DEFENSE TECHNOLOGY OBJECTIVES

for the Joint Warfighting Science and Technology Plan and the Defense Technology Area Plan

Approved for public release
Distribution Unlimited

19980223 059

February 1998

DEFENSE TECHNOLOGY OBJECTIVES

FOR THE JOINT WARFIGHTING SCIENCE AND TECHNOLOGY PLAN AND THE DEFENSE TECHNOLOGY AREA PLAN

February 1998

DISTRIBUTION STATEMENT A
Approved for public release
Distribution Unlimited

DEPARTMENT OF DEFENSE
DIRECTOR, DEFENSE RESEARCH AND ENGINEERING

CONTENTS

Introduction and Summary v

Section I—Joint Warfighting Science and Technology Plan

Information Superiority I-1
Precision Force I-33
Combat Identification I-53
Joint Theater Missile Defense I-61
Military Operations in Urban Terrain I-71
Joint Readiness and Logistics and Sustainment of Strategic Systems I-79
Force Projection/Dominant Maneuver I-107
Electronic Combat I-135
Chemical/Biological Warfare Defense and Protection and Counter Weapons of Mass Destruction I-147
Combating Terrorism I-155

Section II—Defense Technology Area Plan

Air Platforms II-1
Chemical/Biological Defense and Nuclear II-33
Information Systems Technology II-51
Ground and Sea Vehicles II-101
Materials/Processes II-125
Biomedical II-167
Sensors, Electronics and Battlespace Environment II-195
Space Platforms II-251
Human Systems II-269
Weapons II-303

Appendixes

A. Points of Contact A-1
B. Identification of Program Elements and Projects B-1
C. Advanced Concept Technology Demonstrations C-1
D. Glossary of Abbreviations and Acronyms D-1

Preceding Page Blank

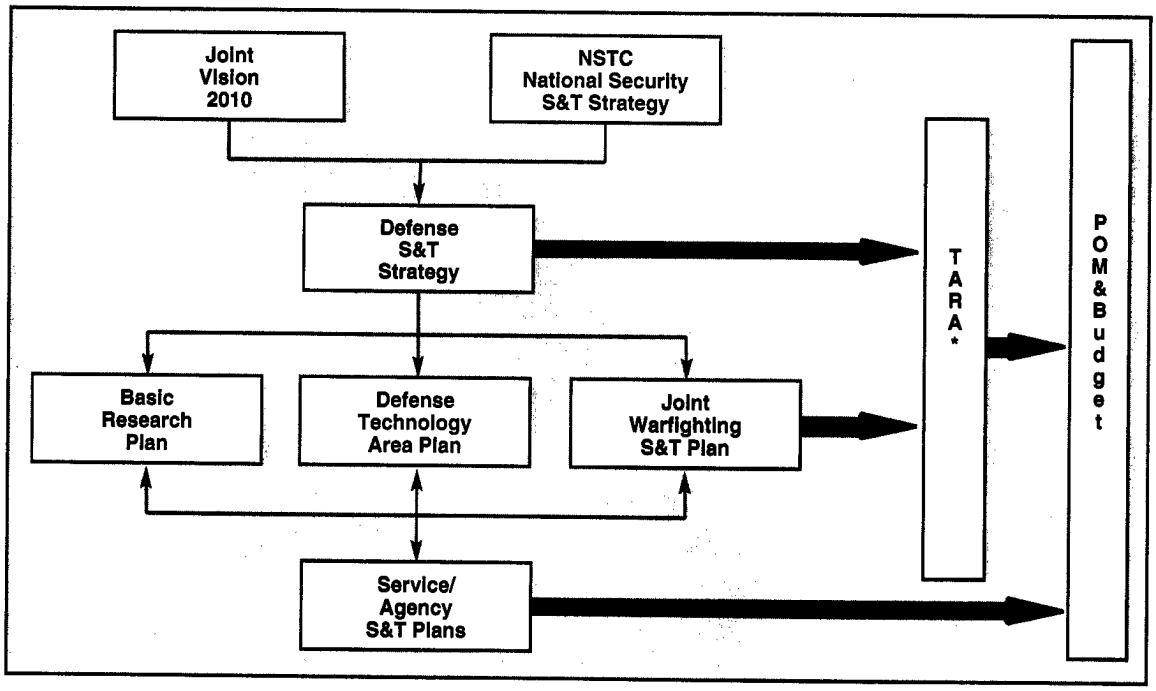
INTRODUCTION AND SUMMARY

Technological superiority has been, and continues to be, a cornerstone of our national military strategy. Technologies such as radar, jet engines, nuclear weapons, night vision, smart weapons, stealth, the Global Positioning System, and vastly more capable information management systems have changed warfare dramatically. Today's technological edge allows us to prevail across the broad spectrum of conflict decisively and with relatively low casualties. Maintaining this technological edge has become even more important as the size of U.S. forces decreases and high-technology weapons are now readily available on the world market. In this new environment, it is imperative that U.S. forces possess technological superiority to achieve and maintain the dominance displayed in Operation Desert Storm. The technological advantage we enjoy today is a legacy of decades of investment in science and technology (S&T). Likewise, our future warfighting capabilities will be substantially determined by today's investment in S&T.

In peace, technological superiority is a key element of deterrence. In crisis, it provides a wide spectrum of options to the National Command Authorities and commanders in chief, while providing confidence to our allies. In war, it enhances combat effectiveness, reduces casualties, and minimizes equipment loss. In view of declining defense budgets and manpower reductions, advancing military technology and ensuring that it undergoes rapid transition to the warfighter are national security obligations of ever greater importance.

To fulfill these obligations, the Director, Defense Research and Engineering (DDR&E), has continually enhanced the strategic planning process for defense S&T. The foundation of this process is the *Defense Science and Technology Strategy* with its supporting *Basic Research Plan* (BRP), *Joint Warfighting Science and Technology Plan* (JWSTP), and *Defense Technology Area Plan* (DTAP) (References 1-4). These documents present the DoD S&T vision, strategy, plan, and objectives for the planners, programmers, and performers of defense S&T.

These documents are a collaborative product of the Office of the Secretary of Defense (OSD), Joint Staff, military services, and defense agencies. The strategy and plans are fully responsive to the National Science and Technology Council's (NSTC's) *National Security Science and Technology Strategy* (Reference 5) and the Chairman of the Joint Chiefs of Staff's *Joint Vision 2010* (JV 2010) (Reference 6), as shown in Figure 1. The strategy and plans and supporting individual S&T master plans of the military services and defense agencies guide the annual preparation of the defense program and budget. The strategy and plans are made available to the U.S. Government, defense contractors, and our allies with the goal of better focusing our collective efforts on superior joint warfare capabilities and improving interoperability between the United States and our allies.



* Technology Area Review and Assessment

Figure 1. Science and Technology Strategic Planning

Defense Science and Technology Strategy (Reference 1). The *Defense Science and Technology Strategy* is responsive to the Secretary of Defense's vision to "develop and transition superior technology to enable affordable, decisive military capability."

The strategy focuses on four generic considerations that have high priority in making strategic decisions about which technologies are pursued:

- *Affordability.* Where appropriate, S&T projects must focus on increasing the effectiveness of a capability and decreasing cost, increasing operational life, and incrementally improving material through planned upgrades.
- *Dual Use.* The S&T program must contribute to building a common industrial base by using commercial practices, processes, and products, and by developing, where possible, technology that can be the base for both military and commercial products and applications.
- *Accelerated Transition.* Advanced Concept Technology Demonstrations (ACTDs) are a key element in the S&T program to focus science and technology on supporting military needs and problems, expediting transitions, and providing a sound basis for acquisition decisions.
- *Strong Technology Base.* The technology base generates DoD's legacy to tomorrow's warfighter. Accordingly, it is imperative to maintain a stable technology base investment to develop options for the truly long term—beyond the threats, situations, and budgets that we can predict.

Basic Research Plan (Reference 2). The BRP presents the DoD objectives and investment strategy for DoD-sponsored Basic Research (6.1) performed by universities, industry, and service laboratories. In addition to presenting the planned investment in each of 12 technical disciplines composing the Basic Research Program, the plan highlights six strategic research objectives holding great promise for the development of enabling breakthrough technologies for revolutionary 21st century military capabilities.

- Biomimetics
- Nanoscience
- Smart structures
- Mobile wireless communications
- Intelligent systems
- Compact power sources

The coupling of the BRP with the DTAP and the JWSTP is carried out in several ways. First, the planning stage of the 12 individual research areas has the active participation of both the Service Laboratories and the Warfighters (through the Operating Commands, such as the Army's TRADOC). This activity takes place by providing requirements and, oftentimes, serving on planning committees that focus on or include basic research. Second, representatives of the Service Laboratories and Operating Commands also take part in the program evaluation process through attendance and participation in Service S&T program reviews and the ODDR&E TARA reviews.

