atmospheric modeling can forecast long-term weather; acoustic and electromagnetic propagation; smoke/ obscurant operations effects; and CB agent dispersal.

Justification: A specific near term ASTMP milestone includes the development of automated 48-hour battlefield weather forecasting capabilities; the development of weather effect decision aids; and the application of virtual reality concepts for simulation of battlefield environmental effects. Use of **Canadian** and **Israeli** experience could enhance progress on these milestones.

Implementation: Active DEAs exist with Israel which could serve as a vehicle for the exchange of information to support ASTMP objectives.

AMC POC:
Dr. Rodney Smith
Army Materiel Command
AMXIP-OB
5001 Eisenhower Blvd
Alexandria, VA 22333-0001
e-mail: icpa@hqamc.army.mil

IPOC:
Mr. Stephen Cohn
Army Research Laboratory
AMSTL-TT-IP
2800 Powder Mill Road
Adelphi, MD 20783-1197
e-mail: scohn@arl.army.mil

M. Human System Interface (HSI)

Most developed nations have significant research efforts in human system interfaces. Information management and display capabilities are also addressed in Section II.G. of this Annex, under Computing and Software. Important trends (see Table E.II-12) in foreign research (in addition to VR and HCI capabilities) include improved modeling of human cognitive processes. Interest in this area is driven by multiple requirements, including the need for improved presentation of information to match human cognition and improved representation of human performance to improve realism and fidelity of computer-generated forces and "actors" in both simulations and operational systems.

Table E.II-12. Human-System Interface

M. HUMAN SYSTEM INTERFACES	UNITED KINGDOM	FRANCE	GERMANY	OTHER COUNTRIES	JAPAN	PACIFIC RIM	FSU
INFORMATION MANAGEMENT AND DISPLAY	Virtual reality interfaces	Display Soldier system interface	Soldier system interface	**Israel** Helmet-mounted display **Canada** VR Display	Displays, VR, Robotics		
PERFORMANCE AIDING		Ergonomics		**Israel Netherlands Sweden** Human performance measures			
DESIGN INTEGRATION	Performance modeling	Performance modeling	Performance modeling				

The U.S. HSI technology area benefits from active collaboration with our research partners in several key areas. Soldier-machine interface work on teleoperations continues with both **France** and **Germany**; negotiations are underway with **France** for a more formal agreement specific to ergonomics issues. Auditory research finds the **United States** a strong partner with the French-German Institute St. Louis research center; we are working on a NATO standard impulse noise model. The French are sharing modern ergonomic performance measuring instrumentation and techniques with the United States, while the United States is sharing its MANPRINT suite of soldier-system performance enhancement tools.

Human performance modeling is a critical factor in meeting future Army requirements. Such modeling contributes to enhanced soldier-system battlefield performance through low-risk, quick-turnaround simulation, permitting assessment of proposed systems concepts.

1. Human Performance Modeling (HPM) (France, Germany, United Kingdom)

Description: HPMs range from anthropometric HSI models, impulse, and acoustic detection models of the human ear through cognitive and physical workload, decision making under stress, up through unit level on availability of field data and its decision to pursue computer-based simulation. France is recognized as a key international source for cooperative research in HSI.

Justification: Success in this cooperative effort will help the United States reduce R&D, acquisition, and effective fielding time while providing more performance effective, survivable, and sustainable systems. The opportunity to co-develop NATO standards will help ensure continued U.S. competitiveness in these technologies.

Implementation: MANPRINT efforts with the United Kingdom fall under TTCP. Hearing research is under auspices of NATO RSG. HPM, VR, and teleoperations coordination with France.

AMC POC: Dr. Rodney Smith
Army Materiel Command
AMXIP-OB
5001 Eisenhower Blvd
Alexandria, VA 22333-0001
e-mail: icpa@hqamc.army.mil

IPOC: Mr. Stephen Cohn
Army Research Laboratory
AMSTL-TT-IP
2800 Powder Mill Road
Adelphi, MD 20783-1197
e-mail: scohn@arl.army.mil

N. Manpower, Personnel, and Training

Investment in manpower, personnel, and training are essential to maximize human military performance. The soldier of the future must be intelligent, physically fit, educated, highly motivated, and well-trained. Table E.II-13 summarizes capabilities for each technical subarea.

Table E.II-13. Manpower, Personnel, and Training

N. MANPOWER, PERSONNEL AND TRAINING	UNITED KINGDOM	FRANCE	GERMANY	OTHER COUNTRIES	JAPAN	PACIFIC RIM	FSU
MANPOWER AND PERSONNEL	➤ **EC Nations have capabilities and are involved in cooperative programs**					➤ **Australia New Zealand** Participate in TTCP in this area	
TRAINING	Λ Dynamic training and simulation	Λ Dynamic training and simulation		Λ **Canada** Simulators and displays	Λ Distributed training and simulation of complex enterprises		

International cooperation in the areas of Manpower, Personnel, and Training (MPT) is taking place through a variety of avenues. The **United States, United Kingdom, Canada, Australia**, and **New Zealand** pursue collaborative research and actively exchange information on defense research and development (R&D) projects through the Technical Cooperation Program (TTCP). Examples of collaborative MPT research include simulator sickness in virtual reality environments, selection tests for tank gunners, and the effects of workload levels and stress on decision-making. Collaborative research also occurs through the Defense Research Group (Panel 8, Human and Biomedical Sciences) of the NATO Armaments and Research Organization. For example, the **United States** is gaining valuable information regarding the fielding of computer-based selection tests in **Germany** and **Belgium** and on use of distance learning in European countries. The NATO Research Study Group on Advanced Training Technologies participated in a workshop on virtual reality in March 1995.

The following section briefly describes one potential area of opportunity.

1. Virtual Reality and Training (France)

Description: Human performance modeling and virtual reality technology contributes to enhanced battlefield (soldier) performance via high fidelity, low-risk simulation and training. **France** and the **UK** are recognized leaders in this opportunity area.

Justification: Several ASTMP milestones involve the use of simulation [distributed interactive simulation (DIS)] and virtual reality concepts in the development of synthetic environments designed to enhance training and performance for commanders, Special Forces, Infantry teams, and aircrews.

Implementation: An umbrella agreement concerning Technology Research and Development Projects (TRDP) exists with France, and is a potential vehicle for establishing a Project Agreement (PA) covering this technology.

AMC POC: Dr. Rodney Smith
Army Materiel Command
AMXIP-OB
5001 Eisenhower Blvd
Alexandria, VA 22333-0001
e-mail: icpa@hqamc.army.mil

IPOC: Mr. Stephen Cohn
Army Research Laboratory
AMSTL-TT-IP
2800 Powder Mill Road
Adelphi, MD 20783-1197
e-mail: scohn@arl.army.mil

O. Materials, Processes, and Structures

Advances in basic materials, materials processing and structures are integral objectives of a number of opportunities discussed throughout the ASTMP and this Annex, including materials for aeropropulsion (E-II.B); characterization of structures for rotorcraft (E-II.C); ballistic protection for soldier systems (E-II.E), materials and structures for hypervelocity missiles (E-II.H) and structures for ground vehicles (E-II.R). Table E.II-14 below provides a summary of key capabilities and trends.

Table E.II-14. Materials, Processes, and Structures

O. MATERIALS, PROCESSES, AND STRUCTURES	UNITED KINGDOM	FRANCE	GERMANY	OTHER COUNTRIES	JAPAN	PACIFIC RIM	FSU
MATERIALS	➤ Metal alloys; Composites	➤ Metal alloys; Composites	➤ Metal alloys; Composites	**Israel** Metal alloys; Organic matrix composite	▲ Ceramics; Composites		▲ Ti Alloy
PROCESSES	▲ Welding and joining	➤ CC ceramic part fabrication	➤ Functional gradient coatings	**Republic of Korea** ➢ Tungsten processing	▲ Polymer processing		
STRUCTURES	➤ Lightweight engineering structures; Smart structures	➤ Energy absorbing structures; Smart structures	➤ Engineering structures; Smart structures				➢ Ti structures

Germany, France, the **UK, Japan**, and **Russia** have strong capabilities in most aspects of this technology, with notable capabilities as follows: **German** EFP and other warhead metallurgy and processes for deposition of functionally gradient materials; **France** has strong capabilities in carbon-carbon and other ceramics and in the design of crash survivable structures as noted previously in this Annex; **Japan** is a world leader in fine ceramics, and **Russia** in titanium and steel alloys, and bulk ceramics. In this context, the term "fine ceramic" denotes material of high purity characterized for specific performance characteristics as opposed to bulk ceramics as might be employed for ballistic protection. **Korea** has a program in tungsten penetrator technology highlighted below as an existing or near-term pending agreement offering potential benefits.

Both the **U.K.** and **Germany** develop and market military systems for lightweight bridging and other civil engineering applications, and have sound capabilities in alloys and structural design for such systems. A growing area of world-wide research interest is "smart structures" -- instrumented structural designs that adapt to external conditions and stimuli to optimize performance.

Japan has been and is expected to continue be a major developer and producer of fibers and matrix feedstock for advanced polymer composites. Finally readers should refer to the discussion of Biological Sciences (Annex E III.K) which addresses the rapidly growing field of bioprocessing, where researchers are looking to biomimetic materials (such as spider silk) to meet critical long-term requirements. In addition, world-wide interest is growing in the potential for bioprocessing to replace more costly and/or environmentally threatening chemical processes.

1. Processing of Tungsten Alloys for Penetrators (South Korea)

Description: The application of advanced materials technology to the manufacture of penetrators provides for enhanced ballistics, increased range, and lethality of projectiles. Specific heat treatment processes for tungsten alloys developed by **South Korea** offer the potential to enhance impact strength of tungsten penetrators. Tungsten penetrators are part of a larger category of anti-armor technology, in which the United States has the most experience. The **United States** has an extensive engineering database covering material processing, fabrication, and performance for this overall category. Within this category, the United States is a world leader in developing high density alloys [including tantalum and depleted uranium (DU) as well as tungsten], and the production of DU penetrators. **Germany** and **Israel** share the lead with the United States in advanced long-rod penetrators manufactured using tungsten alloys.

Justification: A near term objective of the ASTMP is to increase the ballistic performance of tungsten to equal that of depleted uranium (as measured in depth of penetration). South Korea has developed a unique heat treatment process which could greatly increase the impact strength of tungsten to meet ASTMP milestones.

Implementation: There is an active DEA with South Korea which has potential for significant contributions to ASTMP milestones and objectives.

AMC POC: Dr. Rodney Smith
Army Materiel Command
AMXIP-OB
5001 Eisenhower Blvd
Alexandria, VA 22333-0001
e-mail: icpa@hqamc.army.mil

IPOC: Mr. Stephen Cohn
Army Research Laboratory
AMSTL-TT-IP
2800 Powder Mill Road
Adelphi, MD 20783-1197
e-mail: scohn@arl.army.mil

2. High Density Tungsten Carbide Ceramics (France)

Description: With increasing battlefield threat performance, current and future combat vehicles will require armor technologies which obtain maximum protection within compact structures and armor. The U.S. Army Research Laboratory recently initiated development of a new class of high density ceramics, defined as any ceramic whose density is greater than steel (7.85 gm/cc); these ceramics inherently offer high space effectiveness.

ARL research has centered on examining high purity tungsten carbide (WC) ceramics with a density of 15.5 gm/cc. This material is not a metal/ceramic cermet, but a 99.5 percent pure ceramic which can be processed as a conventional hot-pressed ceramic. The research strives to eliminate the traditional liquid metal sintering aids as found in conventional cermets. Ballistic testing of initially developed WC ceramics have provided space efficiencies nearly threefold (as compared to steel).

Justification: While conventional ballistic ceramics offer excellent protection against conventional small arms threats, these low density materials suffer damage accumulation effects and reduced space effectiveness as the impact threat increases, particularly against modern, high density eroding rod penetrators. Ballistic uses of this technology include any compact armor applications such as hatches, roofs, front glacis, or turret/hull side armor.

During a recent exchange France provided their initial data on a concurrent development of high density ceramics which centered on low metal binder content tungsten carbide cermets. A near term objective is to accelerate the optimization of these high density ceramics for ballistic application.

Implementation: A cooperative program has been proposed and drafted as a Project Agreement (PA) to the U.S./France Memorandum of Understanding on Technology Research and Development Projects. The cooperative effort has also been proposed as a Nunn program.

AMC POC: Dr. Rodney Smith
Army Materiel Command
AMXIP-OB
5001 Eisenhower Blvd
Alexandria, VA 22333-0001
e-mail: icpa@hqamc.army.mil

IPOC: Mr. Stephen Cohn
Army Research Laboratory
AMSTL-TT-IP
2800 Powder Mill Road
Adelphi, MD 20783-1197
e-mail: scohn@arl.army.mil

P. Medical and Biomedical Science and Technology

Military medical and biomedical research is concerned with preserving and optimizing combatant's health and capabilities despite extraordinary battle, nonbattle, and disease threats. Table E.II-15 summarizes capabilities and opportunities in each technical subarea.

Table E.II-15. Medical and Biomedical Science and Technology

P. MEDICAL AND BIOMEDICAL SCIENCE AND TECHNOLOGY	UNITED KINGDOM	FRANCE	GERMANY	OTHER COUNTRIES	JAPAN	PACIFIC RIM	FSU
INFECTIOUS DISEASES	Infectious diseases	Infectious diseases	Infectious diseases	**Israel, Kenya, Thailand, Switzerland, Sweden, Italy, Netherlands** Infectious diseases		**Singapore, China** Infectious diseases	Infectious diseases
MEDICAL BIOLOGICAL DEFENSE	Biological and chemical defense	Biological and chemical defense	Biological and chemical defense	**Canada, Israel, Sweden, Switzerland, Netherlands** Chemical defense	**Many countries involved in applicable biomedical defense research**		
ARMY OPERATIONAL MEDICINE	**Broad cooperation sought in all aspects of military medicine and casualty care**				Medical imaging		
COMBAT CASUALTY CARE					Medical imaging		

For humanitarian reasons much of the research and technology related to this area are shared widely. The spread of AIDS and other virulent diseases such as Ebola and other filoviruses, and the emergence of a variety of antibiotic-resistant bacterial strains have spurred world-wide research efforts. Many of the countries involved in this research do may not have efforts directed specifically at biomedical defense, per se. However, any breakthroughs in prevention and treatment of the more virulent diseases would be of interest. Here opportunities for cooperation are driven by a variety of factors, including the geographical location of certain occurrences of diseases (e.g., **Kenya**, **Thailand**) or centers of excellence in specific areas of research (virology in **France**).

In addition, the growth ad dissemination of basic biotechnology has led to growing capabilities in a number of other countries. These are discussed in greater detail in Annex E, Section III.J. Medical Science.

Another area of medicine that is growing rapidly world wide, is the use of internetworking and high quality video to create virtual medical "teams" for diagnosis and treatment (including surgery). This is also one of the objectives of DOD and Army initiatives for battlefield digitization as part of an overall strategy to achieve information superiority.

The highlighted opportunities listed below respond to a clear imperative for international cooperation that derives from both humanitarian and military considerations.

The military concern is the potential use of biological weapons by terrorists or extranational groups, and the need for both preventive and curative measures.