Joint Warfighting Science and Technology Plan (Reference 3). The JWSTP takes a joint perspective horizontally across the Applied Research (6.2) and Advanced Technology Development (6.3) plans of the services and defense agencies to ensure that the requisite technology and advanced concepts for superior joint and coalition warfighting are supported. It ensures that the near-, mid-, and long-term needs of the joint warfighter are properly balanced and supported in the S&T planning, programming, budgeting, and assessment activities of the DoD. The JWSTP is focused around 10 Joint Warfighting Capability Objectives (JWCOs). These objectives support the Joint Warfighting Capability Assessment (JWCA) and the four operational concepts emphasized in JV 2010: dominant maneuver, precision engagement, full-dimension protection, and focused logistics. A significant feature of the JWSTP is the identification of mechanisms for the timely transition of technology to the warfighter in the field before it becomes obsolete or falls in the hands of our adversaries.

Defense Technology Area Plan (Reference 4). The DTAP presents the DoD objectives and the Applied Research (6.2) and Advanced Technology Development (6.3) investment strategy for technologies critical to DoD acquisition plans, service warfighter capabilities, and the JWSTP. It also takes a horizontal perspective across the service and defense agency efforts, thereby charting the total DoD investment for a given technology. The DTAP documents the focus, content, and principal objectives of the overall DoD science and technology efforts. This plan provides a sound basis for acquisition decisions and is structured to respond to the DDR&E emphasis on rapid transition of technology to the operational forces. A separate DTAP annex includes an assessment of the potential technology capabilities of other countries vis-à-vis the United States.

Defense Technology Objectives (Reference 7). The focus of the S&T investment is enhanced and guided through Defense Technology Objectives (DTOs). Each DTO identifies a specific technology advancement that will be developed or demonstrated, the

anticipated date of technology availability, and the specific benefits resulting from the technology advance. These benefits not only include increased military operational capabilities but also address other important areas, including affordability and dual-use applications, that have received special emphasis in the *Defense Science and Technology Strategy*. Each DTO also identifies approximate funding required to achieve the new capability. Because funding for each program element has been rounded to the nearest $100,000, totals for each DTO do not reflect precise investment.

This document contains descriptions of nearly 350 DTOs. Two-thirds of these are identified in the DTAP, which cites the anticipated return on the S&T investment through 10 broad technology areas. The remaining DTOs support the 10 JWCOs of the JWSTP.

The DTOs are presented in two sections—one for the JWSTP and one for the DTAP. JWSTP and DTAP DTOs are easily distinguished from one another by the letter(s) prefix to the DTO number: JWSTP DTOs have a single alpha character prefix and DTAP DTOs have a two-letter prefix that roughly corresponds to the title of the technology area (e.g., WE for Weapons). The DTO numbering sequence does not connote priorities.

The JWSTP and the DTAP document the focus, content, and principal objectives of the overall DoD technology efforts (budget categories 6.2 and 6.3). These plans are presented in separate documents under their respective titles.

This document concludes with four appendixes. Appendix A presents complete addresses and other pertinent data for each of the points of contact cited on the individual DTOs. Appendix B lists the titles of the program elements (PEs) and their associated projects. Appendix C lists the currently approved ACTDs, mapped to the appropriate DTO. Appendix D is a glossary of abbreviations and acronyms used in this document.

References

1. *Defense Science and Technology Strategy*, Director of Defense Research and Engineering, May 1996
2. *Basic Research Plan*, Director of Defense Research and Engineering, January 1997
3. *Joint Warfighting Science and Technology Plan*, Director of Defense Research and Engineering, February 1998
4. *Defense Technology Area Plan*, Director of Defense Research and Engineering, January 1997
5. *National Security Science and Technology Strategy*, National Science and Technology Council, 1995
6. *Joint Vision 2010*, Joint Chiefs of Staff, 1996
7. *Defense Technology Objectives of the Joint Warfighting Science and Technology Plan* and the *Defense Technology Area Plan*, Director of Defense Research and Engineering, February 1998

SECTION I

Defense Technology Objectives for the Joint Warfighting Science and Technology Plan

INFORMATION SUPERIORITY

Defense Technology Objectives
for the Joint Warfighting Science and Technology Plan

Information Superiority

A.02 Robust/Tactical/Mobile Networking I-2
A.05 Integrated Collection Management ACTD I-4
A.06 Rapid Terrain Visualization ACTD I-5
A.07 Battlefield Awareness and Data Dissemination ACTD I-7
A.09 Semiautomated Imagery Processing ACTD I-9
A.10 High-Altitude Endurance Unmanned Aerial Vehicle ACTD I-11
A.11 Counter–Camouflage Concealment and Deception ATD I-12
A.12 Information Dominance (C^2 Protect & Attack for I/O ATD) I-14
A.13 Satellite C^3I/Navigation Signals Propagation Technology I-16
A.14 Tactical Unmanned Aerial Vehicle ACTD I-18
A.16 Navigation Warfare ACTD I-19
A.17 Joint Task Force ATD I-20
A.20 Joint Warfighting Experiments I-22
A.21 Joint Power Projection/Real-Time Support I-24
A.22 Rapid Force Projection Initiative Command and Control TD I-26
A.23 C^4I for Coalition Warfare ACTD I-27
A.24 Unattended Ground Sensors ACTD I-29
A.25 Information Operations Planning Tool ACTD I-30
A.26 Information Assurance: Automated Intrusion Detection Environment ACTD I-31

A.02 Robust/Tactical/Mobile Networking

Objectives. Develop the technology to provide a high-bandwidth, robust, multimedia, theater-level communications networking infrastructure that can be rapidly deployed to support military operations requirements from the early entry phases and throughout the lifetime of a conflict. This DTO consists primarily of the Airborne Communications Node (ACN) and the Warfighter's Internet (WI) programs, along with supporting Army and Air Force technology-base programs. The technical objectives are to develop and demonstrate (1) for the ACN, a lightweight, multifrequency, communications switching payload for the Global Hawk UAV (DTO A.10); and (2) for the WI, the networking protocol technology using a UAV airborne communications payload as well as satellite relays that can provide warfighters with multimedia, high-bandwidth, Internet-type communications support in the mobile and hostile theater environment.

Payoffs. The payload will incorporate software-programmable radio technology and RF microelectromechanical systems (MEMS) to meet the following functionality: 20 channels of frequency-hopping SINCGARS, 20 channels of UHF that can be dynamically allocated between Have Quick or 5- or 25-kHz demand assignment multiple access (DAMA) surrogate satellites, 3 channels of Enhanced Position Location and Reporting System (EPLRS), 2 channels of Link–16, handheld services (includes simultaneous provision of 200 voice calls, 1.544 Mbps of Internet-like data, paging, and a 1.544-Mbps battlefield multicast), and 4 channels of tactical wideband relay (minimum of 1.544 Mbps each). All of these services are expected to be provided simultaneously. The airborne payload will enable over-the-horizon connectivity for isolated and rapidly maneuvering forces and enhance rapid force projection, synchronization, and synergy of joint early entry forces to achieve improved battle command coherency. This technology will support the Advanced Battlespace Information System's (ABIS's) requirement of collaborative situation assessment and planning for forces enroute and on the move. With the achievement of this DTO, responsiveness of interactive sessions or imagery transfers on the battlefield will take place in seconds rather than in minutes or hours, even under the most stringent conditions of user demand.

Challenges. Among the technical challenges facing development and deployment of an airborne communications node are the critical issues of spectrum availability, frequency allocation, and frequency supportability. Added to this are the difficult issues of EMC, EMI, and cochannel radio interference (CRI), which are greatly compounded by the number of simultaneous channels required to provide the desired level of support to the warfighter. The complexity of the payload functionality is borne by the communications controller and further compounded by security management issues. Other technical challenges include the development of the airborne network structure to provide dynamic voice and data routing to thousands of disbursed subscribers in mobile, wireless, asymmetric environments. To ensure high-quality service, this will require multicasting and statistical multiplexing algorithms for dynamic bandwidth allocation (10X-1,000X increase) and integrated multimedia services.

Milestones/Metrics.

FY1998: Develop a laboratory or simulator demonstration of self-organizing airborne backbone at 128 kbps for multiple users (more than five) using multicast software.

FY1999: Perform initial airborne backbone laboratory demonstration. Complete payload systems design and initiate development and integration. Perform laboratory demonstration of controller for high-speed transfer (100 Mbps to 1 Gbps). The Range Extension project will provide an SHF full-duplex connectivity with a remote mobile location using an airborne hub switching among a minimum of four terrestrial terminals at T–1 rates. The DBC ATD Airborne Relay will demonstrate an X-band, DS–3 (45-Mbps full-duplex link) UAV payload.