In addition to the specific medical opportunities listed below, where existing or near-term pending agreements offer significant potential benefits, the ASTMP identifies requirements in the general area of training, conditioning, and treatment for protection, sustainment, and human performance enhancement of soldiers that may be candidates for cooperation. Leading candidates for cooperation in this area include **France**, the **UK**, **Germany**.

1. Infectious Diseases of Military Importance (Thailand, Kenya, Israel)

Description: The Infectious Disease Research Program has international agreements for cooperative research to develop vaccines for the prevention of dysentery, malaria, and dengue fever.

Justification:

Dysentery caused by Shigella leads to severe diarrhea. During Operation Desert Shield/Storm, diarrheal disease became a major threat to U.S. forces: 57 percent of troops had at least one episode of diarrhea, and 20 percent reported they were temporarily incapacitated. The leading cause of lost duty time during Operation Restore Hope was acute diarrhea.

Malaria has long been a serious problem for military forces, especially during combat. Malaria is the world's most common insect-borne parasitic disease. During Operation Desert Shield/Storm, troops in Southern Iraq became infected with vivax malaria. More recently, troops were infected with vivax or falciparum malaria while serving in Somalia for Operation Restore Hope. Treatment of this deadly disease is complicated by the increasing incidence of drug-resistant strains.

Dengue fever is the world's most common mosquito-borne viral disease. Dengue fever was encountered during the Vietnam War and, more recently, in Somalia. It poses a serious problem whenever military forces are deployed to the tropics.

Implementation: Ongoing

AMC POC:
Dr. Rodney Smith
Army Materiel Command
AMXIP-OB
5001 Eisenhower Blvd
Alexandria, VA 22333-0001
e-mail: icpa@hqamc.army.mil

2. Medical Chemical Defense Research (United Kingdom, Canada, Israel, Germany)

Description: The Medical Chemical Defense Research Program involves cooperative efforts between the **United Kingdom, Canada, Israel, Germany**, and other nations in developing methods to protect the soldier from chemical warfare agents. These nations are using the latest medical information and techniques for these developments.

Justification: Current efforts include research into pretreatments, antidotes, and medical therapies. X-ray crystallographic analytical techniques have been employed to elucidate the structure of acetylcholinesterase. This achievement supports mechanistic studies in understanding the actions of nerve agents as well as development of molecular approaches to a countermeasure. In addition, molecular biochemical techniques are being used to mutate genes to produce variants of human acetylcholinesterase and butylcholinesterase. This will improve understanding of nerve agent mechanisms of action and identification of prophylaxes for nerve agents.

Implementation: Ongoing.

AMC POC: Dr. Rodney Smith
Army Materiel Command
AMXIP-OB
5001 Eisenhower Blvd
Alexandria, VA 22333-0001
e-mail: icpa@hqamc.army.mil

3. Medical Biological Defense Research (United Kingdom)

Description: The Medical Biological Defense Research Program includes an international agreement for cooperative research for the development of an improved vaccine for the prevention of botulinum poisoning and for the development of effective treatment drugs.

Justification: Botulinum toxin, a recognized biological threat agent, is one of the deadliest neurotoxins known to man. The toxin prevents the release of acetylcholine and produces nerve cell dysfunction. The cause of death is usually respiratory paralysis, due to the blockage of transmitter release from the phrenic nerve to the diaphragm muscles. The Imperial College of Science and Technology, **United Kingdom**, is an international leader in the area of functional and structural analysis of botulinum toxin binding to cholinergic nerves.

Implementation: Ongoing.

AMC POC:
Dr. Rodney Smith
Army Materiel Command
AMXIP-OB
5001 Eisenhower Blvd
Alexandria, VA 22333-0001
e-mail: amxip@hqamc.army.mil

Q. Sensors

The topic of sensors encompasses a wide range of diverse physical phenomena and technology, including seismic/acoustic ground sensors, and electromagnetic sensors in all regions of the spectrum from extremely low frequency magnetic anomaly detection to space-based UV and even shorter wave optical devices. As defined in the ASTMP, sensor technologies also include associated capabilities for acquiring and processing sensor data to derive useful information regarding operating environment and the location, identity and activities of friendly and adversary forces. Table E.II-16 below summarizes capabilities in areas of sensor technology identified in Chapter IV of the ASTMP.

Table E.II-16. Sensors

Q. SENSORS	UNITED KINGDOM	FRANCE	GERMANY	OTHER COUNTRIES	JAPAN	PACIFIC RIM	FSU
RADAR SENSORS		Optical switching of microwave power		Countermine **various countries**	Electronic components		**Russia**
ELECTROOPTIC SENSORS	Optical processing	IRFPA, laser sensors multidomain sensors		**Netherlands**	Photonic devices		
ACOUSTIC, MAGNETIC, AND SEISMIC SENSORS	Seismic	Seismic		**Israel** acoustic sensors			
AUTOMATIC TARGET RECOGNITION SENSORS	Signal processing	Signal processing	Combat ID Signal processing	**Israel** Target recognition, Signal processing	Signal and image processing		
INTEGRATED PLATFORM ELECTRONICS	Vehicle integration	Multisensor integration	Vehicle integration				

The **US** has traditionally enjoyed a strong lead in military radar systems, particularly in the area of electronically steerable phased array radars. The **UK, France**, **Germany**, and to a lesser extent **Japan** and **Israel** all have significant capabilities and niches of excellence. Selected highlights of these capabilities include: power generation of optical distribution and switching of microwave energy (**France**); target characterization (**Israel**) and microwave integrated circuits and components (**Germany** and **UK**)

France is recognized as a world leader in state-of-the-art IR focal plane arrays; Japanese CCD technology dominates consumer electronics markets, and may provide leveraging opportunities in the future. Most modern armies have some ongoing work in battlefield acoustic sensors, with no one country having a dominant capability. Similarly most countries have active development programs aimed at enhancing ATR capabilities. Underlying feature extraction and pattern recognition algorithms are common topics of academic research. At the same, adaptation of these algorithms for effective military use demands access to specific target and threat characteristics. This information closely held by all nations to protect sensitive collection methods and sources. **Japan**, is highlighted because of their extensive work in visual systems for industrial robots and in Kanji character recognition. While not directed to military ends, the underlying techniques developed may be of interest.

In addition to a potential direct return in enhanced performance, cooperation in integrated platform electronic technologies will contribute to standardization and interoperability of coalition forces. As one would expect, those countries most advanced in development and production of advanced military vehicles (**UK, France**, and **Germany**) offer the best potential for cooperative efforts in this area.

These technologies and the opportunities highlighted below also support DTAP Sensor DTOs and JWTSP Information Superiority (which includes sensors for information acquisition and sensor data fusion) and Combat Identification DTO's. Certain of the technologies involved, particularly photonic signal processing initiatives with the **UK** overlap with, and could directly support advances in optical computing, (II-E.G). The following subsections identify specific opportunities where existing or near-term pending agreements offer significant potential benefits.

1. Hetero-Epitaxial Growth For Multidomain Sensors (France)

Description: For future multidomain smart sensors, large area staring HgCdTe Infrared Focal Planes (IRFPAs) will be required. In the current method of producing IRFPAs, the detector array of HgCdTe grown on a CdZnTe substrate and the Si readout array are manufactured separately and then joined by Indium bumps at each pixel. This method cannot be extended to large arrays due to the difference in the thermal expansion coefficient between HgCdTe/CdZnTe and Si.

For the required large area arrays the detector layer has to be grown directly on Si. Due to the large difference in crystal constants between the Si and HgCdTe, this will generally result in low quality HgCdTe layers.

ARL and scientists from LETI (Grenoble, France) are cooperating to develop techniques to grow buffer layers on the Si ending up with high quality CdZnTe. If this is achieved, the growth of the HgCdTe layer can be performed in the standard way.

Dr. Million from LETI visited ARL/NVESD from June through August 1994 working with Nibir Dhar from ARL; a new very promising technique was developed for the growth of these buffer layers. Defect densities were reduced by 2 orders of magnitude—as of today. Work is continuing at ARL and LETI. Nibir will visit LETI next year for a period of about 3 months.

Justification: Besides supporting ASTMP objectives (Chapter IV), the benefits from this cooperative effort are roughly equal for both countries, and each benefited more with the cooperation than had they gone it alone.

AMC POC: Dr. Rodney Smith
Army Materiel Command
AMXIP-OB
5001 Eisenhower Blvd
Alexandria, VA 22333-0001
e-mail: icpa@hqamc.army.mil

IPOC: Mr. Stephen Cohn
Army Research Laboratory
AMSTL-TT-IP
2800 Powder Mill Road
Adelphi, MD 20783-1197
e-mail: scohn@arl.army.mil

2. Optical Processing, Optical Components, and Optoelectronics (U.K.)

Description: The photonics offer inherently high bandwidth, compactness, power efficiency, and immunity to electromagnetic interference. The non-interfering nature of light and the propagation characteristics lend themselves theoretically to massively parallel, high speed information processing. Analog photonic processors offer extremely high effective processing speeds, and much of the ongoing research is focused on bistable switching components and processing elements needed to implement digital processors.

Justification: This effort supports the immediate Photonic Signal Processing Technology STO. In the longer term, optical computing is seen as an enabling technology for achieving multi-teraOP performance goals of the DoD High Performance Computing Initiatives.

Implementation: There is a data exchange agreement which has the potential for significant contributions to ASTMP technical objectives.

AMC POC:
Dr. Rodney Smith
Army Materiel Command
AMXIP-OB
5001 Eisenhower Blvd
Alexandria, VA 22333-0001
e-mail: icpa@hqamc.army.mil

IPOC:
Mr. Stephen Cohn
Army Research Laboratory
AMSTL-TT-IP
2800 Powder Mill Road
Adelphi, MD 20783-1197
e-mail: scohn@arl.army.mil

3. Advanced Materials for Short Wavelength Lasers (France)

Description: Among the Army's needs for visible and ultraviolet lasers, some optical countermeasures and standoff biological agent detection applications require substantially higher efficiencies than available with current technologies. If appropriate laser media can be developed, ongoing progress in laser diodes and diode pumping techniques can be used to provide highly efficient laser emission directly at the desired wavelengths, avoiding the need to shift frequencies from other, longer wavelength lasers. Cooperative research between the Army Research Laboratory and the Universite de Lyon, France, offers opportunities to leverage their specialized expertise to address these problems. This expertise includes the study of processes important for the stepwise pumping of short wavelength laser materials by longer wavelength diodes, and extensive knowledge of ultraviolet-emitting materials.

Justification: ARL participation in this cooperative research provides us access to the specialized experimental equipment, techniques, and expertise of the U. Lyon laser materials group.

Implementation: There are existing international agreements that support this effort. Under these agreements working visits have been carried out in support of visible laser material research and cooperative research on tunable ultraviolet laser materials is being planned.

AMC POC: Dr. Rodney Smith
Army Materiel Command
AMXIP-OB
5001 Eisenhower Blvd
Alexandria, VA 22333-0001
e-mail: icpa@hqamc.army.mil

IPOC: Mr. Stephen Cohn
Army Research Laboratory
AMSTL-TT-IP
2800 Powder Mill Road
Adelphi, MD 20783-1197
e-mail: scohn@arl.army.mil

4. Acoustic Sensors (Israel)

Description: Acoustic sensor technology involves the use of microphone arrays to detect, locate, track, and identify air and ground target at tactical ranges. Target information from multiple acoustic sensor arrays is digitally transmitted to a remote central location for real-time battlefield monitoring. In addition, acoustic sensors are used to enhance the soldier's long range hearing and detect sniper and artillery fire.

Justification: Current efforts in acoustics include adaptive beamforming algorithms, sound cancellation techniques to eliminate platform and wind noise, and Neural Network algorithms for target identification. Sensor fusion has shown a significant increase in the acoustic detection and ID performance. Advanced helicopter detection, sniper, and mortar location systems are in the final phase of development by the Israelis.

Implementation: A Joint Acoustic Field Experiment has successfully been conducted with the Israeli Army in March 1993 to demonstrate the state-of-the-art in remote needed acoustic detection sensors. Cooperation will provide potential solutions to acoustic propagation problems, long range target detection algorithms, and detection of targets in noisy environments (in the presence of wind and platform noise).

AMC POC: Dr. Rodney Smith
Army Materiel Command
AMXIP-OB
5001 Eisenhower Blvd
Alexandria, VA 22333-0001
e-mail: icpa@hqamc.army.mil

IPOC: Mr. Stephen Cohn
Army Research Laboratory
AMSTL-TT-IP
2800 Powder Mill Road
Adelphi, MD 20783-1197
e-mail: scohn@arl.army.mil

5. Combat Identification (Germany)

Description: The positive identification of friendly troops on the battlefield in order to reduce fratricide is one of the key goals for the Army's Force XXI.

Justification: There is a significant amount of research and development in the area of combat identification being done in Germany. The laser technology being pursued by the Germans is of interest to the U.S. Army for possible use by dismounted soldiers. Siemens is currently a leader in developing algorithms for sensor fusion and high speed processing, integration, and display of multi-sensor inputs. This has immediate application in situation awareness.

Implementation: Combat Identification data is being exchanged with the Germans.

AMC POC:
Dr. Rodney Smith
Army Materiel Command
AMXIP-OB
5001 Eisenhower Blvd
Alexandria, VA 22333-0001
e-mail: icpa@hqamc.army.mil

IPOC:
Mr. Richard Pei
US Army CECOM
ATTN: AMSEL-RD-AS-TI
Ft. Monmouth, NJ 07703
e-mail: peir@doim6.monmouth.army.mil

6. Target Characterization (Israel)

Description: Target characterization generically encompasses signature measurements in radar/MMW, signature rendering in the visual and infrared, and target acquisition modeling enhancements for imaging infrared sensors.

Justification: Sensor technology milestones in the ASTMP include generation of databases of low contrast targets and enhancement to the night vision target acquisition model. This effort may also provide a vehicle for developing other cooperative efforts in data fusion and sensor/signal processing for improved conventional weapons.

Implementation: A cooperative Signature Work Shop was held in the Fall of 1994 with Israel under an existing DEA. This Work Shop covered a number of areas associated with the ASTMP milestones, including characterization of target/clutter; synthetic scene generation model (CREATION Model); quantification of clutter in the IR and the mathematical relationship to the Johnson Criteria for target acquisition modeling enhancement; dynamic measurements using super high resolution MMW; and model validation.

AMC POC: Dr. Rodney Smith
Army Materiel Command
AMXIP-OB
5001 Eisenhower Blvd
Alexandria, VA 22333-0001
e-mail: icpa@hqamc.army.mil

IPOC: Mr. Stephen Cohn
Army Research Laboratory
AMSTL-TT-IP
2800 Powder Mill Road
Adelphi, MD 20783-1197
e-mail: scohn@arl.army.mil

7. Automatic Target Recognition (France)

Description: Development, evaluation, and demonstration of a multi-sensor Forward-Looking Infrared (FLIR)/millimeter-wave (and perhaps laser radar) automatic target recognition algorithm running in real/near real-time on a state-of-the-art processor.

Justification: Exchange of multisensor automatic target recognition algorithm technology for FLIR, millimeter wave radar, and perhaps laser radar. Exchange of computer processor and memory modules technology.

AMC POC:
Dr. Rodney Smith
Army Materiel Command
AMXIP-OB
5001 Eisenhower Blvd
Alexandria, VA 22333-0001
e-mail: amxip@hqamc.army.mil

R. Ground Vehicles

Objectives for this technology area include advances in diesel propulsion (See E-II.B for discussion of advances in gas turbine propulsion), better track and suspension to increase cross-country mobility, and improvements in survivability through improved ballistic protection and reduced observables, including use of electric drive. Table E.II-17 summarizes capabilities and opportunities in each technical subarea.

Table II.E-17. Ground Vehicles

R. GROUND VEHICLES	UNITED KINGDOM	FRANCE	GERMANY	OTHER COUNTRIES	JAPAN	PACIFIC RIM	FSU
SYSTEMS INTEGRATION	**EC Nations have capabilities in various areas**			IS RPV's Teleoperation SW Armored vehicles			
VEHICLE CHASSIS AND TURRET			Structure and design	**Israel Italy Sweden Switzerland**		**China ROK**	
INTEGRATED SURVIVABILITY			Vehicle survivability	**Israel Sweden**			**Russia** Bulk ceramics
MOBILITY	Gas turbine	Secondary batteries	Autonomous control; diesel engines electric drive	**Austria** Diesel engines	Ceramic engine; Electric drive		**Russia** Electric drive components; batteries, switches
INTRAVEHICULAR ELECTRONICS SUITE		Multisensor integration	Integrated electronics and optronics				

Advances in ground vehicle system integration and chassis and turret design are likely to be found among traditional developers and manufactures of military armored systems. The **UK, France, Germany, Israel, Japan**, and **Russia** manufacture or have development programs for main battle tanks. **Japan** and **Germany**, with the **US** are leaders in automotive propulsion, with both having significant capabilities in functionally gradient coatings, with **Germany** a world leader in air-cooled diesel propulsion.

Integrated survivability involves a suite of capabilities ranging from detection avoidance to ballistic protection. Again, niche capabilities may be found in countries that develop and manufacture armored systems. Highlights of note include German capabilities in integrated CB defense, and Russian developments of bulk ceramics with potential applications to ballistic protection.

Primary interest in electric drive is found in major automobile producing and exporting countries (specifically, the **US, Japan**, and **Germany**) driven primarily by growing restrictions on exhaust emissions. In electric drive **Japan** is world leader in virtually all aspects, with strength in batteries, fuel cells, power control and switching components. **France** is strong in batteries, and **Russia** has strengths in certain types of rechargeable batteries and in power switching components. **Germany** is a world leader in autonavigation and autonomously-driven vehicle technology; **Japan** also has a strong research program in this area, and in remote control. Finally, **Israel's** experience in the tactical use of RPVs and UAVs may contribute to advances in teleoperation of ground vehicles.

The following subsections identify specific opportunities where existing or near-term pending agreements offer significant potential benefits.

1. Next-Generation Autonomous Vehicle Navigation Control System (AUTONAV Project) (Germany)

Description: U.S./German collaborative research program entitled Next Generation Autonomous Navigation System (AUTOVON). The participating research laboratories and their technology contributions to the project are as follows:

—Universitat der Bundeswehr Munchen (UBM), Germany: UBM will produce an advanced autonomous road navigation system with cost effective collision avoidance technology. For a number of years, UBM has been a leader in the European Prometheus program—a program oriented towards the development of commercial highway automation. As part of the Prometheus program, UBM has been developing a sophisticated highway lane-following system using only normal video for sensor input.

—Dornier GmbH, Germany: Dornier will provide advanced off-road obstacle detection and avoidance capabilities using laser radar technology.

—David Sarnoff Research Center (DSRC), Princeton, NJ: DSRC will perform as technical lead in obstacle detection and recognition. DSRC's obstacle detection approach is entered on high definition, area-based recognition technology which, together with UBM's research orientation on feature-based recognition, shows promise of complementary research products that, when combined, will offer significant obstacle detection potential. DSRC contributions will include a faster, low-cost, processing capability allowing faster autonomous speeds of operation.

—National Institute of Standards and Technology (NIST), Gaithersburg, MD: NIST will develop a common computer architecture base. The common computer architecture thrust could lead to a standard vehicle controller system supporting technology transfers in a wide range of future developments. The U.S. Army Research Laboratory (ARL) will support NIST with a sensor platform stabilization system and global positioning system/inertial navigation system (GPS/INS) integration to enhance navigation system sensor performance.

Justification: AUTONAV will accelerate progress in existing DoD/Army UGV programs since German researchers hold a lead in the development and implementation of autonomous vehicle control technology. The UBM researchers have been demonstrating autonomous road following since the mid-1980s and autonomous vehicle tracking and following for the past few years. The latter technology could be used for Army convoying applications.

AUTOVON will save U.S. dollars for development of comparable technology. The development of a common baseline controller platform with interface standards has several advantages. In addition to allowing for ease in exchanging developed technologies between the participating research labs, such a control system would provide the DoD/Army with the means of quickly leveraging mature, advanced vehicle navigation control technology from the German research programs, thus accelerating U.S. Army activities in robotic technology applications. AUTOVON will allow the leveraging of developed advanced technology from the project for dual-use applications. Technology transfer from the DoD-sponsored program could also lead to greater progress in automation of commercial vehicles (smart trucks) and support the Department of Transportation (DoT) Intelligent Transportation System (ITS) program.

Implementation: The AUTOVON Project is proposed for Nunn funding as an annex to an existing agreement. The draft AUTOVON annex has been prepared and distributed for final review. OSD and the German MOD have sent a letter to Headquarters U.S. Army Materiel Command encouraging support for this project.

AMC POC: Dr. Rodney Smith
Army Materiel Command
AMXIP-OB
5001 Eisenhower Blvd
Alexandria, VA 22333-0001
e-mail: icpa@hqamc.army.mil

IPOC: Mr. Stephen Cohn
Army Research Laboratory
AMSTL-TT-IP
2800 Powder Mill Road
Adelphi, MD 20783-1197
e-mail: scohn@arl.army.mil

2. Combat Vehicle Crew Compartment Design/Technology (Germany)

Description: Germany, specifically the firm of Pietsch, has conducted extensive future combat crew compartment studies, focusing crew size reduction, human factors such as man-machine interface, endurance, and multiple taskings. Integration of technologies such as sensor suites, optronics, and robotics (automation) have been demonstrated and continue to be pursued. U.S./GE cooperation under the Combat Vehicle Command and Control (CVC2) MOU and ongoing Vetronics exchanges are important factors influencing future crew and compartment design with respect to required displays and relief of human tasks.

Justification: German research and development activities in this area support STO/ATD Crewman's Associate, Advanced Tank Technologies (ATT), and potential initiatives under the TARDEC/ARL Advanced Armored Vehicle Technologies Program.

Implementation: There are existing agreements in this technology area with Germany which could potentially expedite implementation of a specific program. The agreements provides for the exchange of information to include studies of possibilities, concepts, and developments in the following areas:

- Day and night observation equipment
- Sighting and fire control equipment including stabilization and gun control systems
- Data processing equipment, sensors, modes logic
- Radio and navigation equipment
- Test, display, and operating equipment
- Laser application for battle tank fire control
- Laser application for artillery fire control

Inquiries regarding cooperative projects and arrangements in this area should be directed to the AMC POCs identified below.

AMC POC:
Dr. Rodney Smith
Army Materiel Command
AMXIP
5001 Eisenhower Blvd.
Alexandria, VA 22333-0001
e-mail: icpa@hqamc.army.mil

MSC IPOC:
Mr. William Lowe
U.S. Army Tank-Automotive and Armaments Command
AMSTA-TR-D/273
Warren, MI 48397-5000
e-mail: lowee@cc.tacom.army.mil

3. Combat Vehicle Electric Drive (Germany)

Description: GE (Magnet Motors) has conducted extensive hybrid electric vehicle technology development and demonstration in the last 10 years. They have attained the state of the art in variable torque Multiple Electronic Permanent Magnet (MED) motors and generators as well as Magnet Dynamic Storage (MDS). GE (Siemens, AEG, Max Plank) is also a world leader in microsystem technology as characterized by a combination of micromechanical and microelectrical components. These technologies will make electric drives smaller, more robust, and more responsive.

Justification: A critical technological ingredient of TARDEC's Tank Mobility Technology STO, is advanced electric drive to include demonstration of advanced motor and generator configurations and advanced high power switching devices.

Implementation: In the near term, Army testing of the latest generation of MED motors is planned in conjunction with GE industry. There is an existing agreement in this technology area with Germany which could potentially expedite implementation of a specific program. The agreement provides for the exchange of information to include studies of possibilities, concepts, and developments in the following areas:

- Internal combustion engines (reciprocating engines and gas turbines)

- Transmission systems

- Air filters (commercial and special designs)

Inquiries regarding cooperative projects and arrangements in this area should be directed to the AMC POCs identified below.

AMC POC: Dr. Rodney Smith
Army Materiel Command
AMXIP-OB
5001 Eisenhower Blvd.
Alexandria, VA 22333-0001
e-mail: icpa@hqamc.army.mil

MSC IPOC: Mr. William Lowe
U.S. Army Tank-Automotive and Armaments Command
AMSTA-TR-D/273
Warren, MI 48397-5000
e-mail: lowee@cc.tacom.army.mil

4. Secondary Batteries (France)

Description: Secondary batteries, such as Lithium Polymer, are of great interest for military applications, due to their high energy density, high power density, long life cycle, and rapid charging/discharging abilities. These batteries are also lightweight, compact, vibration resistant, and have no magnetic signature. Potential applications include future electric vehicle propulsion (15 Kw or more of power), and Silent Watch (a few hundred watts of power). World leaders in the development of lithium batteries include the United States, the United Kingdom, Japan, France, and Russia.

Justification: ASTMP goals include the identification of alternate power sources for vehicles, including vehicle systems applications and future electric propulsion.

Implementation: Existing agreements have potential to contribute to ASTMP goals and objectives.

AMC POC: Dr. Rodney Smith
Army Materiel Command
AMXIP-OB
5001 Eisenhower Blvd
Alexandria, VA 22333-0001
e-mail: icpa@hqamc.army.mil

IPOC: Ms. Annette Chomsky
US Army CECOM
ATTN: AMSEL-RD-AS-TI
Ft. Monmouth, NJ 07703
e-mail: chomsky@doim6.monmouth.army.mil

5. Combat Vehicle Survivability (Germany)

Description: Germany is very active in the areas of indirect protection (detection and hit avoidance), direct protection (composite armor, shock, and fire protection), and vulnerability reduction. Germany, particularly the firm of Deisenroth, continues to be a leader in composite armor developments for light, medium, and heavy vehicles both as integrated and modular add-on packages. In detection avoidance, the firm of Buck has conducted extensive research in multispectral obscurants. The firm of Condat specializes in analytic and predictive modeling for armored system vulnerability assessments.

Justification: German technology in this area supports Composite Armored Vehicle (CAV) ATD, Hit Avoidance ATD, and Distributed Defense STO as well as potential initiatives under TARDEC/ARL technology program annexes.

Implementation: There are existing agreements along with ones being developed in this technology area with Germany which could potentially expedite implementation of a specific program. The agreements provides for the exchange of information to include studies of possibilities, concepts, and developments in the following areas:

- Ballistic effects of current of current and developmental ammunition on all forms of armor.

- Camouflage

- Advanced Armor Protection System

- Hit Avoidance

Inquiries regarding cooperative projects and arrangements in this area should be directed to the AMC POCs identified below.

AMC POC: Dr. Rodney Smith
Army Materiel Command
AMXIP-OB
5001 Eisenhower Blvd.
Alexandria, VA 22333-0001
e-mail: icpa@hqamc.army.mil

MSC IPOC: Mr. William Lowe
U.S. Army Tank-Automotive and Armaments Command
AMSTA-TR-D/273
Warren, MI 48397-5000
e-mail: lowee@cc.tacom.army.mil

6. Combat Vehicle Structures and Design (Germany)

Description: Germany continues to be one of the few world leaders in combat vehicle research and development in all weight classes. Germany continues to develop and field wheeled combat vehicles which meet and exceed tracked vehicle capabilities. Success of these designs is evident by successful sales to other nations. Mercedes design and prototyping has provided the basis for a GE/FR cooperation in medium-weight armored vehicles (GTK) to be fielded starting in 2002. Germany's main battle tank development and prototyping continues beyond Leopard 2 block improvements. The EGS heavy combat vehicle technology demonstrator, developed by Krauss Maffei with firms such as Pietsch, Diehl, MTU, and a host of others incorporates state-of-the-art construction and materials fabrication technology with a focus on signature management.

Justification: German technologies support Composite Armored Vehicle (CAV) ATD, Future Scout and Combat System ATD, and Future Combat System, as well as potential initiatives under the TARDEC/ARL Technology Program Annexes.

Implementation: There are existing agreements along with ones being developed in this technology area with Germany which could potentially expedite implementation of a specific program. Future bilateral development and demonstration could be accomplished under the U.S./Germany Technology Research and Development MOA. Near term systems improvement and integration is possible under the M1/Leopard 2 Harmonization MOU.

Inquiries regarding cooperative projects and arrangements in this area should be directed to the AMC POCs identified below.

AMC POC: Dr. Rodney Smith
Army Materiel Command
AMXIP-OB
5001 Eisenhower Blvd.
Alexandria, VA 22333-0001
e-mail: icpa@hqamc.army.mil

MSC IPOC: Mr. William Lowe
U.S. Army Tank-Automotive and Armaments Command
AMSTA-TR-D/273
Warren, MI 48397-5000
e-mail: lowee@cc.tacom.army.mil

S. Manufacturing Science and Technology

Manufacturing science and technology focuses on technologies that will enable the industrial base to produce reliable and affordable materials and products. It requires integration of all aspects of manufacturing from raw materials through design and integration of components, subsystems, and systems. Table E.II-18 summarizes capabilities in key technical subareas.

Table II.E-18. Manufacturing Science and Technology

S. MANUFACTURING SCIENCE AND TECHNOLOGY	UNITED KINGDOM	FRANCE	GERMANY	OTHER COUNTRIES	JAPAN	PACIFIC RIM	FSU
ADVANCED PROCESSING	➤ Bioprocess engineering	➤ Bioprocess engineering	➤ Bioprocess engineering	▲ **Israel Netherlands Nordic Group** Bioprocess engineering	▲ Fuzzy logic for process control; ➤ Bioprocess engineering		
MANUFACTURING ENGINEERING SUPPORT TOOLS	➤ COOPERATIVE EFFORTS--CASE tools; Industrial robotics				➤ Industrial robotics		
ADVANCED MANUFACTURING DEMONSTRATIONS	ADVANCED MANUFACTURING DEMONSTRATIONS PROGRAM-SPECIFIC						

No specific opportunities are identified for this technology area; however, biotechnology applications can contribute to U.S. Army efforts. Large-scale production of biomaterials and products is necessary to capitalize on emerging biotechnology developments. The techniques for providing these large quantities of biomaterials (bioprocess engineering) are of significant interest to the U.S. Army, and include production of the material (including cell culture and fermentation), downstream product processing, and packaging. The United States is an overall world leader in this area, with several nations having significant capabilities including the **United Kingdom**, **Japan, Germany, France, Israel, the Netherlands**, and the **Nordic Group** (Norway, Sweden, and Denmark).