FY2000: Achieve receiver/transmitter antenna delivery and laboratory demonstration and test. Initiate system integration and demonstration of form, fit, and function parameters.

FY2001: Perform Global Hawk integration test to demonstrate end-to-end mobile RF networking system of a tactical, mobile internetwork using components interoperating with legacy systems, with bandwidth greater than 100X, and 100 user terminals. Perform field demonstrations; demonstrate full complement of capabilities, including gateway, bridging, and relay/range extensions.

Customer POC	**Service/Agency POC**		**USD(A&T) POC**
COL Neil Putz, USA	Dr. Matthew Ganz	Mr. Daniel McAuliffe	Mr. Iftikhar Jamil
Joint Staff (J6T)	DARPA/STO	AFRL	DDR&E(IT)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602702F	4519	0.8	0.6	0	0	0	0
0602782A	AH92	1.2	0	0	0	0	0
0603006A	247	2.1	3.7	0	0	0	0
0603006A	257	0.5	0.5	0	0	0	0
0603760E	CCC-02	11.1	21.0	18.2	11.4	0	0
0603761E	CST-02	5.8	15.0	15.0	0	0	0
	Total	**21.5**	**40.8**	**33.2**	**11.4**	**0**	**0**

A.05 Integrated Collection Management ACTD

Objectives. Provide an initial capability for visualization, strategy to task planning, dynamic retasking, and status feedback. The Integrated Collection Management (ICM) ACTD will concentrate on space and airborne collection of imagery and SIGINT. Provisions will be made for other "INTs" and other platforms to be added in the future.

Payoffs. The goal is to develop an ACTD that demonstrates ICM of SIGINT and IMINT national and theater sensors to optimize collection for the Joint Task Force (JTF). Other platforms and sensors will be included in the planning process for later insertion. The ACTD will address collection management for integration of national and airborne systems at the JTF level, provision of tasking-level data and status feedback to the JTF, dynamic integrated tasking of sensors from all-source strategies and cross-cueing of collection assets, and tasking inside friendly and enemy operating cycles (less than 24 hours, goal of 2–4 hours). Measures of merit will be based on establishment of assured collection for support to operations (routine use of intelligence, surveillance, and reconnaissance data in operational planning; accuracy and timeliness of tasking, status, and feedback data; impact of improvements on operational tasks (more timely and accurate geolocation for strike operations, etc.); and more accurate situation awareness of operational and collection nodes).

Challenges. Cooperation and participation by requisite stovepipe systems.

Milestones/Metrics.

FY1998: The second prototype will be completed.

FY1999: Complete a third prototype that has more dynamic integrated tasking and cross-cueing and improved intelligence cycle times.

FY2000: Complete a fourth prototype that demonstrates improving capability.

FY2001: Final delivery of the system is planned.

Customer POC	Service/Agency POC	USD(A&T) POC	
Mr. Chris Jackson	Ms. Marsha Hart	Dr. Charles Perkins	Mr. Iftikhar Jamil
USACOM	DIA	ADUSD(SP)	DDR&E(IT)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
S&T Funding							
0603750D	P523	1.1	1.2	1.0	1.0	0	0
Total S&T		**1.1**	**1.2**	**1.0**	**1.0**	**0**	**0**
Non-S&T Funding							
03E05884L	010012	1.4	1.4	1.9	0	0	0
Total Non-S&T		**1.4**	**1.4**	**1.9**	**0**	**0**	**0**

A.06 Rapid Terrain Visualization ACTD

Objectives. Develop and demonstrate rapid collection and generation of high-resolution (up to 1-m grid spacing) digital terrain elevation data using imagery from aircraft and satellite platforms to generate terrain feature data and map backgrounds. The Rapid Terrain Visualization (RTV) ACTD will provide and leave behind computer workstations and applications software to (l) generate high-resolution terrain databases, (2) accept high-bandwidth data feeds for remotely processed information, (3) analyze courses of action using mission planning and embedded wargaming software, and (4) conduct mission rehearsals. This ACTD also will provide a tool for exploring warfighting concepts and doctrine. Four elements will be integrated in this ACTD: source data collection, digital terrain database generation and tailoring, database dissemination, and applications software. Six parameters will be evaluated: rapid access to archived terrain data and imagery; rapid collection of high-resolution terrain elevation data and multispectral imagery using a tactically viable platform; rapid generation of digital terrain databases including semiautomated extraction of selected terrain features; tailoring of terrain databases to meet specific user needs; a hierarchical spatial database management system that will accommodate dynamic revisions and provide users quick access to data sets optimized for their needs; and mission planning, rehearsal, course-of-action analysis, and embedded wargaming software to enable the commander to determine mission approach and to monitor execution of that mission.

Payoffs. The goal of this ACTD is to demonstrate and leave behind the ability to rapidly collect source data and generate high-resolution digital terrain databases to support crisis response and force projection operations. The timelines identified by the warfighter are an area of 20 x 20 km in 18 hours, 90 x 90 km in 72 hours, and 300 x 300 km in 12 days. The RTV ACTD also will demonstrate capabilities for the commander to integrate these terrain databases with current situation data. This integration will permit manipulation and display of the integrated databases to determine how to achieve the JTF's objectives and to visualize the desired end state. By FY98, the program will demonstrate a capability to merge multiresolution elevation and feature data with real-time tactical databases, and demonstrate on a prototype battlefield visualization system. It will generate tailored databases for visualization workstations. By FY99, the goal is to demonstrate an accelerated semiautomated terrain feature-extraction process and a capability to disseminate and integrate selected sets of intelligence, C^2, logistics, weather, situation awareness, and high-resolution terrain data. The FY00 goal is to demonstrate and leave behind an objective rapid battlefield visualization capability with XVIII Airborne Corps.

Challenges. Challenges include demonstrating the capability to deploy an all-weather, day/night IFSAR sensor on a U–2 aircraft for rapid generation of high-resolution digital terrain elevation data (DTED Level V = 1 meter); rapidly generate minimal essential feature data required for terrain analysis, mission planning, and execution; and achieve an automated transformation process to rapidly tailor terrain data for specific applications on legacy and evolving systems.

Milestones/Metrics.

FY1998: Demonstrate a capability to merge multiresolution elevation and feature data with real-time tactical databases; demonstrate on a prototype battlefield visualization system.

FY1999: Demonstrate an accelerated semiautomated terrain feature-extraction process and a capability to disseminate and integrate selected sets of intelligence, C^2, logistics, weather, situation awareness, and high-resolution terrain data.

FY2000: Demonstrate and leave behind an objective rapid battlefield visualization capability with XVIII Airborne Corps.

FY2001: Deliver final, enhanced version of objective rapid battlefield visualization capability.

Customer POC	**Service/Agency POC**	**USD(A&T) POC**	
COL Richard Zahner, USA	Mr. Chris Moscoso	COL John Fricas, USA	Mr. Iftikhar Jamil
525 MI Bde	Joint Precision Strike Office	DUSD(AT)	DDR&E(IT)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0603734A	T12	9.9	13.3	11.5	0	0	0
0603750D	P523	1.7	2.4	3.0	3.0	0	0
	Total	**11.6**	**15.7**	**14.5**	**3.0**	**0**	**0**

A.07 Battlefield Awareness and Data Dissemination ACTD

Objectives. Integrate and demonstrate information management and battlefield awareness technologies that will allow operational users to easily assess and exploit an expanded, massive information flow and for commanders to manage it. The combination of an explosive growth in battlefield sensing (e.g., Predator, Global Hawk), combined with the growth of wideband communications capabilities (e.g., DSS, GBS, ACN), will result in the ability to push thousands of times as much data to the warfighter. The right awareness services can mean the difference between providing increased battlefield awareness or drowning users in information overload. Battlefield awareness and data dissemination (BADD) will provide information profiling services that allow users to specify and control the flow of information into their forward sites; policy management services that allow commanders to manage information flows; and wideband delivery services that allow these services to operate across high-bandwidth broadcast links. These information management and battlefield awareness services will be delivered as defense information infrastructure common operating environment (DII COE)-compliant software modules to facilitate the transition process.

Payoffs. This DTO will provide the capabilities for forward warfighters to access and use very large information products that were previously inaccessible to them and to seamlessly integrate these products with emerging 3D visualization applications such as rapid terrain visualization (RTV), Joint Situation Awareness System (JSAS), and Global Command and Control System (GCCS) migration integrated database/imagery product archive. It will also provide the commander with the ability to maintain battlefield awareness from forward and moving command sites and to manage the information flows in their battlespace based on their operational priorities.

Challenges. Major challenges include constructing the proper framework for making information management services independent of the communications and transport medium, developing the proper schema for efficient profile management, developing a profile aggregation process that can scale up to thousands of users, creating policy management services that are consistent with and supportive of military operational command structures, and incorporating security features that address coalition operations and information assurance.

Milestones/Metrics.

FY1998: Stand-Up CONUS Pilot Service that provides near-real-time delivery of imagery, geo, and video products (hundreds to thousands of times faster) (Oct '97); demonstrate joint information management profiling tools across services at JTFEX–98–1 (improved interoperability, a 10X–100X increase in field-available information sources) (Jan '98); demonstrate policy management services (50 or more simultaneous sessions) and battlefield awareness services (integrating at least 10 information categories) at UFL98 (U.S. Forces Korea exercise).

FY1999: Deliver and demonstrate software-only version of BADD services (up to 99% reduction in forward-based hardware and software footprint); sustain PACOM/USFK.

FY2000: Extend BADD services to EUCOM; sustain PACOM/USFK.

Customer POC	Service/Agency POC	USD(A&T) POC	
Lt Col James Dorman, USAF	Mr. Robert Beaton	Mr. Tom Perdue	Mr. Marshall Potter
USACOM/J62	DARPA/ISO	DUSD(AT)	DDR&E(IT)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0603750D	P523	4.5	2.4	2.0	0	0	0
0603760E	CCC-02	43.2	6.0	5.1	0	0	0
	Total	**47.7**	**8.4**	**7.1**	**0**	**0**	**0**

A.09 Semiautomated Imagery Processing ACTD

Objectives. Provide the image analyst with the tools needed to rapidly analyze high-volume reconnaissance and surveillance imagery, and permit the rapid generation of reports and image products in support of the theater, JTF, or component commanders' requirements. Semiautomated imagery processing (SAIP) will integrate template-based SAR automatic target recognition (ATR), cluster analysis, object-level change detection, interactive target recognition, EO and SAR site monitoring, and force structure into an integrated imagery exploitation capability. The SAIP demonstration capability will grow from initially supporting current U–2 Advanced Synthetic Aperture System (ASARS)–2 sensor resolutions to support the higher resolution and data rates associated with the U–2 ASARS–2 improvement program and Global Hawk high-altitude UAV programs. Key technologies being pursued by SAIP in the baseline (FY97) capability include real-time SAR image/image registration, high-definition imaging, object-level change detection, terrain analysis, cluster analysis, template-based ATR, and advanced tools for human–computer interface (HCI). Key technologies being pursued by Enhanced SAIP (FY98) include real-time SAR image/map registration, real-time EO image/map registration, real-time EO image/image registration, model-based ATR techniques, force structure analysis, site monitoring (EO and SAR), and offline site modeling.

Payoffs. The goal of this effort is to make imagery a more responsive resource for the tactical commander, thus providing dominant battlespace awareness by focusing theater and tactical sensor exploitation, tactical surveillance, and site monitoring on critical, timely intelligence requirements. The program will increase imagery analyst efficiency in exploiting large volumes of image data produced by current theater and future tactical imaging platforms. The system will aid the analyst in detecting and recognizing isolated targets and recognizing force structures (e.g., maneuver battalions) at significantly reduced false alarm rates. The goal of 0.9 probability of target detection will reduce exploitation timelines for SAR imagery from 15 to 2 minutes per image. This will enable image analysts to exploit more data in shorter timelines and will support the high-volume imagery data feeds that will be supplied by planned reconnaissance and surveillance platform upgrades.

Challenges. The SAIP ACTD must provide an integrated set of automated imagery analysis tools capable of operating at real-time rates. Technical challenges to be overcome include (1) development of an appropriate COTS-based, real-time hardware/software architecture; (2) selection, identification, modification, and tuning of appropriate ATR and image understanding algorithms; (3) integration of operational sensor feeds (with their associated image artifacts, geo-referencing errors, and dynamic range limitations); (4) ingestion of sensor feeds at continuous, operational data rates; and (5) provision of a consistent, efficient HCI to the analyst. These tasks must be performed with high probabilities of detection (system goal, $P_d = 0.9$) and very low false alarm rates.

Milestones/Metrics.

FY1998: Complete integration of the enhanced configuration. Add both SAR and EO site monitoring capabilities, enhanced force structure analysis tools, and 10 additional target sets. Demonstrate a laboratory working model. Evaluate SAIP in field exercises under USACOM sponsorship. Demonstrate SAIP functionalities with the CARS MIS upgrade at the Flight Test Facility, Palmdale, CA. Achieve Enhanced SAIP capability of 20-target capability at Global Hawk data rates.

FY1999: Achieve Residual SAIP capability of 30-target capability at Global Hawk data rates. USACOM will conduct a final operational assessment demonstration of the SAIP system. The Residual configuration will be stood up and tested at a CONUS site. The system will be used by military operators as required.

Customer POC
Ms. Patricia Moore
USACOM J-2

Service/Agency POC
Mr. Stephen Welby
DARPA/ISO

USD(A&T) POC
Dr. Judith Daly
ADUSD(AD)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
S&T Funding							
0603750D	P523	2.3	2.3	0	0	0	0
0603762E	SGT-04	24.5	9.5	0	0	0	0
Total S&T		**26.8**	**11.8**	**0**	**0**	**0**	**0**
Non-S&T Funding							
035102BQ	None	4.1	0	0	0	0	0
Total Non-S&T		**4.1**	**0**	**0**	**0**	**0**	**0**

A.10 High-Altitude Endurance Unmanned Aerial Vehicle ACTD

Objectives. Develop and demonstrate a joint, adverse-weather, long-endurance, wide-area, day/night reconnaissance and surveillance capability in both a low-observable and a conventional configuration. Operationally, the High-Altitude Endurance Unmanned Aerial Vehicle (HAE UAV) system will provide continuous, broad-area surveillance over the battlefield with real-time connectivity to existing service exploitation centers.

Payoffs. Upon successful completion of this program in FY00, a new airborne reconnaissance capability will exist that will enable replacement of current U–2 and SR–71 systems with Global Hawk and DarkStar UAV systems. These systems will provide unprecedented long-dwell battlefield coverage at substantially lower O&S costs than current manned reconnaissance systems.

Challenges. Both DarkStar and Global Hawk employ predominately commercial, mature, off-the-shelf technologies, consistent with the execution of an ACTD. The challenge in this program is not new technology development but rather engineering a complete airborne reconnaissance capability for a stated, and somewhat stressing, unit flyaway price (UFP). In both cases, the target production UFP for aircraft and sensors is $10 million.

Milestones/Metrics.

FY1998: Initiate developmental flight testing.

FY1999: Complete developmental flight testing; initiate ACTD operational demonstrations.

FY2000: Complete ACTD and transition into further P^3I development and production.

Customer POC	**Service/Agency POC**	**USD(A&T) POC**
LtCol John Wellman, USMC	Mr. Charles Heber	Lt Col Marty Meyer, USAF
USACOM/J-RC/J-33	DARPA/TTO	DUSD(AT)

Non-S&T DTO Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0305205D	P804	96.0	64.6	19.1	0	0	0
0305205D	P805	54.6	37.9	4.5	0	0	0
	Total	**150.6**	**102.5**	**23.6**	**0**	**0**	**0**

A.11 Counter–Camouflage Concealment and Deception ATD

Objectives. Provide the warfighter the ability to detect and classify targets obscured by foliage and tactical deception techniques. The current theater surveillance and reconnaissance suite lacks the capability to reliably detect counter–CC&D (camouflage, concealment, and deception) targets or to penetrate any level of foliage. A significant outcome will be a concept of operations (CONOPS) for the use of this class of sensors on the Predator and Global Hawk UAVs and integration of the image exploitation capability on the battlefield into the semiautomated IMINT processing common integrated ground/surface system (CIGSS) architecture being developed under DTO A.09, SAIP ACTD.

Payoffs. The capability afforded by this ATD is essential to achieving dominant battlefield awareness, as there is no current capability to detect and cue targets under any significant foliage concealment. From a sensor aspect, it focuses on a foliage-penetrating (FOPEN) radar (VHF or UHF) on the high-altitude Global Hawk UAV and the use of hyperspectral imaging (HSI) on medium-altitude Predator platforms to detect and identify obscured and camouflaged targets. Integration of additional sensor modalities into the CIGSS architecture will provide the warfighter more timely, higher confidence IMINT for both intelligence and operational utilization. Completion of this DTO will be via satisfactory transition to Global Hawk as an advanced payload in FY02.