In the future, international developments are likely to drive greater standardization in manufacturing engineering support tools, including CASE, virtual prototyping, and enterprise integration and control technologies. Already we are seeing rapid growth in technologies for distributed design and management of very complex enterprises in highly industrialized countries, notably **Japan, UK**, **France**, **Germany,** and throughout the **EC.** This trend will be further supported and enabled by the growth of the Internet and its underlying telecommunications infrastructure. Ultimately we can expect to see a seamless integration of distributed modeling and simulation with enterprise operation, which will further speed the international exchange of advanced manufacturing capabilities.

T. Modeling and Simulation

Modeling and simulation objectives, as defined for this technology area, are critical for achieving the JCS vision for seamless integration of mission planning and rehearsal and effective execution required for dominant maneuver and the application of precision forces to overwhelming effect. Further, international cooperation will be essential. Standardization of distributed interactive simulation (DIS), development of common standards for computer generated forces, and a consistent and common of the battlespace based on a high-fidelity representation of the physical environment will be crucial to effective employment and interoperabiltiy of coalition forces. Table E.II-19 summarizes capabilities and potential opportunities for each technical subarea.

Table E.II-19. Modelling and Simulation

T. MODELING AND SIMULATION	UNITED KINGDOM	FRANCE	GERMANY	OTHER COUNTRIES	JAPAN	PACIFIC RIM	FSU
SIMULATION INTERCONNECTION	**NATO countries active in standardization of Distributed Interactive Simulation**				Distributed industrial enterprises	**Australia New Zealand** DIS	
SIMULATION INFORMATION	Dynamic training simulation	Dynamic training simulation	Battle modeling and simulation	**Canada Netherlands** Battle modeling and simulation	VR		
SIMULATION REPRESENTATION	Modeling and simulation	Modeling and simulation	Modeling and simulation	**Netherlands** Modeling and simulation	Distributed enterprises		
SIMULATION INTERFACES	VR	VR		**Canada** VR 3D visualization **Italy** Tactile **Netherlands** Visualization **Sweden** Virtual reality	VR		

In addition to **Canada**, the **UK**, **Australia** and **New Zealand**, all of whom participate with the **U.S.** in TTCP activity highlighted below, **France**, and **Germany** have strong capabilities in modeling and simulation, and in the underlying information systems technologies required to distribute and process the information. **Japan** has had an extensive program aimed at modeling, simulation, and management of large, complex, distributed enterprises. Other countries, including those of **Israe**l cited in E-II.I (Battlespace Environment) and Q (Sensors) may also contribute.

Several factors are fostering rapid growth and internationalization of Simulation Information and Representation. Coalition operations as a dominant theme in the use of military force. The threat to these forces, geographically-dispersed and increasingly capable technologically, demands more effective transnational mission planning and rehearsal. The same requirements and capabilities are, to only a slightly lesser extent reflected in the operations of large multinational companies. World-wide availability of low-cost powerful information management systems are allowing exchange of data and promoting standardization of data and models for terrain, weather, and environmental effects. The resulting advances will contribute directly to improved interoperability of coalition forces.

In the area of simulator interfaces, leading technologies are found primarily in those countries that have been traditionally strong in dynamic training and simulation--**Canada** (which is also developing significant capabilities in data visualization), the **UK, France**, and **Germany**, and in **Japan**, which is actively pursuing the development of VR for industrial applications, including visualization of complex systems and enterprises.

1. Distributed Interactive Simulation (DIS)

Description: The primary mission of DIS is to define an infrastructure for linking simulation of various types at multiple locations to create realistic complex, virtual "worlds" for the simulation of highly interactive activities. This infrastructure brings together systems built for separate purposes, technologies from different eras, products from various vendors, and platforms from various Services and permits them to interoperate. DIS exercises are intended to support a mixture of virtual entities (man-in-the-loop simulators), live entities (operational platforms and test and evaluation systems), and constructive entities (wargames and other automated simulations).

Justification: The DIS infrastructure provides interface standards, communication architectures, management structures, fidelity indices, technical forums, and other elements necessary to transform heterogeneous simulations into unified seamless synthetic environments. These synthetic environments support design and prototyping, education and training, test and evaluation, emergency preparedness and contingency response, and readiness and warfighting.

Implementation: There is an agreement, in draft as of May 1995, which has the potential to contribute to ASTMP modeling and simulation goals in support of DIS standards.

AMC POC:

Dr. Rodney Smith
Army Materiel Command
AMXIP-OB
5001 Eisenhower Blvd
Alexandria, VA 22333-0001
e-mail: icpa@hqamc.army.mil

III. INTERNATIONAL RESEARCH CAPABILITIES AND LONG-TERM OPPORTUNITIES

A. Overview

Access to international capabilities through existing exchange mechanisms offers a potential vehicle for a near-term return on investment. Equally important, these programs are the base from which our longer term strategy will evolve. As part of that long-term strategy, our objective is to emphasize high leverage opportunities, with partnerships where we anticipate the best prospects for sustained excellence in technology. The following pages, provide a snapshot of international basic research capabilities and trends having potential to address one or more of the long-term research goals identified in Chapter V of the ASTMP. Many of these areas overlap opportunities highlighted in the previous section, and indicate prospects for long-term partnerships and further cooperative advances. Others indicate areas where future opportunities may develop, either under an existing exchange or a new initiative.

The following discussion and trends charts portray very clearly the international scope and advance of science and technology. As might be expected, opportunities for cooperation in basic research are far more pervasive, and widely dispersed, than those for applied research in technology discussed in the previous section. Increased global accessibility of scientific information is such that no researcher is out of touch with his or her field. Collaborative research across international boundaries is commonplace.

Taken as a whole, the trends charts indicate a high and growing level of scientific research capabilities abroad in virtually every aspect identified as of importance to the U.S. Army. This suggests the importance of an international cooperative strategy that can effectively encompass both immediate opportunities and long-range cooperative partnerships.

The POC for requests for further information regarding International Cooperative Opportunities described in this section is:

Mr. Stephen Cohn
Army Research Laboratory
AMSTL-TT-IP
2800 Powder Mill Road
Adelphi, MD 20783-1197
e-mail: scohn@arl.army.mil

Parties with interests in specific cooperative programs and wishing to determine contacts in other countries should contact the appropriate Army Regional Offices, as follows:

Dr. Iqbal Ahmad
AMXRO-RT-IP
Director ARO International Programs
and ARO-Pan American
POB 12211, Research Triangle Pk, NC 27709
e-mail: <ahmad@aro-emh1.army.mil>

Dr. Julian Wu
Director ARO-Far East
Akasaka Press Center
7-23-17 Roppongi, Minato-ku
Tokyo 106, Japan
e-mail: <arofe-01@zama-emh1.army.mil>

Dr. Karl Steinbach
Director European Research Office
USRDSG-UK
223 Old Marylebone Road
London NW1 5TH
e-mail: <ksteinbach@army.ehis.navy.mil>

These offices are tasked with keeping abreast with important developments in science and technology in their respective areas

B. Mathematical Sciences

Table E.III-1 summarizes international research capabilities for the major subareas of mathematical science.

Table E.III-1. Mathematical Sciences

MATHEMATICAL SCIENCES	UNITED KINGDOM	FRANCE	GERMANY	OTHER COUNTRIES	JAPAN	PACIFIC RIM	FSU
Applied Analysis and Physical Mathematics	Fluid dynamics ➤	Bolzman's equations, Dynamic systems, Computer vision ➤	➤	**Hungary** △ Real variables; **Canada** ▷ Analytic geometry, ▷ Fluid dynamics; **Israel** ▷ Symplectic geometry	▷	**China** △	**Russia** Numerical methods, Mechanics ▼
Computational mathematics	Linear algebra △	Finite elements, Nonsmooth optimization ➤	▲ Finite elements, Interactive methods	**Israel** ➤ Computational physics; **Canada** △	△	△ **China**; ▲ **India**	Russia ▽
Stochastic Analysis Applied Probability and Statistics	▲	Levy processes ▲	△	**Canada** △	➤	△ **China**; ▲ **India**	Russia ▼
Systems and Control	△	Control theory ▲	△	**Canada** ▷	△	**China** △	Russia ▽
Discrete Mathematics	△	Computer algebra △	△	▷ **Hungary**; △ **Canada**; ▷ **Czech Republic** Computational geometry	△	**China** △	Russia ▽

Basic research in applied analysis and physical mathematics directly contributes to the modeling, analysis, and control of complex phenomena and systems active within the Army. Applied mathematicians define practical boundaries, set the framework of analysis, and act as collaborators for scientists and engineers on many development projects. Many nations show significant capability in a number of areas identified as having potential impact on future Army technologies. This is consistent with the fact that many advanced applied mathematics research efforts involve only a small number of researchers and have minimal hardware requirements. Thus even nations without an extremely powerful industrial or research base can have a few specific points of excellence in mathematics.

There are many examples of specific areas of computational mathematics which hold promise for military applications. Computational fluid dynamics studies in the **United Kingdom, Canada**, and **Israel** can contribute significantly to missile, rotor and explosive design. Advanced work in finite element analysis in **France** and **Germany** can be applied to the problems of the design and function of complex mechanical structures. Also of interest are international research efforts in optimization, linear algebra (**France**), fuzzy logic (**Japan**), and computational geometry (**Czechoslovakia**) which are applicable to the development of new computer network hardware and software platforms. Control theory work has also been used for the development of computer systems, as well as applications in robotics.

Germany, **France,** and the **United Kingdom** are all considered to be on a par with the **United States** in a number of these areas of mathematics research. In general, **Canada** and **Japan** are also considered to be working at or near this high level. Both **China** and **India** exhibit strong potential research efforts, which are constantly improving and will conceivably soon be world-leading. The **countries of the former Soviet Union** show a declining capability, largely due to a lack of resources. For example, though many important numerical methods for modeling physical phenomena were developed in the Soviet Union in the 50's and 60's, current research is no longer considered world-leading. Additionally, **Ukraine** is noted for a traditional weakness in more basic research, and tends to be stronger in development areas. Many other small countries also have very strong mathematical talent -- **Holland, Denmark, Hungary, Israel, Poland, Romania, Greece, Sweden,** and **Norway**, and all could be considered for potential cooperative efforts in specific areas.

The nature of basic mathematics research implies that it often has no stated or direct tie to any specific application, military or otherwise. It is often the case that seemingly unrelated research will have effects on the development of critical technologies, for example, the influence of advances in control theory on the development of non-skid brakes.

C. Computer and Information Sciences

Computers and information systems are pervasive in virtually all military systems and operations and are essential to maintaining the present leading position of US military capabilities. Table E.III-2 summarizes international research capabilities for each major subarea.

Table E.III-2. Computer & Information Systems

COMPUTER AND INFORMATION SYSTEMS	UNITED KINGDOM	FRANCE	GERMANY	OTHER COUNTRIES	JAPAN	PACIFIC RIM	FSU
Theoretical Computer Science	➤	➤	➤	Sweden Netherlands ➤	➤	India A	Russia A
Formal Methods for Software Engineering	➤	➤	➤	Sweden Netherlands Finland ➤	➤		Russia A
Software Prototyping, Development and Evolution	➤	➤	➤	Sweden Netherlands ➤	**A**	A	
Knowledgebase Data base Sciences	**A**	A	A	Netherlands **A**	A		Russia A
Natural Language Processing	**A**	➤	**A**	Netherlands **A**	➤		Russia A

Theoretical computer science is directed at extending the state-of-the-art of high-performance computers, an enabling technology for modern tactical and strategic warfare. Formal methods of software engineering and knowledgebase database science are the software parallels to improving the computer hardware addressed in computer studies. US software development has been a driving force in enhancing the overall tactical and strategic capabilities of the US armed forces. Natural language processing has taken on an increased importance with the use of multi-national/multi-language forces in the field. The need for rapid communication between such forces is essential to the efficient and safe military cooperation between various national forces.

The **United States** has been the world leader in computer science and most areas of software development. However, a number of countries have world class capabilities in various aspects of the overall science. The **UK** and **Netherlands** are leaders in most areas, with extensive capabilities in knowledgebase database science and natural language processing. **Germany** is a leader in most areas, with extensive capabilities in natural language processing. **France** is also quite advanced and has active programs in language processing. **Japan** has world class capabilities in software prototyping, as well as being very active in most other areas. **Russia,** while seriously limited in overall funding, has demonstrated increasing capabilities in most areas. A number of other countries have niche capabilities; e.g. **India, Sweden**, and **Finland.**

D. Physics

Basic research in physics broadly supports advanced technology developments by providing insight into the nature and interaction of substance. These enable ongoing advancement in microminiaturization and optical subsystems. This, in turn, improves sensor capability and continued development of image analysis and target recognition. As Table E.III-3 shows, a wide range of countries possess capabilities in the subareas of physics because the technologies have a wide range of civil and military applications.

Table E.III-3. Physics

PHYSICS	UNITED KINGDOM	FRANCE	GERMANY	OTHER COUNTRIES	JAPAN	PACIFIC RIM	FSU
Nanotechology	Capability in microscopy	Capability in molecular chemistry	Broad capability in sub-micron research		World leader in nanotechnology		
Photonics	Optical switching, Optoelectronics, Signal processing	Optical switching, Optoelectronics, Signal processing Optical computing	Optical switching, Optoelectronics Signal processing	**Belgium, Canada, Sweden** Optical switching	Optical switching, Optoelectronics, Signal processing, Optical computing		**Russia** Optical sensors, Optical computing
Obscured Visibility & Novel Sensing	Sensors, Signature reduction, Lasers	Sensors, Signature reduction, Lasers	Sensors, Lasers	**Israel** Signature reduction	Fiber optic gyroscopes, Sensors, Lasers		**Russia** Glonass, Signature reduction, Lasers
Optical Warfare	High energy lasers, Sensing of CB agents	High energy lasers, Sensing of CB agents	High energy lasers, Sensing of CB agents	**Israel, Canada** Sensing of CB agents	Non-linear optics		**Russia** Non-linear optics, High energy lasers, Sensing of CB agents
Image Analysis Enhancement Technology	Signal processing, Software & modeling	Signal processing, Software & modeling	Signal processing, Software & modeling	**Canada** Signal processing, Software & modeling; **Sweden** Software & modeling	Signal processing, Software & modeling		

Japanese and **German** research in sub-micron imaging and **Japan**'s overall capabilities in nanotechnology offer great potential in producing smaller, faster, devices designed to consume less power. Advances in photonics should yield further improvements in optical switching, high-speed computing and improved information storage. The **UK, France, Germany** and **Japan** have ongoing research in the various areas of photonics. The army's ability to operate under conditions of poor visibility is enhanced by improved sensing capabilities. The **UK, France** and **Japan** have significant capabilities in the related technology areas. **Germany** and **Israel** have capabilities that also merit consideration. The concept of optical warfare is becoming increasingly important, with applications which include remote sensing of chemical and biological agents. This is still a relatively new research area but many countries have interest in applicable research. Image analysis and target recognition are of increasing importance; because of the increasing speed of modern weapons, and the need for faster and more accurate identification of "friend or foe." Again, this is an area where a number of countries are developing capabilities.