Challenges. The quantitative FOPEN ATD challenge is to demonstrate less than one false alarm (FA) in 10 km^2 at a 25-km range on a manned demonstrator for targets in foliage or under tactical camouflage. For the FOPEN radar, a significant challenge exists for obtaining onboard processing at 20 km^2/min so that the detected images can be transmitted down the narrowband (50 Mbps) datalink. The preferred FOPEN radar frequency, the wavelength and number of bands required for HSI, and the ability to geolocate and register images must be determined to size the ground exploitation technology and obtain a combined one FA in 100 km^2. The radar capability will be capable of 85% form, fit, and function for integration into the Global Hawk UAV to provide coverage out to a 50-km standoff range upon completion of the DARPA FOPEN ATD.

Milestones/Metrics.

FY1998: Validate near-real-time target detection and cueing (20 km^2/min) in SAIP architecture.

FY1999: FOPEN SAR on manned demo platform at 85% form, fit, and function of the Global Hawk UAV.

FY2000: CONUS test at 20 km^2/min FOPEN and HSI collection rate in CIGSS architecture.

FY2001: User-defined EUCOM real-time ATD (one FA in 100 km^2) in CIGSS architecture

FY2002: Transition to users via integration into Global Hawk advanced payload.

Customer POC	Service/Agency POC		USD(A&T) POC
LTC James Burch, USA JRC, EUCOM	Dr. Mark Davis DARPA/STO	Mr. Kirk Willey CECOM, NVESD	Dr. Graham Law ADUSD(TSI)
COL William Knarr, USA TM TRADOC	Mr. Dennis Mukai AFRL		

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0603762E	SGT-04	22.7	25.0	20.0	10.0	10.0	0
0603772A	243	0.4	1.6	2.5	2.3	0	0
0603203F	665A	0.6	2.5	2.5	3.0	0	0
	Total	**23.7**	**29.1**	**25.0**	**15.3**	**10.0**	**0**

A.12 Information Dominance (C^2 Protect & Attack for I/O ATD)

Objectives. Execute an ATD that will develop, integrate, and validate hardware, software tools, tactics, techniques, and procedures for securing the systems and networks of the Army's Tactical Internet (TI) and the First Digitized Division. The ATD will provide new operational capabilities in the areas of advanced network access control, secure tactical network management, auditing, intrusion detection, and response mechanisms. It will also leverage information from interactive testing of the protection systems and develop attack tools, techniques, and applications that will be integrated into existing or emerging intelligence and electronic warfare systems/platforms to achieve the Army's goal of information dominance. Initial emphasis will be primarily on the TI, Mobile Subscriber Equipment (MSE) and the First Digitized Division; however, some tools developed under this ATD will also be used to secure the strategic and sustaining/fixed-base systems and networks. Ongoing projects and technologies that feed this ATD include existing public and private sector efforts. Capability objectives to be maintained over multiple years as additional systems/threats are added include *intrusion detection*—detection of existing attack signatures 90% of the time and of BC anomalous behavior 75% of the time; *network access control*—resistance to basic dictionary attacks 95% of the time and prevention of unauthorized access to the TI from external network connection 80% of the time; *code modification*—detection of unauthorized modification of system software 95% of the time; *tool integration*—limit overhead to <10% of existing TI performance.

Payoffs. The deployment of a fully digitized force will make information warfare an essential aspect of combat operations. The explosive proliferation of information-based technology will have a significant impact on all phases of military operations in the future. Reliance on these technologies creates dependencies and vulnerabilities, resulting in new requirements for defensive and offensive information warfare capabilities. Utilization of the same technologies by our adversaries also creates vulnerabilities that can be exploited, thus providing an enormous advantage to our warfighters. The greatest payoff will be providing the ability to maintain a comprehensive and unified protect and attack information warfare capability that will render the decisive edge to our forces.

Challenges. The rapid and revolutionary nature of commercial hardware and software products in the area of information technology creates many challenges for adaptation into highly mobile, narrowband, tactical communications systems. The primary challenge is to evaluate, adapt, and integrate COTS or GOTS protection products that can reside on the network or host without imposing a high overhead or creating bottlenecks. Due to the large quantities of hardware and software tools that will be required to secure the systems and networks, across the force, recommended solutions must be affordable, maintainable, and sustainable. Ease of use and training are also major considerations. Evolving technical and operational architectures associated with the fielding of a fully digital force will require continuous vulnerability testing, evaluation, and validation of the integrated products/tools, tactics, policies, and procedures. As new computers, software capabilities, and applications are developed, the security of the fielded systems will have to be evaluated and validated through the use of state-of-the-art attack tools.

Milestones/Metrics.

FY1998: To the extent possible, integrate the tools demonstrated in TFXXI in division systems for participation in DIV XXI AWE (Nov '97). Tools identified for the Army toolkit will be evaluated for applicability; those found acceptable will be integrated in the systems that will participate in the FBCB2 limited user test scheduled for the fourth quarter FY98. By end of FY98, a security architecture for the Army's TI will be developed as a recommendation for the 1st Digitized Division.

FY1999: Integrate COTS and GOTS tools adapted for the tactical applications in the ABCS and other systems for participation in the First Digitized Division JOT&E, 4Q99.

FY2000: Extend security architecture to include MSE; conduct a field test/demonstration (exercise with the First Digitized Division) for RF attack against threat information systems.

FY2001: Conduct a laboratory experiment that demonstrates a unified protect and attack capability and a proposed architecture.

FY2002: Integrate protect and attack tools on the systems of the First Digitized Division; demonstrate a unified protect and attack capability in an AWE; revise the security architecture and extend down to include small unit operations. Additional metrics have been established and are classified.

Customer POC	**Service/Agency POC**	**USD(A&T) POC**
Mr. Nick Keselowsky	LTC Ed Hillenbrand, USA	Mr. Iftikhar Jamil
PEO, C^3S	RDEC	DDR&E(IT)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602120A	140	0.3	0.3	0.3	0.3	0	0
0602270A	906	0.3	0	0	0	0	0
0602782A	779	0.3	0	0	0	0	0
0602782A	H92	0.5	3.5	0.4	0.4	0.5	0
0603006A	247	0	1.0	3.0	3.0	3.6	0
0603270A	K15	0.4	1.1	4.3	4.1	1.2	0
	Total	**1.8**	**5.9**	**8.0**	**7.8**	**5.3**	**0**

A.13 Satellite C^3I/Navigation Signals Propagation Technology

Objectives. Develop technology to provide reliable real-time specifications and forecasts of ionospheric conditions and disturbances and their effects on communications, surveillance, and navigation systems (including GPS). To achieve this, other key objectives must be met, including identification of the key ionospheric parameters that must be imbedded in C^3I operational models; characterization of the physical processes that trigger ionospheric disturbances that spread out to almost global proportions, causing severe disruptions (even blackout) of C^3I operations; development of new ground- and space-based (battlespace) environmental sensors; and validation of real-time, sensor-driven, operational ionosphere specification and forecast models. A focus of this DTO is on equatorial ionosphere disturbance effects, owing to the geopolitical importance of that region. In the near term, the exploitation of existing ground-based ionospheric sensing data, coupled with the Scintillation Network Decision Aid (SCINDA) being developed as part of this DTO, will lead to greatly improved specifications of the battlespace environment. A mid-term goal is to fly the Communications/Navigation Outage Forecasting System (C/NOFS), an instrumented satellite to provide in situ, real-time, ionospheric data, to improve ionospheric specifications and forecasts. The long-term goal is to couple ground- and space-based sensor data with efficient numerical models to provide the required specifications and forecasts of the battlespace environment.

Payoffs. By providing accurate ionospheric specifications, radio frequencies, modulation schemes, data rates, and other system parameters can be set to match what the prevailing ionosphere will allow. Timely, reliable, advance warnings of disruptive ionospheric (scintillation) disturbances will allow operators to adjust system parameters to mitigate those effects and, if necessary, switch to backup systems to ensure uninterrupted C^3I operations. Current operational capabilities for ionospheric disturbance specification and forecasting, limited by their 50% accuracy, do not meet mission requirements.

Challenges. A thorough understanding of polar and equatorial ionospheric dynamics and variability based on comprehensive measurements must be established. A major challenge is to identify mechanisms that trigger severe disruptions in both the polar and the equatorial ionosphere that spread out over large areas and cause severe disruptions (even blackout) to C^3I systems.

Milestones/Metrics.

FY1998: Obtain experimental data and quantify the effects of equatorial ionosphere (scintillation) disturbances on SATCOM and GPS radio signals. This will lead to a 50% improvement in the accuracy of specifying C^3I/GPS-navigation system outage conditions.

FY1999: Quantify the impact of ionospheric disturbances on MILSATCOM for Middle East locations. This will result in a 75% improvement in MILSATCOM connectivity specifications.

FY2000: Complete development of C/NOFS satellite (ionospheric) sensors; upgrade ground-based SCINDA network to incorporate satellite sensor data as it becomes available.