Japan is a leader in many niche areas of research. They are a world leader in nanotechnology, have world class capabilities in photonics and excellence in obscured visibility and novel sensing. **Germany** has world class capabilities in sub-micron research and photonics, while the **UK** and **France** have capabilities in photonics and obscured visibility and novel sensings. **Russia** has considerable capabilities in photonics and obscured visibility and novel sensings; however, decreased funding points to a decreasing capability. Finally, **Israel, Canada, Sweden** and **Belgium** have important niche capabilities.

E. Chemistry

This area includes important research on chemical/biological defense and on a number of advanced materials. Advanced materials provide the Army with capabilities for new and improved systems and devices. Performance, life cycle cost, sustainability, maintainability, costs, availability, etc. are all strongly influenced by advances in materials. The Army is especially interested in nonlinear optical materials for laser protection, smart materials, structural polymer composites, ballistic protection polymer composites, fire retardants for vehicles, and surface resistance to corrosion and wear, among other topics. These are areas where special Army requirements place stringent demands on materials, and especially on materials chemistry. Table E.III-4 summarizes international research capabilities for each major subarea.

Table E.III-4. Chemistry

CHEMISTRY	UNITED KINGDOM	FRANCE	GERMANY	OTHER COUNTRIES	JAPAN	PACIFIC RIM	FSU
Chemical/Biological Defense	Detection, Protection, Decontamination ➤	Detection, Protection, Decontamination ➤	Detection, Protection, Decontamination ➤	Netherlands Sweden Finland Detection, Protection, Decontamination ➤	Detection, Protection, Decontamination ➤	China Detection, Protection, Decontamination ➤	Russia Ukraine Detection, Protection, Decontamination ➤
NLO Materials for Laser Protection	➤	➤	▷	Israel ▷	▷		Russia ➤
Smart Materials		△	△	Israel Netherlands ▷	➤	S. Korea △	▷ Russia
Polymer Composites (Structural)	➤	➤	▲	➤ Canada △ Israel △ Spain ▷ Sweden	▲	△ S. Korea △ China ▷ India	▷ Russia
Polymer Composites (Ballistic Protection)	▲	▷	▷	➤ Israel	▷		▷ Russia
Fire Retardants for Vehicles	➤	➤	▷	➤		△	
Surface Resistance to Wear and Corrosion	▲	➤	▲	➤ Switzerland △ Sweden △ Canada △ Netherlands △ Italy Israel	▲	▲ S. Korea ▲ China ▷ India	➤ Russia Ukraine
Explosives and Propellants	➤	▷	▲	▲ Sweden Israel Canada	▲	➤ Singapore S. Korea	➤
Soldier Power	▲	▲	▲	▷	▷	▷	▷
Demilitarization, Restoration, and Pollution Prevention	▲	➤	➤	▷	▷	▷	▷

A number of countries are active in materials research and development for chemical/biological defense. Generally, European countries as well as **Japan** and **China** have world class capability and have ongoing efforts to provide better defense against chemical and biological agents. For the most part, efforts are more concentrated in the biological area where the need is greatest. **Russia** and **Ukraine** also have programs, however, no country is seen to be making greater strides than the others. The **United Kingdom** has been at the forefront of CB defense for years and can be expected to continue to devote resources in this area.

The nonlinear optical (NLO) materials area is of importance to the Army because they are required for wavelength conversion in some laser systems and in personnel eye protection. The materials must be very uniform, of very high purity, and the selection of useful materials currently is limited. The **UK**, **France**, and **Russia** have strong efforts in preparation and characterization of NLO materials, and **Japan** and **Israel** have credible capabilities. **China** is also working intensively in this area.

Smart materials are ones which can sustain sensory capabilities, actuator activity, and information processing as part of their basic microstructure. Design, synthesis, and processing of such materials is a chemical challenge, as it is done at the atomic/molecular level. Applications such as damage detection and control, vibration damping, and precision manipulation and control motivate the field. At the microstructural level, challenging areas of interest include phase transitions (e.g., shape memory alloys), layer-by-layer design of materials, materials with defect structures which can sustain sensing and responses, biocomposites, piezoelectric ceramics, multifunctional macromolecules, and others. This area offers large payoffs in areas such as delamination control of composite helicopter blades and increased battlefield survivability of materials via active damage control. World activity in smart materials continues to grow rapidly. The Army program is at the leading edges for smart materials. **Japan** is a clear leader in some aspects. **France**, **Germany**, and **South Korea** have growing programs.

Structural polymer composites are of interest to the Army because they offer weight savings while providing other systems-useful, stringent characteristics, with controlled costs. Much attention is being given to processing, the nature of the interface between the polymer matrix and the reinforcing phase, and resistance to environmental degradation. Thick section composites of this kind offer the Army much in structural integrity. Major foreign capabilities in this area are rather widespread. The **UK, France**, **Canada, Germany**, and **Japan** all have broad capabilities and research in polymer matrix composites. **Israel, Spain**, and **South Korea** have important and growing capabilities.

Similarly polymer matrix composites offer much to the Army for ballistic protection for personnel, equipment, emplacements, and vehicles. The challenges are to learn how to make very high quality material at a controlled, low cost and to understand and improve upon dynamic response for these materials. The **UK** and **Israel** have strong capabilities in polymer matrix composites for ballistic protection. **France, Germany**, **Japan**, and **Russia** also have developing capabilities in this area.

Fire retarding materials for vehicles are of significance to the Army to protect personnel from conflagrations and to allow Army assets to return to operation as rapidly as possible. These materials are essential in order to enable Army systems to perform under battlefield conditions. This capability allows for sustainability of vehicles involved in force projection and advanced land combat. In addition to fire retardancy, these materials must be easily applied to vehicles and also not produce toxic products when experiencing high temperatures. The countries with strong capabilities in these areas are the **UK**, **France**, and **Israel**.

Wear and corrosion cost the Army several billion dollars each year due to premature failures, excessive wear of systems and components, application and removal of protective coatings and paints, and the need to have high spares inventories to meet all of these challenges. Corrosion control and avoidance is a challenging scientific area, as is tribology (the study of surfaces in contact). Elements of materials science, chemistry, and mechanics enter into understanding these systems-defined problem areas. These areas are exceptionally important for maintainability and affordability, in terms of life cycle costs, for Army systems. Nearly all industrialized nations have programs of some extent in wear and corrosion. The strongest are in the **UK, Germany, Japan, France**, and also **Sweden** and **Switzerland**, with niche capabilities existing elsewhere.

Basic research is often undertaken to solve problems of explosive/propellant effectiveness or to compile properties sufficient to improve detection or identification. Army applications include the basic outgassing chemistry for detection of mines and charges. Chemistry used to mimic vehicle IR signatures is applicable to decoy flares. Chemistry of propellant bonding provides insight into the life cycle projections for Army missile systems. **Germany**, with a world class tradition of expertise in chemistry, leads in most of these areas. Traditional leadership in the **UK** across broad chemistry areas is fertile for international interest. **Japan's** space interest promote expertise in missile propellants. Long-term military requirements underscore ongoing basic research in **Israel, Singapore** and the **Republic of Korea**. Research in the **FSU** suffers from lack of operating capital

Soldier power embraces a menu of appliances which provide the 21st century warrior with power sources and devices to enable advanced sensors, communications and other electrical devices. This suite of tools will enhance the soldier's situational awareness and provide a selection of force applications tailored to varying situations. Power sources of importance include electrolytes for fuel cells and batteries of advanced and environmentally friendly types. The **UK, Germany**, and **France** are leaders in these technologies with **Japan** close behind.

The **U.S.** has a strong lead in research related to demilitarization, restoration, and pollution prevention. Sensing pollution, destroying pollutants and practices which prevent pollution all lead to more efficient or more effective military operation. Of foreign countries, the **UK** has the strongest potential. **France** and **Germany** follow, but their potential for military applications is weaker due to budgetary constraints.

F. Materials Science

Materials provide the enabling technologies for fabrication of all physical devices and systems used by the Army. Advances in materials science, engineering, and technology make possible the solutions, options, and improvements for performance, durability, and life cycle costs of all these systems. Table E.III-5 summarizes international research capabilities in each major subarea of materials science.

Table E.III-5. Materials Science

MATERIALS SCIENCE	UNITED KINGDOM	FRANCE	GERMANY	OTHER COUNTRIES	JAPAN	PACIFIC RIM	FSU
Structural Materials	Steel Al, Ti PMC Superalloys Intermetallics Welding and joining MMC CC	Steel Al, Ti PMC Superalloys Intermetallics CMC MMC CC	Steel Al, Ti PMC Superalloys Ceramics MMC CC	Austria Sweden Israel Canada S. Africa Steel Canada Sweden Spain Israel PMC Sweden Superalloys Sweden Canada Intermetallics Israel Italy CC	Steel Al, Ti MMC PMC CC CMC Superalloys Intermetallics	China S. Korea India Steel China India CC China India Al, Ti	Russia Steel Superalloys Al, Ti PMC Ukraine Welding and joining
PMC - polymer matrix composites; MMC - metal matrix composites; CC - carbon-carbon composites; CMC - ceramic matrix composites							
Materials for Armor and Antiarmor	Personnel armor, Armor, Anti-armor	Personnel armor, Heavy-armor, Anti-armor, Tungsten-carbide armor	Armor, Anti-armor	Israel Slovakia Armor Israel Sweden Anti-armor Israel Personnel armor	Armor, Anti-armor, Ceramic armor	China Armor, Anti-armor S. Korea Tungsten alloy penetrators, Armor	Russia Ukraine Armor Anti-armor
e- electonic and electrical; o - optical and optoelectronic; m - magnetic							
Processing of Functional Materials	e o m	e o m	e o m	Slovakia Italy Netherlands e Netherlands m Netherlands Israel Italy o	e o m Supercon-ductors	Taiwan S. Korea e	Russia e o m Supercon-ductors
e- electonic and electrical; o - optical and optoelectronic; m - magnetic							
Engineering of Material Surfaces	Coatings MFP Ion	Coatings MFP Ion	Coatings MFP Ion	Switzerland Sweden Coatings Canada Netherlands Italy Coatings Italy Sweden MFP Netherlands Switzerland MFP S. Africa Israel Diamond deposition	Coatings MFP Ion	China MFP Coatings S. Korea MFP Coatings	RU, UK Coatings MFP Diamond deposition
MFP - machining, finishing and polishing; ion - ion implantation							
Non-destructive Characterization of Components	Metrology NDE systems	Metrology NDE systems	Metrology NDE systems	Sweden Switzerland Metrology NDE systems Italy Sweden NDE systems	Metrology NDE systems Automat.	China S. Korea Metrology NDE systems	Russia NDE systems
Automat - computer controlled and data reduced in real time for components							

Materials Science provides the bases for materials with desired, high level properties needed by the Army in structural armor, anti-armor, chemical/biological agent protection, laser protection, infrastructure applications, propulsion, and biomedical applications. All materials classes are included: metals, ceramics, polymers, composites, coatings, energetic solids, semiconductors, superconductors, magnetic and other functional materials. Army research in materials includes vital areas such as synthesis of new materials, modifications of existing materials, and design of microstructures and composite architectures to meet property-specific performance needs. Also included are advanced characterization concepts and methods to specify and control microstructure, properties, and degradation events.

Processing of materials is a key part of this program. It spans the flow of precursor materials on through microstructural developments into useful materials or components at acceptable costs. Materials processing includes topics such as casting, rolling, forging, sintering, polymerization, composite lay-up, machining, chemical vapor deposition, and surface modifications, among others.

There are many unique Army requirements which make stringent demands on materials. As a prime example, armor/anti-armor clearly is a high priority area for the Army. Armor materials include those specifically designed to protect equipment and personnel from enemy threats. Anti-armor materials are used in the projectiles, penetrators, shaped-charge liners, etc. designed to defeat enemy armor. For armor, the **UK**, **France**, **Germany**, **Israel**, and **Russia** are overall world leaders, along with the **US**. For anti-armor projectile materials, the **UK, France, Israel, Sweden**, and **Russia** have very significant and relevant dense alloy capabilities.

Processing of functional materials is key to providing military advantage to materials which fulfill optical, magnetic, electrical, and electronic needs. Although many commercial applications exist for such materials, these are often at lower performance levels than those of the Army. Thus, understanding of the processing of functional materials allows their use in military systems with performance at the upper limits of their capabilities. These functional materials must be of the highest quality also because of their influence on sustainability and for operations of all types of Army platforms, vehicles, weapons systems, etc. Optical materials interest include waveguides, lenses, mirrors, laser hosts, and sensor covers. For magnetics, the Army is concerned with magnetic data recording media, signature control, power supplies, and motor applications. Electrical materials needs focus on solenoids, mine sweeping, and high field magnets. Since electronic materials are the key foundations of the Army's electronic systems, they are of interest for functions including logic, amplification, memory, display, delay, signal generation, sensing, switching, etc.

For processing of functional materials, the US generally has the lead overall, but others (viz., **France,** the **UK, Germany**, **Japan**, other **European nations**, and **Russia**) have strong capabilities which rival those of the **US. Japan** is more advanced than the US in some areas of electronic materials. The **UK, Russia, Japan, Israel, Germany**, and **China** are very active across several areas of optical materials. For magnetic materials, the US is the leader overall, though **Japan** has some capabilities in all areas of magnetic materials as well. The **UK** is capable in high permeability magnetic alloys. For magnetorestrictive alloys, **Sweden** and the **UK** have technologies comparable to that of the **US**. Many other nations are active in selected areas of magnetic materials. For electrical materials, the US has the lead in superconducting wire. **Japan, Germany, Italy**, and the **UK** have capabilities in wire processing as well. High temperature superconducting materials work goes on all over the world, with the US in the lead with prototype wire processing.

Precise control, fabrication, and modification of materials' surfaces are areas with great impact on Army systems. The surface is the region where the component meets its operating environment, be it chemical, mechanical, thermal, electromagnetic, etc. in nature. It is the region within which failure usually originates during system performance or storage. Control, modification, tailoring, and precise definition (e.g., of dimensions, geometry, optical figure, flaw content, etc.) contribute very strongly to the costs/value added of Army materials. Thus, activity on machining, ion implantation, chemical vapor deposition and sputtering for coatings, adhesion of protective layers, etc. all are fertile topics in engineering of surfaces for Army use.

Materials surface engineering capabilities are widely held across the world. For precision machining and polishing, **Japan, Germany, France**, and the **UK** are very strong, as are **Switzerland** and Sweden. For coatings of many types, **France, Germany,** the **UK**, and **Russia** are among the leaders. Areas of strength exist abroad in ion implantation and thin film diamond deposition.

Non-destructive evaluation (NDE) of components divides into a few focus areas. For quality of materials produced, **France**, **Germany**, the **UK**, **other European countries**, and **Japan** have increased capabilities with NDE systems. In all aspects of metrology, **Japan** is excellent, as are the **UK**, **France**, and **Germany**. **Switzerland** and **Sweden** also excel in selected areas. All of these nations are paying growing attention to automation in the use and interpretation of NDE both for product quality and process control.

All industrialized and rapidly developing countries have materials related activities and capabilities. Many nations now can produce materials for specific military usage, including materials engineered to defeat enemy threats and those which preserve the capability of high performance systems in the field. Thus, Army capabilities can face challenges internationally. Also of importance for materials science and materials technology is that all industrialized nations continue to do advanced work across these fields, and rapidly developing nations are building strengths in materials fields as well.

G. Electronics Research

Basic research in electronics supports advanced technology development with millions of applications. Important examples include continued advancement in solid state devices, telecommunications, microwave and millimeter wave circuit integration, image analysis, and low power electronics. As Table E.III-6 shows, many countries host capabilities in these various areas, which support military applications and a wide range of civil applications.

Table E.III-6. Electronics

ELECTRONICS	UNITED KINGDOM	FRANCE	GERMANY	OTHER COUNTRIES	JAPAN	PACIFIC RIM	FSU
Solid State Devices	JESSI/MEDEA research	JESSI/MEDEA research	JESSI/MEDEA research	Many European countries JESSI/MEDEA research	All phases of solid state devices		
Mobile, Wireless Tactical Communications Systems and Networks	C3, Networking, Switching, Transmission	World leader in battlefield communica-tions	Networking, Switching, Transmission	**Canada** Networks, Switching, Transmission **Italy** Transmission	Computing, Networking, Switching, Transmission		
Electromagnetics, and Microwave/Millimeter Wave Circuit Integration	JESSI/MEDEA programs, Microwave tubes, Antennae	JESSI/MEDEA programs, Microwave tubes, Antennae	JESSI/MEDEA programs, Microwave tubes, Antennae	**Canada** Microwave tubes, Antennae	MMIC, Acoustic wave devices, Microwave tubes		
Image Analysis for Automatic Target Recognition and Information Fusion	Signal processing, Target recognition, Sensors	Signal processing, Target recognition, Sensors	Signal processing, Target recognition, Sensors	**Sweden** Airborne radar **Israel** Sensors, Target recognition, Signal processing	Signal processing, Sensors		**Russia** 3rd gener-ation image intensifier tubes
Minimum Energy, Low Power Electronics and Signal Processing	JESSI/MEDEA programs, Non-linear optics, Antennae, Low power devices	JESSI/MEDEA programs, Non-linear optics, Antennae, Low power devices	JESSI/MEDEA programs, Antennae, Low power devices	Many European countries JESSI/MEDEA research	MIMIC, Non-linear optics, Low power devices		**Russia** Non-linear optics

There are many technical areas which have the potential to advance U.S. military capabilities. Solid-state devices, extensively researched across several decades, has high potential payoff. Basic research continues in an effort to develop new families of devices that operate in the terahertz region or at extremely low power levels. **Japan** and a number of European countries, through their JESSI/MEDEA program, are active in this area. Battlefield communications continues to be an application of great interest, as the need for real-time battlefield information becomes more critical. A number of countries have developed extensive research capabilities in niche areas ranging from C^3 to networking, switching and transmission. Microwave/millimeter wave circuit integration helps to satisfy the need for improved communications, radar and seeker systems. Other direct applications support the "digitized" battlefield. **Japan**, with its research in MMIC devices and coustic wave devices, is a leader in applicable areas. Again, European countries are involved through the JESSI/MEDEA consortium. Image analysis and target recognition are critical to maintaining superior US forces. This involves the full energy spectrum IR, visible and radar. A number of European countries and **Israel** are active in these areas and **Japan** has a rapidly developing capability. Low power electronics is critical for man-portable systems, and has a direct bearing on all of the technologies in this section. **Japan** has extensive experience in this area and several European countries have developing capabilities.

The **Japanese** have world class capabilities in solid state devices, telecommunications, microwave and millimeter wave circuit integration and low power devices. The European JESSI/MEDIA consortium has resulted in a number of European countries, particularly the **UK**, **France**, and **Germany**, developing extensive capabilities in solid state devices and increasing capabilities in low power devices. **France** is considered a world leader in battlefield communications. The **UK**, **Germany**, **Japan** and **Canada** have extensive niche capabilities.

H. Mechanical Sciences

Table E.III.7 summarizes international research capabilities in each major subarea of mechanical sciences.

Table E.III-7. Mechanical Sciences

MECHANICAL SCIENCES	UNITED KINGDOM	FRANCE	GERMANY	OTHER COUNTRIES	JAPAN	PACIFIC RIM	FSU
Structures and Dynamics	Smart/active structures, Structural acoustics, Modeling and simulation	Smart/active structures, Modeling and simulation	Smart/active structures, Modeling and simulation	**Italy** Smart/active structures, Modeling and simulation **Brazil** **Israel** **S.Africa** **Poland** Smart/active structures, Modeling and simulation	Smart/active structures, Modeling and simulation	**India** **S. Korea** **China** Smart/active structures, Modeling and simulation	**Russia** **Ukraine** Smart/active structures, Modeling and simulation
Fluid Dynamics	CFD Theoretical Experimental,	CFD Theoretical Experimental	CFD Theoretical Experimental	**Canada** CFD **Australia** Experimental, Theoretical	CFD Theoretical Experimental,		**Ruissia** **Ukraine** CFD Experimental, Theoretical
Combustion and Propulsion	Small GT, Recipricating engines, Sol/liq. gun	Small GT, Solid gun, Recipricating engines	Recipricating engines, Solid gun Small GT	**Canada** **Australia** Solid gun, Recipricating engines Small GT **S. Korea** Solid gun	Recipricating engines Sol/liq. gun, Small GT	**S. Korea** **India** Solid gun **S. Korea** Solid gun **S. Korea** Recipricating engine	**Russia** Novel gun propulsion Small GT, Recipricating engine

CFD - Computational fluid dynamics; GT - Gas turbine engine; Sol/liq gun - Solid/liquid gun propulsion

The area of Structures and Dynamics consists of structural dynamics and simulation and air vehicle dynamics. Within structural dynamics, priority research applies to ground vehicle and multibody dynamics, structural damping, and smart structures. The goal of significant vibration reduction in army vehicles offers substantial increases in weapons platform stability, weapons system reliability, weapons lethality, and crew performance. Within air vehicle dynamics, priority research applies to integrated aeromechanics analysis, rotorcraft numerical analysis, helicopter blade loads and dynamics, and projectile elasticity. In solid mechanics, research areas are the mechanical behavior of materials, integrity and reliability of structures, and tribology. The latter area contributes to damage tolerance, damage control, and life prediction, while tribology contributes to lubrication, dynamic friction, and low heat rejection.

Basic research in fluid dynamics can directly contribute to advances in predicting the capabilities of maneuvering projectiles. Future advances would enhance the ability to predict the capabilities of smart munitions, integrated propulsion systems, flight dynamics, guidance and control, and structural dynamics within the Army. Fluid dynamics research priority areas are unsteady aerodynamics, aeroacoustics, and vortex dominated flows. Complementary research on computational fluid dynamics (CFD) of multibody aerodynamics would provide a capability to predict and define submunition dispensing systems. Multidisciplinary research in this area will lead to hypervelocity launch technology as well as low speed military delivery systems.

Combustion and Propulsion research supports advanced technology development providing continued advancement in small gas turbine engine propulsion, reciprocating engine propulsion, and solid, liquid, and novel gun propulsion technology. The development of high performance small gas turbine engines requires basic research in turbomachinery stall and surge, as well as advances in CFD simulation. These basic research areas directly contribute to highly loaded, efficient turbomachinery components. This type of research is necessary to meet the Integrated High Performance Turbine Engine Technology (IHPTET) goals of a 120% increase in turbo shaft power to weight ratio. Reciprocating engine technology research tends to move forward at a more evolutionary pace with advances in ultra-low heat rejection, enhanced air utilization, and cold start phenomena as priority areas. Solid gun propulsion technology requires research priority to be placed on ignition and combustion dynamics and high performance solid propellant charge concepts. Liquid gun propulsion requires priority research in atomization and spray combustion, ignition and combustion mechanisms, and combustion instability, hazards and vulnerability. Novel gun propulsion depends on electrothermal-chemical (ECT) propulsion, active control mechanisms, and novel ignition mechanisms.

In the field of Structures and Dynamics, the **UK**, **Germany**, **Italy**, **France**, and **Japan** all demonstrate world class capabilities in smart/active structures and modeling and simulation development. **India**, **South Korea**, **China**, **Brazil**, **Israel**, **South Africa**, **Poland**, **Russia**, and **Ukraine** all demonstrate potential future capabilities in the same area. However **Russia** and **Ukraine**'s potential appears to be dwindling because of lack of resources. The **UK** also demonstrates a world class capability in structural acoustic research and development.

A balanced world class capability in the theoretical, experimental and CFD elements of fluid dynamics research is not resident in any single foreign country. There are a number of examples of world class capability in specific areas of research which hold promise for military applications. Computational fluid dynamics studies in the **United Kingdom**, **France**, and **Japan** can contribute significantly to missile, rotor and explosive design. **France** and **Japan** also excel in theoretical ability and **Japan** also exhibits excellent experimental ability. The **UK**, **France** ,and **Germany** are maintaining a mature experimental capability. Both **Russia** and **Ukraine** have had mature experimental and theoretical ability, however they show a declining capability, largely due to a lack of resources.

In the Combustion and Propulsion area, the **UK** and **France** both demonstrate world class capabilities in small gas turbine engine development. **Canada**, **Germany,** and **Japan** approach this level of capability in limited areas, but show good potential over the next decade to make significant contributions to small gas turbine power to weight ratio improvement. **Germany** leads in reciprocating engine development technology with **Japan** also demonstrating world class capability. Both countries particularly excel in the application of ceramic materials to low heat rejection technology. The **UK** also demonstrates excellent reciprocating engine development capability, with **France**, **Canada**, **Australia**, and **South Korea** exhibiting good future potential. **Russia** and **Ukraine** both have demonstrated mature capability in the past, however limited resources reflect a declining future potential. Novel gun propulsion technology leadership is still maintained by **Russia**, however their future growth potential may be muted. Liquid gun propulsion development technology is lead by the **UK** with **Japan** showing significant potential. Solid gun propulsion development technology is resident in a number of countries including the **UK**, **France**, **Germany**, **Canada**, and **Australia**. **Japan** and **South Africa** both demonstrate significant future potential.

I. Atmospheric and Terrestrial Sciences

The proliferation of sensing satellites, ground weather collections sites, and advances in modeling and simulation have brought about a significant capability to predict local and regional weather. Much remains to be done to provide the needed lower atmospheric data to support the rapid increase of smart and brilliant weapons whose operation can be affected by weather phenomena. The **US** and **Russia** have been sharing space solar flare radiation data which has aided in better prediction of communication and GPS navigation variances due to atmospheric scintillation in the equatorial and polar regions of the world. Many countries have focused their weather development programs on regional issues, such as **Japan** in pollution monitoring of tropical cyclones. Results of these efforts will have multiple applications across the full spectrum of weather modeling and prediction. The flow of both weather data and research information to all members of the World Meteorological Organization is well established and for the foreseeable future this collaboration will continue. It can be anticipated that some of these research efforts will provide solutions directly to current Army needs.

Most of the industrialized countries have capabilities in certain niches of these technology areas. As Table E.III-8 shows, the **UK, France, Germany, Japan**, and **Russia** have the widest technology coverage, while **Canada**, **the Netherlands**, **Denmark**, **Brazil, Israel**, and **China** have narrower coverage.

Table E.III-8. Atmospheric and Terrestrial Sciences

ATMOSPHERIC & TERRESTRIAL SCIENCES	UNITED KINGDOM	FRANCE	GERMANY	OTHER COUNTRIES	JAPAN	PACIFIC RIM	FSU
Atmospheric	➤ Atmospheric backscater, Global and regional ➤ weather prediction	➤ Atmospheric electricity - aircraft interactions		**Canada** Ice flow & weather prediction, Tracer technology for atmospheric dispersion **Netherlands** IR celestial background **Denmark** Polar cap & aerial ionophere interactions **Brazil** Weather & ionosphere experiments ➤	➤ Ionosphere & troposphere interactions & predictions	**China** Upper ▷ atmosphere testing ▷	**Russia** ➤ Solar flare prediction, Atmospheric ➤ spectral transmissivity
Terrestrial (Lower Atmosphere)	Low level weather prediction ➤ ➤	IR physics of the atmosphere ➤	Low level weather prediction ➤	➤ **Israel** Low level weather, lidar measurements **Denmark** ➤ Atmospheric turbulance **Canada** Technology for atmosperic ▲ dispersion	➤ Tropical cyclone, ➤ Urban polution		**Russia** Low level weather prediction ➤

J. Medical Research

Table E.III-9 summarizes international capabilities in medical research. Basic research efforts in the medical sciences related to military missions address four areas: infectious diseases; combat casualty care; Army operational medicine; and medical biological defense. The first relates to protection/prophylaxis of personnel deployed to a mission area from indigenous organisms or to biological (B) agents; the second to care of personnel following acute injury; the third to enhancers/sustainers of performance in the field; the fourth to treatment and care of persons following exposure to B agents. These areas of investigation are dual use and impact on general health care delivery, although the military aspects often differ from civilian concerns in several critical instances. For example, deployed military personnel may be more susceptible than indigenous populations to infectious agents because of lack or prior exposure. Also, developing novel means useful in delaying onset of clinical disease in the face of the physically and mentally demanding nature of combat is of critical importance, as incapacitating military forces for short periods may have profound effects on the outcome of operations.

The Human Genome effort has identified those gene profiles that render specific populations more susceptible to disease than other populations. The Human Genome project is a multinational effort spearheaded by the **US**, **nations of EC**, and **Japan**; the information is freely available on the Internet. Novel combinatorial chemistry strategies have allowed the synthesis of non-peptide molecules that bind gene fragments, receptors, or cell proteins and thereby offer the potential of protection against threat agents. These same materials also may provide utility in multi-array sensors used for the detection of B agents. Combinatorial chemistry strategies are being pursued in many developed nations through the pharmaceutical sector. **Switzerland, Sweden, the Netherlands**, and **Israel** have expertise in these areas, as do the above mentioned nations.

Foreign efforts in medical chemical defense closely parallel those in medical biological defense. For the most part, countries that are engaged in one are also active in the other. The one exception for countries listed is the **Netherlands**. The Dutch effort in medical chemical defense is not as extensive as in medical biological defense. All countries listed have world leading capabilities but none are expected to pull ahead of the others.

The critical areas of care for combat casualties in the next decade include treatment for fluid loss and accompanying shock, management of impact injury on the nervous system including the spinal cord, increased susceptibility to infection at points of projectile entry because of stress related events, and prevention of B agent dissemination by friendly forces exposed to agents. Biocompatible materials that bind oxygen and have utility as blood expanding agents are in development in the **US**, **EC,** and **Japan**. Cellular growth factors, acting on neural tissues, have been found to stimulate the repair of transected spinal cord and other CNS regions. Macromolecular growth factors, acting on tissues other than the nervous system have been shown to enhance the rate of wound healing and to increase resistance to disease. This research is actively explored in the **US**, **Canada**, **Germany**, **UK**, **France**, **Japan**, **Israel**, and **Sweden**.