FY2001: Launch C/NOFS satellite for in situ monitoring and warnings of ionospheric conditions that will disrupt C^3I/GPS navigation systems and operations.

FY2002: Validate operational sensor-driven models to assimilate C/NOFS data to specify and forecast equatorial ionospheric disturbance conditions.

FY2003: Validate radio wave propagation prediction models used to evaluate and correct for the effects of the ionosphere on the performance of space-based radars.

Customer POC		Service/Agency POC	USD(A&T) POC
Mr. Jack Miller	Maj Michael. Volek, USAF	Dr. Edward Weber	Col Alan Shaffer, USAF
AFSPC/SCZ	AFSPC/XPX	AFRL/VSB	DDR&E(SEBE)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602601F	1010	2.2	2.2	2.2	2.3	2.6	2.7
0603410F	2822	0.9	0.5	0.2	0.1	0.1	0
	Total	**3.1**	**2.7**	**2.4**	**2.4**	**2.7**	**2.7**

A.14 Tactical Unmanned Aerial Vehicle ACTD

Objectives. Provide the Army brigade, USMC Marine Air Ground Task Force, and Navy commanders with a dedicated UAV system that delivers timely, accurate, and complete targeting and other battlefield information to their units in near real time (i.e., military utility).

Payoffs. The TUAV system consists of ground control equipment, one remote video terminal to provide payload information in the area of operation, four modular mission payloads, communications devices, four air vehicles (a means of launch and recovery), and one mobile maintenance facility for every three TUAV systems.

Challenges. Failed heavy fuel engine (HFE) effort transferred outside of ACTD, but suitable HFE engine remains critical for maritime application of TUAV. Outrider air vehicle development proceeding much slower than scheduled, putting system deliveries and military utility assessment at risk to meet a 2 May 1998 ACTD completion. FY98 Outrider program funding was transferred to the Army. An FY97 $20 million rescission of funding may have to be offset (in whole or in part) by Outrider. Estimated costs to complete the ACTD continue to grow.

Milestones/Metrics.

FY1998: Program will be completed. Significant accomplishments will include completion of an MUA at III Corps, Fort Hood, TX, that will focus on land-based applications. Four USMC UAV operators will participate. Also, a sea demonstration will be held in 3Q98 to demonstrate range and endurance plus autoland and takeoff distance repeatability. For ILS planning purposes, a TUAV system for the Navy produced during full-rate production would consist of eight air vehicles and modular mission payloads, as well as maintenance facilities configured to the specific ship.

Customer POC		Service/Agency POC	USD(A&T) POC
MAJ William Gladbach, USA USA DCSOPS	Maj Mark King, USMC Navy-N8	COL Michael Howell, USA UAV Joint Project Office	COL John Fricas, USA DUSD(AT)

Maj Damien Lott, USMC
HQ USMC (APW-61)

Non-S&T DTO Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0305154D	P801	38.8	0	0	0	0	0
	Total	**38.8**	**0**	**0**	**0**	**0**	**0**

A.16 Navigation Warfare ACTD

Objectives. Provide a limited number of GPS protection (enhanced receivers) and prevention (jammer) assets to the operational warfighter for the independent assessment of military utility, and assist the warfighter in the development of future GPS requirements.

Payoffs. Through the assessment of military utility of the assets produced by this ACTD in operational training exercises, high-technology equipment is developed and refined at a much faster rate than normal acquisition.

Challenges. GPS denial activities within CONUS have been conducted to a small extent on developmental test and evaluation ranges. The denial of GPS in some areas of CONUS is likely to pose considerable challenges for the ACTD and future navigation training, exercising, and testing because of the dual use of the GPS signals by both the civil and the military communities.

Milestones/Metrics.

FY1998: Delivery and exercise of enhanced handheld GPS receivers (Oct '97).

FY1999: Participation of advanced avionics GPS receivers in operational exercises (Apr '99).

Customer POC	**Service/Agency POC**	**USD(A&T) POC**	
Maj Kirk Little, USAF	Maj Joseph Lortie, USAF	Dr. Charles Perkins	Mr. Marshall Potter
USACOM/J362D	GPS JPO	ADUSD(SP)	DDR&E(IT)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0603750D	P523	4.4	0.4	0	0	0	0
	Total	**4.4**	**0.4**	**0**	**0**	**0**	**0**

A.17 Joint Task Force ATD

Objectives. Demonstrate how advanced information processing technology can provide a deploying commander, Joint Task Force (JTF) with a rapid crisis response capability for a range of situations, from major regional conflicts to operations other than war. The program develops advanced processing concepts to support a geographically dispersed staff in crisis management. Concepts include an architecture and infrastructure, software tools, applications, and repository that can be integrated to form the foundation of a next-generation JTF C^4I capability for planning, execution, and management of joint force operations in the areas of logistics, transportation, weather, and communications. Technologies supporting this development include Common Object Request Broker Architecture (CORBA), object-webs, adaptive objects, C^2 schema, bandwidth adaptive networking, distributed collaboration, mobile code, and modeling and simulation.

Payoffs. The JTF ATD will provide the warfighter a scaleable, joint distributed, collaborative, crisis planning, replanning, and execution system providing enhanced collaboration, visibility, and common perception of the battlespace. Specific technology advancement will be achieved in applications and tools that, when combined, form a series of anchor desks (weather, transportation, and communications) and toolkits (JTF planner and Air Campaign Planning Toolkit (ACPT)) providing common information services. They include a series of information servers: a communications server to provide adaptive and dynamic bandwidth facilitating collaboration, sharing, and information retrieval; a map server for mapping tools; a data server for query-based views of distributed, heterogeneous databases; a web server to exploit web technologies; a situation server for complex situation interpretation; a plan server for course-of-action development; and a model server for simulation modeling. The ATD will develop an object repository and schema to provide access to consistent C^4I and planning processes to which new objects can be easily added. The combination of the applications, servers, schema, and architecture is termed the Joint Planning System (JPS). The JTF ATD is envisioned to afford significant operational payoff, with goals of 100X faster dynamic planning and 10X more options than present systems, 15 minutes to learn to use, and rehearsal and refinement enroute.

Challenges. Challenges include definition of an architecture for system interoperability, integration, and bandwidth agility across multiple and disparate military communities involved in joint planning. Established on that architecture is the development of servers and applications offering functionality with scaleability, extensibility, and interoperability for present and future needs. To support the servers and applications, a flexible schema and supporting infrastructure to provide a common base among current and future programs employing the reference architecture had to be developed. The environment itself is challenging in that it pioneers object-oriented development for maximum code portability, with the developer community distributed across multiple organizations and locations. Adding to the challenge is the implementation of a multi-ORB (object request broker) approach to optimize system flexibility and performance to support future expansion, reuse, and evolvability by this and related programs.

Milestones/Metrics.

FY1998: Commence advanced anchor desk, services, and other expanded capabilities development; demonstrate initial execution and dynamic replanning functionality; extend architecture and support additional COTS ORB; demonstrate wide-area, near-real-time collaboration among planners from at least three sites operating on plans built from Web-based object repositories consisting of at least 1,000 objects.

FY1999: Demonstrate initial advanced execution and dynamic replanning functionality; demonstrate capabilities for collaboration among planners from at least 10 sites on object-web plans consisting of at least 2,500 objects.

Customer POC	Service/Agency POC	USD(A&T) POC
Mr. Jens Jensen	Dr. Refugio Delgado	Mr. Marshall Potter
USCINCPAC	DARPA/ISO	DDR&E(IT)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0603761E	CST-02	13.3	6.0	0	0	0	0
	Total	**13.3**	**6.0**	**0**	**0**	**0**	**0**

A.20 Joint Warfighting Experiments

Objectives. Achieve an open architecture end-to-end system that allows joint and coalition forces to rapidly configure and interconnect the right information resources in the right place at the right time. Information superiority is fundamental to *Joint Vision 2010*, of which information technology is a key enabler. In order to achieve and maintain force dominance in the 21st century, the emphasis on information technology development must shift from a platform-centric to a network-centric approach. The shift to an open architecture network-centric focus will allow the joint warfighter to achieve greater agility in responding to changes in threat and exploiting continuing advances in technology. The development of a global C^4ISR grid, or information technology (IT) backplane, in conjunction with a series of experiments, will provide the capability to more rapidly develop, evaluate, and integrate new sensor technologies, information systems, and engagement planning and execution systems.