Table E.III-9. Medical Science

MEDICAL SCIENCE	UNITED KINGDOM	FRANCE	GERMANY	OTHER COUNTRIES	JAPAN	PACIFIC RIM	FSU
Infectious Diseases	a,b,c,d,e ⋀	a,b,c,d,e ⋀	a,b,c,d,e ⋀	a-e Switzerland ▲ b,c,e Sweden ▲ b,c,e Israel ▲ b,c, Italy ▲ b,c,e Netherlands ▲	a,b,c,e ⋀	China b,c ⋀	a,b,c ➤
Combat Casualty Care	a,b,c ⋀	a,b,c ⋀	a,b,c ⋀	⋀ Switzerland a,b ⋀ Sweden a,b,c ⋀ Israel a,b,c ⋀ Italy a,b,c,	a,b ⋀	China a,b ⋀	b,c ⋀
Army Operational Medicine	a,b,c ⋀	a,c ⋀	a,b,c ⋀	⋀ Israel a,c ⋀ Sweden a,b,c	c ⋀		
Medical Biological Defense	a,b,c,d ⋀	a,b,c,d ⋀	a,b,c,d ⋀	Sweden Switzerland Netherlands Israel a,b,c,d ⋀	a,b,c,d ⋀	Taiwan d ⋀	d ⋀

Infectious Diseases - a: Human genome and Desease Susceptibility; b: non-peptide antivirals; c: rapid diagnosis; d: vaccines; e: delivery of vaccines post exposure
Combat Casualty Care - a: manage acute trauma shock (blood loss, CNS change and perfusion); b: pharmacology of wound healing and CNS injury repair; c: containment of personnel and equipment after exposure (containment pods and telemedicare)
Army Operational Medicine - a: biomarkers for toxicant exposure (GST, P450, acute phase proteins); b: nutrient additives; c: countermeasure to intense noise
Medical Biological Defense - a; immune response enhancers (interferon, interlukin); b: intracellular transport molecules (M protein); c: block viral docking and replication; d: enhance uptake of drugs to cells (Botox)

Biomarkers for toxicant exposure in humans and animals have been identified; these materials are body catalysts and enzymes that serve to detoxify chemicals. The absence of some of these normally occurring enzymes in specific persons has been shown to increase susceptibility to disease. It is now possible to screen blood and urine samples and determine the concentration of these biomarkers in select persons. It is likely that biomarker profiles will have utility in selection of persons resistant to toxicants (for special operations) and for reviewing fitness for duty. The Human Genome project is likely to increase the number of biomolecules that can serve as biomarkers for exposure. The **US**, **Canada**, **EC**, and **Japan** have expertise in this area.

Normally occurring biomolecules have now been identified that enhance or degrade the immune response of persons to infectious material or to toxins. These materials are called biological response modifiers (BRM). Treatment, with novel BRMs, of military forces who may have been exposed to pathogenic agents as a consequence of deployment or through B agent attack, may enhance the survival or sustain the performance of the affected personnel. In the past few years, it has been shown that transport of infectious materials across cell membranes is a critical element in viral replication and maturation. Chemical treatment that interferes with the ability of a virus to bind to a target cell or with intracellular transport, can impede viral multiplication and infectivity; such treatments may sustain performance of affected personnel for long periods after exposure to such agents. The **US**, **Japan**, **France**, **UK**, **Germany**, **Sweden**, and **Netherlands** are leaders in this area.

K. Biological Sciences

Basic research in the biological sciences contributes directly to a knowledge of food production in deployed areas, production of potable water, protection of military personnel from infectious agents in a deployed region, production of sensors for chemical and biological agents, reduction of signatures to increase stealth, and the production of materials useful in communications, sensing and self-assembly. Biomaterials have the ability to self-assemble (phospholipids), to transduce light and pressure to electrical signals, to encode large amounts of information in very small areas or volumes (the entire genetic information for a human resides in each cell nucleus which has a diameter of 5 micrometers (μm) or less).

Table E.III-10 summarizes international research capabilities in the technical areas of biological sciences. These include: 1) biochemistry, biophysics and molecular biology; 2) microbiology, physiology and pharmacology; 3) biodegradative processes; 4) food science and 5) bioscience. Biochemistry, biophysics, and molecular biology examine the structural and functional properties of biopolymers (such as DNA and RNA) involved in information storage, the catalytic properties of proteins that function as enzymes, and the recognition properties of proteins that function as antibodies and receptors. The second area concerns the role of intact cells, cell membranes and ion fluxes across membranes in the operation of the intact organism. The third area addresses remediation of soil and water to produce potable end product and reduce signatures. The fourth investigates mechanisms to increase shelf life of food and the nutritional quality of food. The fifth area is concerned with the use of biopolymers as structural materials -- ceramics, silks, signal transducers, etc.

The Human Genome project utilizes biochemistry, biophysics, and molecular biology to explore questions of intrinsic disease susceptibility in humans and crops. These technologies also reveal the nature of molecules that allow viruses to infect cells and allow cells to communicate with each other (i.e. receptors). Since the effect of toxins on cells is a result of their action on specific cell receptors, these technologies reveal how we can neutralize toxins. The **US**, **Canada**, **Japan**, **EC**, **Taiwan**, **China**, **Korea**, **Brazil,** and **Israel** have capabilities in these areas.

Microbiology, physiology, and pharmacology are essential sciences in the production of fermented and processed foods (bread, yogurt, beer, wine), of pharmaceuticals and human hormones (the latter using genetic engineering), and in evaluating human performance (neural function, vital signs). The **US**, **Japan**, **Germany**, **France**, and **Russia** have a long tradition of expertise in these areas. The Russians had a developed expertise in the use of biological toxins to deliver molecules to specific cells. The Russian capability has decreased in many of these areas during the past five years but still remains strong in targeted delivery (associated with MOD laboratories). **Hungary** has an established capability in production of fermenters.

Remediation of soils and water, using biological organisms to metabolize contaminants, has been an area of extensive research in the past decade. The **US**, **Germany**, **Netherlands**, **Sweden**, **Finland**, **Japan**, and **Israel** have expertise in this area, with the **US** and **Israel** particularly active in water purification.

Table E.III-10. Biological Sciences

BIOLOGICAL SCIENCES	UNITED KINGDOM	FRANCE	GERMANY	OTHER COUNTRIES	JAPAN	PACIFIC RIM	FSU
Biochemistry, Biophysics and Molecular Biology	▲ Combinatorial chemistry, ▲ Genome project, Receptor ▲ characterization, NMR ▲	▲ Genome project, Receptor ▲ characterization	▲ Combinatorial chemistry, ▲ Genome project, Receptor ▲ characterization	**Netherlands** ▲ Transducer molecules, ▲ NMR **Israel** Combinatorial chemistry, ▲ Receptor characterization ▲ **Australia** Combinatorial ▲ chemistry	▲ Genome project, Receptor characterization, NMR		Russia ▼ Transducer molecules, Receptor characterization
Microbiology, Physiology and Pharmacology	▲ Microbial products for nutrition, ▲ Stress resistance	▲ Nutrient additives	▲ Sensing mechanisms, ▲ Nutrient additives		▲ Visual sensing, ▲ Metabolic products		**Russia** ▼ Research in all areas
Biodegradative Processes	Bioremediation ▲	Bioremediation ▲	▲ Bioremediation, Water ▲ purification	**Israel** ▲ Bioremediation, Water ▲ purification	Bioremediation ▲		►
Food Science	▲ Nutritional additives from microbiological products, ▲ Protein stabilizers	▲ Nutritional additives from microbiological products, ▲ Protein stabilizers	▲ Protein stabilizers, ▲ Encapsulation, ▲ Shelf life, ▲ IR irradiation	**Netherlands** **Switzerland** ▲ Protein stabilizers, ▲ Encapsulation, Sugar ▲ modification	Protein stabilizers ▲		►
Biosciences	▲ PHB plasticizer, ▲ Energy transduction, Biomaterials for tensile ▲ strength	▲ Energy transduction, Biomaterials for tensile ▲ strength	▲ Energy transduction, Biomaterials for tensile ▲ strength,	**Israel** ▲ **Netherlands** **Australia** Energy transduction, Biomaterials for tensile strength	Biomaterials for tensile strength ▲		►

The preparation of nutritious, palatable foods with long shelf life and biodegradable containers is the focus of the fourth set of technologies. Biopolymers have been used as elastomers in food containers. Encapsulation and irradiation technologies have been used to increase shelf life and encapsulation also increases palatability. Most **EC nations**, **Japan**, and the **US** have advanced food technology programs. Strong capability in the use of biopolymers as packaging is primarily resides in the **US** and **EC**.

The use of biomaterials, as structural elements or as models to construct non-biological materials that function as biomimetics, has grown along with the demand for miniaturization. Polyhydroxybutyrate and silks are two examples of biomaterials with good tensile properties. New materials emerging from nanotube technology, ceramics based on marine shell structures and isolated bacterial rhodopsin (bR) have applications in signature reduction and information storage. **Russia**, in collaboration with the former DDR, utilized bR to construct a read/write device called Biochrome. The reduction in financial resources in the **former Soviet Union (FSU)** has caused a decline in this capability. A "Biochrome" material is currently available from **Germany**. The **UK**, **Japan, France**, **Netherlands**, **Israel**, and **US** also have strong capabilities in this area.

L. Behavioral, Cognitive and Neural Sciences

Table E.III-11summarizes international research capabilities in the various subareas related to this field. Basic research in these areas contributes directly to: 1) the ability of a soldier to analyze and act on information presented on a video display terminal (multi-modal display systems and iconography), 2) training in virtual and constructed realities, and 3) determining fitness for duty as well as when training goals have been achieved.

Table E.III-11. Behavioral, Cognitive & Neural

BEHAVIORAL, COGNITIVE AND NEURAL SCIENCES	UNITED KINGDOM	FRANCE	GERMANY	OTHER COUNTRIES	JAPAN	PACIFIC RIM	FSU
Cognitive Skills and Abilities	a, b, d ↑	a, b ↑	a, b, d ↑	↑ Israel Netherlands Sweden a, b	b ↑	↑ S. Korea China ↑ Taiwan Malaysia	a Due to reduced activity ↓
Noncognitive Skills and Abilities	a, b, d ↑	a, b, c ↑	a, b, d ↑	↑ Israel Netherlands Sweden a,b,c	a,b,c ↑	↑ S. Korea China Taiwan a,b,c	b, d ↓
Perceptual Processes	a, b ↑	a, b ↑	a, b ↑	Netherlands a ↑	a, b ↑	↑ S. Korea China b	a, b Due to reduced activity ↓
Leadership	→		Multinational force integration ↑				

Cognitive Skills and Abilities - a: Distributed simulation and constructed reality (US ADS system); b: iconograph compatibility with human user; c: aging and performance; d: vital sign remote

Noncognitive Skills and Abilities - a: Neurophysiological measures of human performance; b: pharmacological performance sustainers; c: neuropsychological profile; d: stress reduction

Perceptural Processes - a: Multimodal data presentation (couple visual presentation on display panel with auditory display); b: iconographic compatibility with human user

The current era in command and control systems is characterized by acquisition of such large amounts of data simultaneously that processing of the information is limited by perceptual processes of the human mind. To manage this reality, C3 systems have made progress in iconographic representations and in multimodal data presentation by using auditory input to complement visual display systems. Color coded icons can be used to present complex data in a relatively simple manner. Auditory cues improve the operator's attentiveness and response to changing incoming data. Nonetheless, as our ability to sense battlefield conditions improves through the use of multiarray sensors, the amount of information to be processed will increase dramatically. The task then is to present the large volume of data in a compressed and comprehensible manner. Research therefore addresses mechanisms by which the data presented can be compressed; also required is information concerning the ability of the operator to comprehend the data and how this ability changes as a function of sleep deprivation, medication, and aging. Iconographic systems are under development in the **US**, **Canada**, **EC**, and **Japan**. **The Netherlands**, **Israel**, and some **Pacific Rim nations** also have efforts in this area. Unobtrusive measures of vital signs require miniaturized sensors (of blood pressure, respiration, electrical conductivity) and compact, light weight relay systems. The **US**, **Japan**, **EC** (including the **Netherlands**), and **Pacific Rim nations**, including **Taiwan, South Korea**, and **Malaysia**, have increasing capability in this area.

The advent of computer generated auditory and visual data presentation modes led to advanced distributed simulation (ADS) techniques and programs. This allows multiforce operations to be imaged from distributed sites. Such technology facilitates training activities and integration of activities across the services. The software and hardware used in model systems are developed in the **US, Japan**, and **EC.** Pharmacological performance sustainers (e.g. melatonin) are being explored for efficacy. Nations with extensive programs in the pharmaceutical area or in processed foods have capabilities here. These include the **UK**, **Japan**, **France**, **Switzerland**, **Netherlands**, **Sweden**, and **Germany**.

Annex F

U.S. SPECIAL OPERATIONS COMMAND TECHNOLOGY OVERVIEW

CONTENTS

U.S. SPECIAL OPERATIONS COMMAND TECHNOLOGY OVERVIEW

A. INTRODUCTION

The U.S. Special Operations Command (USSOCOM) was formally stood up as a unified command on 16 April 1987. It is one of nine unified commands reporting to the Secretary of Defense through the Chairman, Joint Chiefs of Staff. The primary mission of USSOCOM is to provide combat-ready special operations forces (SOF) in peacetime and in war for the theater combatant commanders, American ambassadors and their country's teams, and other Government agencies. The Commander in Chief of USSOCOM (USCINCSOC) carries out that primary responsibility by performing several supporting functions, which include developing and acquiring SOF-unique equipment, materiel, supplies, and services. Within USSOCOM, the Special Operations Acquisition Executive (SOAE) is directly responsible for the research, development, and acquisition (RD&A) of systems peculiar to special operations (SO). The SOAE manages this responsibility in two ways: (1) program execution within USSOCOM for systems unique to SOF; or (2) working cooperatively with the services and Department of Defense (DoD) agencies such as the Defense Advanced Research Projects Agency (DARPA), with other Government agencies such as the Department of Energy and the National Aeronautics and Space Administration, and with industry as well as academia.

In 1986, Title 10, U.S. Code (USC), Section 167, was signed, which provided USSOCOM the responsibility to develop and acquire SO-peculiar equipment, materiel, supplies, and services; in 1988, the Secretary of Defense (SECDEF) granted USSOCOM the opportunity to establish a contracting activity; in 1989 the acting SECDEF assigned Major Force Program 11 (MFP-11) Program Objective Memorandum (POM) and budget authority to USSOCOM; and, in 1992, USSOCOM appointed the SOAE to execute the command's acquisition objectives and strategies. However, because of the limited funding in MFP-11, Congressional Committees on Appropriations directed that USSOCOM work with all research activities to ensure that SO technology needs are considered in the development of their technology base programs. To this end, Congress reiterated that the unique missions of SOF require their capabilities be based on the leading edge of technology, and, therefore, expects these activities "to expend an appropriate amount of the technology base effort identifying and developing technologies that have Special Operations potential." While USSOCOM has a Service-like responsibility for research, development, and acquisition, the command is a user rather than a developer of technology, and does not have a dedicated laboratory structure as do the military departments. USSOCOM's technology strategy is to monitor emerging technology relevant to SOF needs, participate in selected programs that relate to SOF technology development objectives, and execute selected high priority projects to exploit emerging technology for near-term SOF application. A key thrust of this strategy is to proceed urgently with the prevailing objective to "increase the capability of assigned forces through the fielding of SO-peculiar materiel meeting user requirements in the shortest possible time, i.e., aggressive use of prototyping."

B. TECHNOLOGY PROGRAM

To execute the MFP-11 responsibilities for technology development, USSOCOM has developed a Technology Development Program that is comprised of the following efforts, as well as the leveraging and influencing of technology thrusts ongoing in defense-related research programs, entitled: Special Operations Technology Development (SOTD), which concentrates on exploratory development and technology studies; Special Operations Special Technology (SOST), which concentrates on advanced engineering development and rapid prototyping; SOF Medical Technology Development (MED-TECH), which does studies on basic exploratory medical technologies centering on physiologic, psychologic, and ergonomic factors to enhance the ability of SOF operators to better perform their missions; Small Business Innovative Research (SBIR); and Tactical Exploitation of National Capabilities (TENCAP), which explores the tactical use and interface with national systems/ architectures.

The principal driver of USSOCOM's Technology Development Program evolves around a list of prioritized Technology Development Objectives (TDOs). This prioritization reflects the SOF's command and field perspective of their operational deficiencies and future capability needs, and typically requires either a new technology application or an advanced technology demonstration. The TDOs are required by DoD Instruction 5000.2. They are developed jointly by the USSOCOM staff and its four components, are reviewed and, if necessary, updated every two years in conjunction with the POM process, and are officially approved by USCINCSOC. These TDOs provide focus to the command—as well as to technologists, engineers, and industry representatives—on areas of technology that potentially can address SOF operational deficiencies and meet future requirements or operational capability objectives for USSOCOM. They are used as the foundation for selecting USSOCOM technology projects and to influence service/agency technology efforts. They also assist with resource allocation decisions to support technology-based projects and studies. In an abbreviated form these TDOs are denoted as follows:

(1) Weapons of Mass Destruction
(2) Individual Survivability
(3) Sensors
(4) Power Sources
(5) Mobility Platforms
(6) C4I
(7) Information Warfare
(8) Countermine and Demining
(9) Targeting and Tracking
(10) Weapons and Munitions
(11) Simulation and Training

A wide and diverse set of concepts or systems is required to satisfy the deficiencies within each TDO. However, the following general characteristics that are particularly important to SOF operators pervade across multiple concept/system requirements: lightweight, small, rugged, minimal signature, lethal, survivable, maintainable, and affordable.

The following is a more complete description of each of the USSOCOM TDOs, along with a narrative of the types of technologies that are important in reducing the SOF shortcomings in these combat and non-combat functional areas.

1. Weapons of Mass Destruction (WMD) Detection, Classification, Neutralization, and Protection Systems

Technologies that should have the potential to provide capabilities for rapidly detecting, precisely locating, and accurately classifying fixed and mobile WMD threats from standoff distances in both semi- and non-permissive environments. Proposed technologies should demonstrate potential for use as either a man-portable or a SOF mobility platform (ground, air, maritime) mounted system useable in underground facilities. Technology must be compatible with SOF mission scenarios and be suitable for SOF tactical or clandestine environments. Technologies are needed to detect deep underground structures; and also to assist SOF in disabling or defeating systems in such facilities. Technologies should be able to detect U.S., foreign, and improvised nuclear, biological, and chemical agents currently available or projected to be used on the battlefield or in an Operations Other Than War (OOTW) scenario. Technologies are desired to assess and analyze nuclear, chemical, and biological weapons in order to cause yield reductions; to assist in disassembly; to perform advanced diagnosis; and to help neutralize, render safe, or otherwise destroy the weapon in a semi- or non-permissive environment. Technologies are also desired to perform initial chemical agent analysis and identification in a remote and austere environment. Most individual and unit NBC detection and protection technologies are more Service-like items and, although desired and utilized by SOF forces, they usually are not suitable for SOF-only missions. For example, SOF requires very lightweight, one-time-use but low-volume NBC protection.

2. Lightweight, Low-Volume Survival, Sustainment, and Personal Equipment

Technologies that, in both favorable and adverse environment and mission conditions, should have the potential to provide enhanced performance, sustainment, and protection of SOF personnel, that will include endurance/fatigue reduction, mobility, active and passive camouflage, signature reduction, lethality, alertness, protection against ballistic, D.E.W., etc. Proposed technologies should be applicable to the full range of individual SOF equipment and systems, to include: C4I equipment, rations, protective clothing, camouflage, signature reduction, laser and direct energy protection, body armor, sensors, maritime and diving equipment, individual water purification, etc. Camouflage/deception concepts should show adaptability to a variety of topographical and climatic backgrounds. Development of technologies and follow-on systems must not reduce durability, performance, or usability due to size and weight reduction; or adversely affect the individual's physical strength, flexibility, endurance, etc. Robotic technologies for ground and air platform applications will be of interest to reduce the burden of non-combat essential equipment. Such technologies should demonstrate improvements in operational capabilities utilizing current and future advances in miniaturization and weight reduction, fatigue reduction, biochemistry, nutrition, electronics, fabrics, textiles, hybrid materials, metallurgy, or the life sciences. Medical technologies to enhance the treatment and prevention of battle injuries and non-battle casualties will also be of interest.

3. Advanced Vision Devices, Sensors, Fire Controls for SOF Weapons, and Human Sensory Enhancement and Performance Amplification Equipment

Technologies that should have the potential to enable the individual SOF operator, driver, pilot, or crew member to significantly improve their ability to detect threats and avoid obstacles in both favorable and inclement weather and environment conditions. Technologies should improve the ability to detect, identify, track, and maintain surveillance of threats (weapons systems, personnel, installations, sensors, emitters, targets, etc.). Technology should be capable of multi-spectral detection (radar, thermal, infrared, acoustic, visual) and be adaptable to both man-portable and mobility platform uses. The technology should not detrimentally interfere with normal sensory functions of hearing, smell, or sight. Sensor technology should provide enhanced sensory capabilities in night, fog, precipitation, smoke, dust, etc. Technologies should also improve range, magnification, field of view, and resolution during periods of both good and limited visibility. Technologies should encourage the ability to increase information and intelligence awareness. Any such technology should demonstrate potential for integration into all applicable planned system acquisitions.

Proposed technologies should significantly increase the capability, speed, and accuracy of SOF operators to acquire and engage targets--in all environmental and visibility conditions--using current and proposed SOF individual, crew-served, and platform-mounted weapon systems. Technologies should demonstrate adaptability to man-portable systems with all-weather capabilities, reliability, sustainability, and maintainability in field conditions. Technologies must possess the ability to process a full ballistic solution in near real-time; have variable power optic/sensors; and provide day, night, and limited visibility capabilities.

4. Lightweight, Low-Volume Power Supply, Storage, Management, and Generation Technologies

Technologies that should have the potential to provide SOF with improved power sources, power storage, power generation, or power management capabilities for C4I systems, weapons, mobility platforms, and SOF equipment. Technologies should demonstrate significant improvements in power density, transportability (land, sea, and air), rechargeability, disposability, reliability, commonality, and size and weight characteristics. Substantially improved electrical generation storage and conditioning capabilities are required to enhance vehicle propulsion and support current and future weapons systems/concepts.

5. Enhanced SOF Mobility and Attack Platforms With Increased Speed and Range, Decreased Detectability, and True All-Weather Capabilities

Technologies that should have the potential to significantly reduce mobility mission area deficiencies that include: improving performance; lowering the probability of detection; improving the supportability of SOF air, land, and maritime mobility platforms; and reducing the logistics signatures of SOF mobility platforms. Technologies should address reductions in multi-spectral (radar, thermal, infrared, acoustic, visible) signatures while providing mobility platforms with increased maneuverability, speed, range, all-weather capability, threat avoidance, survivability and protection, transportability, reliability, maintainability, and durability. Technologies must show potential for application to future SOF mobility platforms or upgrades to current systems.

Resupply technologies should have the potential to enhance the capability to provide accurate and timely resupply to SOF operators in an unmarked, denied, tactical environment without causing undue loss or damage to items being resupplied. Enhanced resupply systems must have increased accuracy in all weather, have significant standoff range, and have a low probability of detection (LPD). Systems may include unattended resupply vehicles, low platforms and rigging gear. Proposed technologies should show significant improvements over current systems capabilities.

6. Improved Digital Transmission, Switching, Information Transfer Automation, and Human-to-Machine Interface Communications (C4I) Technologies

Technologies that should have the potential to provide improvements in weight reduction, size, LPI/LPD, power consumption/management, over-the-horizon capabilities, transmission rates, processor throughput, programmability, modularity, multi-band operations, simultaneous transmission/reception capabilities, real-time information, imagery/system/sensor fusion, spectral utilization, compatibility, seamless GPS integration, and miniaturized automated data processing (ADP). Technologies must be suitable for application in extreme environments and be compatible with standardized open architectures and complementary technologies, such as integrated navigation, direction finding, security, IFF, automatic encryption/authentication, etc. New systems must comply with USSOCOM's architectural tenets, which specify that systems must be seamless, robust, automated, use the full spectrum, and be standards compliant.

7. Automated Information Warfare (IW) Systems Enhancements to Influence and Protect Information Systems, Links and Nodes

Technologies that should have the potential to provide SOF advanced capabilities for deception, electronic warfare (EW), Psychological Operations (PSYOP), and speech technologies.

Technologies for deception and EW should enhance capabilities to disable, jam, spoof, or otherwise confuse enemy sensor and detection systems, including radars; thermal imageries and other optical-electronic systems; acoustic detectors; and seismic sensors and systems. Other areas for enhanced tactical deception include disruption, disablement, or reducing the efficiency of communication and command and control systems, which may have radio frequency (RF), laser, hard-wire, fiber-optic, or other links.

Advanced PSYOP technologies are also required to develop, produce and disseminate PSYOP products, including: radio (AM/FM/ SW); television broadcasts; and printed material. Technology must support production, distribution, and dissemination of PSYOP products to, from, and within forward and remote locations. It also should include the integrated utilization of broadcasts or products using broadcast range extenders, aerial pamphlet disseminators, loudspeakers, high capacity print facilities, translators, etc. Technologies should enable the development of new and advanced means of disseminating or projecting PSYOP messages to a target audience. Such technologies might include direct satellite broadcasting, UAV payloads, digital signal processing, voice synthesizing, laser video, acoustic generators, holograms, artificial intelligence applications, and attitudinal/ behavior agents. Applicable speech technologies should provide automated recognition and translation both from English to the target language and from the target language to English. Technology must have the potential to achieve real-time, voice-to-voice translation; speaker identification; be a small, light-weight package; interface with C4I systems; and transcribe and translate text at a near real-time rate.

8. Passive Shallow Water/Terrestrial Mine, Explosive, and Booby-Trap Detection, Identification, and Neutralization Technologies

Technologies that should have the potential to provide passive, accurate, tactical detection and classification of surf zone, shallow water, and terrestrial mines, explosives, and booby-traps. Demonstrate or identify technologies that enhance the ability to destroy or disable mines and booby-traps on land and in shallow water without posing a threat to the individual operator. Technologies should be applicable to all ground and sea-bottom soil types, lead to increased detection capabilities, longer ranges, lower false alarm rates, and autonomous or stand-off capabilities. Technologies should apply to magnetic, acoustic, command-detonated, and pressure mines, as well as to future mine and fusing/detonation systems and must be transferable to man-portable, modular packages. Technologies should be applicable for land and water applications and be compatible with either timers, command detonation, or smart activation. Technologies and systems must apply to both SOF sub-missions: anti-mining and demining. Anti-mining is a combat mission where SOF identifies, marks, or neutralizes mines and booby-traps during, or just prior to, combat operations. Demining is a humanitarian assistance mission where SOF either trains-the-trainers in demining activities, or SOF trains and assists indigenous personnel to detect, mark, avoid, and neutralize mines and booby-traps in a permissive environment.

Attaching systems should demonstrate or identify technologies that provide SOF the capability to accomplish positive non-magnetic adhesion in fresh and salt water; and on dirty, uneven, non-metallic, and petroleum coated surfaces. The adhesive needs to have comparable holding/bonding properties as current adhesives are used to bond explosives to dry, smooth, non-metallic surfaces. The system must be user friendly underwater. It must retain its holding abilities in the surf zone and on an ocean/lake/river floor for an extended period of time and in extreme temperature ranges.

9. Clandestine Target Locating, Tracking, and Marking Technologies

Technologies that should have the potential to provide SOF an improved passive or semi-active method to mark both fixed and mobile targets for identification, tracking, targeting, and precision munitions guidance to include GPS integration. Marking methods must be undetectable by the enemy, but positively identified by both SOF and conventional airborne, waterborne, and ground/vehicular sensors and targeting systems, to include the AC-130 gunship. Technologies for Identification Friend or Foe (IFF) and Combat Identification (ID) must seamlessly interface and integrate with Service systems, plus provide SOF IFF to deep strike fire-and-forget conventional weapons. Marking methods should include a removal capability without special equipment.

10. Future Force Application Weapons and Munitions, Enhanced Explosives and Munitions, and Non-Lethal Technologies

Technologies that should have the potential to provide the basis for advanced offensive and defensive weapons and weapons related systems which demonstrate significant improvements in responsiveness, range, accuracy, reliability, and target effects. Systems are desired for fixed and rotary wing aircraft, small boats, and HMMWV-size vehicles.. Defensive weapons are desired to counter IR, laser, TV, and other smart or seeker-head guided munitions. Demonstrate or identify technologies that provide miniature guided or precision projectiles with long-range, non-line of sight destructive capabilities. Technologies must destroy, disable, or render unusable fuel tanks, light armored vehicles, fortified positions, other soft military vehicles, and SO critical military and industrial target nodes and systems. Technology should allow the operator to conduct firing operations with a LPD and from within enclosed areas.

Applicable technologies should have the potential to provide SOF operators a man-portable, reliable, long-range, accurate, signature-less, sustained rate of fire, day and night capable, tunable, or non-lethal weapons systems. In the non-lethal role, the system must be able to stun an opponent or temporarily incapacitate multiple targets in proximity to the operator. Non-lethal technologies are needed for area applications (crowd control), for point applications (selected individuals in close proximity to non-combatants, prisoners, etc.), and for anti-material applications. Non-lethal technologies are needed for both man-portable and platform mounted systems.

In the lethal role, the weapon system must be able to be used in a medium-range (250 to 600 meters) sniper role to defeat key personnel and to disable soft targets, such as radars, C2 vans, aircraft, sensors, POL containers, weapons systems, etc. Effective ranges to 2,000 meters are the eventual goal. Demonstrate or identify technologies that provide increased lethality, enhanced flexibility, reduced weight and volume, increased accuracy and controllability, and improved safety of explosive charges and munitions. Technologies should demonstrate anti-material capabilities for a wide range of target types for small and medium caliber SOF weapons systems--both hand-held and platform mounted. Multipurpose, low-detectable munitions and explosives are preferred. Items must be certifiable as safe for use and transportability (land, sea, and air) by all Service or USSOCOM safety review and certification boards.

11. Advanced Learning, Training, and Mission Planning/Rehearsal Technologies

Technologies that should have the potential to provide for fusion of diverse and multi-spectral data, application of artificial intelligence, effective use of constructive, virtual, and live simulations as the basis for future systems for enhanced Mission Planning, Analysis, Rehearsal, and Execution (MPARE); or provide integrated, insertable upgrades to current systems. Technologies should address the potential for networking and include realistic sight, sound, olfactory, and motion sensations. Technologies must have application to as many SOF mission areas, skills, environments, and component-unique requirements as is feasible. Improving rapid learning and retention techniques for foreign language are also of interest.