Payoffs. A flexible and extensible open architecture will provide the joint warfighter with the ability to quickly configure and evaluate new and emerging tools, products. and concepts. In turn, this will provide increased battlespace awareness synchronized with combat operations resulting in maximizing effects, while decreasing dependence on massing of forces in order to dominate the battlespace. The IT backplane will be established and deployed using COTS hardware and existing software, incurring minimal cost in setup and operation. This will provide a state-of-the-art baseline upon which new prototypes will be evaluated and, if successful, deployed in the same type of environment. This reduces risk because new technologies can be exercised early, well in advance of development and fielding. Overall benefits of this DTO include cost-effective exercise of prototypes by the warfighter–acquisition–technology team early in the life cycle; the ability to test interoperability of prototypes with established legacy systems; early insight into the potential for increased joint combat power enabled by advanced information technology and concepts; better information system development and upgrade requirements; and more rapid insertion of information technologies. The JWEs provide a basis for the integration and demonstration of advanced technology for field experimentation and assessment of a system of systems within an operational environment. This leads to greatly improved understanding of the joint warfighting utility and value of the technology assessed in a realistic, joint operational context. While ACTDs rapidly prototype and transition technological solutions to specific threat scenarios, this DTO allows organization and doctrine to coevolve with the application of new technology.

Challenges. The close coupling of doctrine and technology has always been difficult to achieve. The combination of rapidly evolving threats and technologies, coupled with the continuing downsloping of the cost of technology and its availability to a greater number of potentially hostile nations, has created an urgent need to close the gap between doctrinal and technology evolution. By enabling the joint warfighter and service battle laboratory system to function as an integrated team to experiment with and quantify the impact of advanced technologies and concepts, this gap can be closed. The use of COTS and GOTS products will also help overcome the obstacles to achieving the information superiority required by JV 2010/ABIS.

Milestones/Metrics.

FY1998: Develop an IT backplane compliant with the joint technical architecture to provide an environment of existing information technology components into which prototype and other emerging products can be inserted, exercised, and evaluated with respect to interoperability and joint warfighting potential. A second milestone for FY98 will be development of a 5-year roadmap consisting of 18–20 information superiority experiments (ISXs) that cover Dominant Maneuver, Precision

Engagement, Full-Dimension Protection, and Focused Logistics. A third major milestone will be execution of two ISXs.

FY1999: Design and field five ISXs that collect various emerging S&T capabilities and that vary across all three of the Sensor, Information, and Engagement Grids. Analysis, feedback, and technology transition will again be integral components of the activity. Advanced concepts for a single-threaded end-to-end joint warfighting experiment (JWE) will also begin.

FY2000: Develop a comprehensive JWE to seamlessly integrate the three grids with other warfighter experiments. Analysis of the component ISXs and JWE will be fed back to the user organizations. The IT backplane will be incrementally improved with emphasis on dynamic load balancing and system reconfiguration. The process of transitioning joint warfighting programs to user organization(s) will continue.

FY2001: Expand and improve the IT backplane based on lessons learned from the single-threaded ISX; conduct three additional small scale ISXs (for the three grids) focusing on improved scalability across communications, processing, storage, and security.

FY2002: Include end-to-end ISXs in a second large-scale JWE, with results fed back to user organizations to support incremental improvements for coevolving organization and doctrine with the application of new technology.

FY2003: Expand and improve the IT backplane; conduct three additional technology-specific ISXs (the three grids) focusing on improved information protection and increased robustness.

Customer POC
Col Dan Ryan, USMC
J6

USD(A&T) POC
Dr. Ann Miller
DDR&E(IT)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0603727D	P727	8.3	23.7	27.3	30.2	29.9	30.8
	Total	**8.3**	**23.7**	**27.3**	**30.2**	**29.9**	**30.8**

A.21 Joint Power Projection/Real-Time Support

Objectives. Provide ability to address fleet requirements for C^{4}ISR technology development and demonstration leading to warfighter evaluation and early implementation. Joint power projection/real-time support (JPP/RTS) elements have participated in joint and national exercises, been installed in service platforms, and been operationally deployed. Primary focus areas are (1) sensor-to-shooter use of real-time data for mission execution and targeting; (2) next-generation shipboard C^{4}ISR system definition; and (3) network-centric battle management for distributed collaborative planning and execution.

Payoffs. JPP/RTS is collaborative with Navy, joint, and national programs to reduce risk and achieve interoperable solutions. Technology project areas within the Navy project include the Airborne Tactical Information Management System (ATIMS), which provides automated in-flight, in-cockpit mission management capabilities including threat updates, retargeting, rerouting, and improved situation; Tactical Advanced Situation Display (TASID), which provides tactical units with direct access to nonorganic sensors to extend their surveillance and targeting capabilities; Advanced Power Projection Planning and Execution (APPEX), which provides improved mission planning, coordinating weaponeering, targeteering, routing, weapon target allocation, and rapid and interactive planning between the operational commander and his tactical forces from initial buildup through the cessation of hostilities; and Scaleable High-Performance Local Area Network (SHPL), which provides high-capacity asynchronous transfer mode (ATM) communications compatible with the Joint C^{4}ISR backbone. Two SHPL installations exist, one aboard USS *Theodore Roosevelt* (CVN–71) and one at Naval Strike and Air Warfare Center (NSAWC) Fallon.

Challenges. The challenge is to evolve an aggregation of requirements and integration of a variety of functions into a cohesive, interoperable C^{4}ISR capability. Developing effective C^{4}ISR technologies requires understanding of joint and service systems and environments at a fundamental level. As a result, achieving the goals of this project necessitates a design, demonstration, and implementation strategy that can be tailored to a highly dynamic operational environment.

Milestones/Metrics.

FY1998: Conduct combat system/C^{4}ISR system experiment at NSWC Dahlgren. This experiment is designed to prove concepts and techniques for SC–21, including real-time targeting for advanced surface weapon systems within an integrated combat system/C^{4}ISR system, automated resource control, and use of a common computational environment responsive to the joint technical architecture and SC–21 requirements. Conduct combat search and rescue (CSAR) demonstration at NSAWC Fallon. This demonstration is structured to drive acquisition requirements for the HH–60R upgrade and to demonstrate interoperability with advanced shipboard and special warfare systems. The demonstration will employ modified ATIMS units that have flown in Sea Dragon-Hunter Warrior, modified Special Warfare Automated Mission System, and the Real-Time Retargetting Module at NSAWC. Conduct TASID demonstration at SPAWARSYSCEN. This demonstration will address information management of operational and intelligence data in a common display environment and serve to refine and validate designs for participation in RIMPAC 99 in conjunction with a national program.

FY1999: Conduct final C^{4}I Combat System Demonstration (CCSD) at NSWC to show full Combat Direction System (CDS) resource management based on time-critical information (partial integration of '97 demo; use of SPAWAR 3D display for Naval Surface Fire Support; full-up use of Link–16 and real-time ELINT); follow-on CSAR demonstration at NSAWC Fallon. Install TASID on three CG/DDG units in conjunction with Tactical Real-Time Targeting System (TARTS) and participation in "RIMPAC 99" exercise.

FY2000: Final ATIMS demonstration at NSAWC Fallon and Sea-Based Battle Lab to transition mission management technology insertion device with programmable digital electronics. Prototype demonstration of JMCIS tactical/mobile system incorporating ATIMS and TASID technology.

Customer POC	**Service/Agency POC**	**USD(A&T) POC**
Dr. Dale Uhler	CAPT John Vinson, USN	Mr. Iftikhar Jamil
CNO N6H	SPAWAR PD133A	DDR&E(IT)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0603794N	X2091	8.0	7.8	7.8	3.1	3.1	3.2
	Total	**8.0**	**7.8**	**7.8**	**3.1**	**3.1**	**3.2**

A.22 Rapid Force Projection Initiative Command and Control TD

Objectives. Demonstrate an integrated and enhanced sensor-to-shooter linkage so that the early entry light forces disrupt and defeat an enemy armor force before that force can bring its direct fire strength to bear. The technology demonstration will take place as an integral part of the Rapid Force Projection Initiative (RFPI) ACTD. The RFPI C^2 TD program is complete at the end of FY98. Sustainment, modification, and enhancement of RFPI C^2 TD-developed items during the residual period of the ACTD is the responsibility of the RFPI ACTD program. The RFPI C^2 TD has delivered to the Dismounted Battlespace Battle Lab, Fort Benning, the Light Digital Tactical Operations Center Simulator (LDTOC SIM) consisting of RFPI workstations containing appliqué, appropriate battlefield operating systems (e.g. AFATDS, MCS, FAADC^2, and ASAS), a local area network (LAN), and a communications processor. A fully tactical LDTOC will be delivered to the 101st Airborne Division at Fort Campbell during early FY98. In addition, three vehicles of a brigade tactical command post will be digitally equipped and connected to the LDTOC either through a LAN or via VHSIC Enhanced Position Location Reporting System (EPLRS) radios depending on location.

Payoffs. All systems will participate in the RFPI ACTD, a 4th quarter FY98 full field exercise involving XVIII Airborne Corps units. Following the ACTD, the LDTOC SIM will remain at the Land Warrior Testbed, Fort Benning, while the LDTOC and brigade TAC will be refurbished and remain with the XVIII Airborne Corps as a go-to-war capability for a 2-year evaluation period.

Challenges. Challenges include adding digital capability without exceeding weight constraints imposed by using the XVIII Airborne Corps' requirement to be airlifted in a limited number of flights and meeting goal of 15-second observer-to-weapon fired elapsed time.

Milestones/Metrics.

FY1998: The program will conclude with the delivery of a fully tactical LDTOC simulator to the 101st Airborne Division at Ft. Campbell. In addition, three vehicles of a brigade TAC will be digitally equipped and connected to the LDTOC through either the LDTOC LAN or RFPI WAN using VHSIC EPLRS radios. The final demonstration will consist of a proof-of-principle exercise in which the LDTOC SIM and the LDTOC will participate. All systems will participate in the RFPI ACTD, a full-field exercise involving XVIII Airborne Corps units.

Customer POC	Service/Agency POC		USD(A&T) POC
COL Timothy Bosse, USA	Ms. Gayle Grant	CAPT John Vinson, USN	Mr. Iftikhar Jamil
USA DBBL	USA CECOM	SPAWAR PD133A	DDR&E(IT)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0603772A	101	2.0	0	0	0	0	0
	Total	**2.0**	**0**	**0**	**0**	**0**	**0**

A.23 C4I for Coalition Warfare ACTD

Objectives. Create a technological solution that is also a migration path for the U.S. Army to achieve message and data-replication-based interoperability between its command and control systems and those of its allies at corps through to battalion level. Key technologies to be integrated will be an internationally standardized data model, internationally agreed preformatted messages (based on NATO standards), message parsing software, and an internationally developed data replication mechanism. Initial communications connectivity will be developed from the solutions used in the current Quadrilateral Interoperability Program (QIP) and Battlefield Interoperability Program (BIP) initiatives.

Payoffs. Currently there is no capability for U.S. Army systems to interoperate with C^2 systems of any allies. During the ACTD, the level of interoperability will start from a limited set of situational awareness messages to the ability to replicate any part of a common standardized database (based on internationally agreed information exchange contracts). The full capability will allow passage of information covering all aspects of multinational Army C^2 ranging from contact reports to full corps operations orders. The Maneuver Control System (MCS) is the vehicle for capability development. The capability will be developed with France, Germany, and the UK. (Canada and Italy will have a partial capability.) Data-replication-based interoperability may also be achievable with the Netherlands, Denmark, and Spain before 2002. The software package will be tailored to allow it to be added to other Army C^2 systems.

Challenges. A single, coherent international management structure is needed to control the development of multiple international standards. The three current international initiatives (BIP, QIP, and Army Tactical Command and Control Information System (ATCCIS)) need to be fused. The countries must work to an agreed fielding schedule for the capability.

Milestones/Metrics.

FY1998: Demonstrate brigade-to-corps-level message exchange (QIP Demo Paris, JWID Jul/Aug '98 (TBD) United States, United Kingdom, France, Germany, Italy, Canada); demonstrate battalion-level message exchange (BIP demo, Germany 18-21 Nov '97, United States, United Kingdom, France, Germany).

FY1999: Field brigade-to-corps message exchange capability in MCS; demonstrate data replication capability in field.

FY2000: Field battalion-level message exchange capability.

FY2001: Field initial data replication capability; full capability demonstration and final capability fielding.

Customer POC	Service/Agency POC	USD(A&T) POC
Ms. Deirdre Cunningham PEO C4S, HTIO	MAJ Graham Le Fevre, UKA SAIS-PAA-S, DISC4	Dr. Judith Daly ADUSD(AD)
Mr. Paul Ulrich MCS	Mr. Bruce Zimmerman SARD-TT	Mr. Iftikhar Jamil DDR&E(IT)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
S&T Funding							
0603750D	P523	0.5	1.6	1.0	1.1	0.8	0
Total S&T		**0.5**	**1.6**	**1.0**	**1.1**	**0.8**	**0**
Non-S&T Funding							
0122018A	C2SIP	0.2	0.2	0.2	0.2	0.2	0
023758A	374	1.7	1.0	1.3	0.6	0.3	0
0273740A	484	1.0	1.0	1.0	1.0	1.0	0
0603790A	671	0.2	1.0	1.3	0.6	0.3	0
Total Non-S&T		**3.1**	**3.2**	**3.8**	**2.4**	**1.8**	**0**

A.24 Unattended Ground Sensors ACTD

Objectives. (1) Prosecute deep, time-critical targets by continuous surveillance of critical choke points (7 days a week, 24 hours a day) to provide positive target identification and to permit retasking/cueing of surveillance and attack assets. (2) Measure and report localized weather in denied areas ("now weather") to improve mission planning and safety for weather-sensitive operations (e.g., Special Forces insertion operations). Agency POC is developing an end-to-end system and CONOPS. The Unattended Ground Sensors (UGS) ACTD will satisfy standing CENTCOM and SOCOM requirements for UGS.

Payoffs. The UGS ACTD will address the end-to-end solutions for the use of unattended sensors for both the time-critical target and the "now weather" problems. The end-to-end issues are planning where to place sensors, placing them, operation of the sensors, collecting and processing the data (data exfiltration), and disseminating the results. The sensors involved are acoustic/seismic detection and identification sensors and weather sensors. The end-to-end supporting technologies include planning tools, air-delivery techniques, communications subsystems, and data exploitation tools. The interim capability provided by the ACTD will be approximately 10 hand-emplaced acoustic sensors, 20 air-delivered acoustic sensors, and 6 air-delivered weather systems.

Challenges. The principal challenges will be to develop the concepts of operation for these sensors and to determine the military utility of UGS in a meaningful way. The plan is to include these sensors in tests and exercises in sufficient numbers that they can be thoroughly evaluated.

Milestones/Metrics.

FY1998: Develop and conduct testing scenarios to demonstrate planning and analysis capability.

FY1999: Develop and conduct exercise scenarios to demonstrate hand- and air-deployed sensors and long-haul communications for exfiltration.

FY2000: Provide capability for support of leave behinds.

Customer POC	**Service/Agency POC**	**USD(A&T) POC**
CPT Mike Long, USA	CPT Mark Donofrio, USA	Dr. Charles Perkins
USCENTCOM	CMO	ADUSD(SP)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
S&T Funding							
0603750D	P523	2.0	1.5	0.8	0.8	0	0
Total S&T		**2.0**	**1.5**	**0.8**	**0.8**	**0**	**0**
Non-S&T Funding							
0305884L		8.5	3.0	1.0	0	0	0
1160402BB	S200	0.9	0.5	0	0	0	0
Total Non-S&T		**9.4**	**3.5**	**1.0**	**0**	**0**	**0**

A.25 Information Operations Planning Tool ACTD

Objectives. Demonstrate how information operations (IO) planning, modeling, and analysis tools can aid in the effective prosecution of a CINC's battle objectives. These tools will support the planning, development, synchronization, deconfliction, and management of an IO campaign integrated between a joint HQ staff and the CINC components. The ACTD will also show how modeling and analysis tools with connectivity to current intelligence databases and a reach-back capability to a garrison force can support the development of target recommendations and optimized courses of action aligned with CINC IO taskings against an integrated air defense system (IADS). Operational capabilities to be demonstrated include (1) assisting in the development of an IO campaign, (2) providing analytical capabilities required to produce targeting recommendations against an adversary's IADS and supporting infrastructure to support the CINC's IO objectives and taskings, (3) assisting the CINC's J3 IO staff to collaborate on the development/execution of IO solutions with components and supporting agencies, and (4) assisting in the horizontal collaboration between components in the development and execution of IO solutions.

Payoffs. The Information Operations Planning Tool (IOPT) ACTD will provide more effective and responsive IO campaign development against threat systems and infrastructure to include enhanced collaboration between a CINC's J3 IO staff, components, and supporting agencies to develop and execute IO solutions; and improved targeting and course-of-action development recommendations against adversary IADS and related infrastructures in support of CINC's IO objectives and taskings.

Challenges. Major challenges are incorporating analytical results in an automated, collaborative environment to develop consistent, high-quality, timely, IO targeting, and course-of-action recommendations by merging multiple sources of intelligence data.

Milestones/Metrics.

FY1998: Use HQ CENTCOM, Internal Look–98 exercise to demonstrate IO collaboration and IO course-of-action analysis tools against an enemy IADS.

FY1999: Conduct military exercise to further demonstrate IOPT capabilities for different threat scenarios, weapon systems, and intelligence sources and types.

Customer POC	Service/Agency POC	USD(A&T) POC	
LCDR Keith Menz, USN	Mr. Mike Kretzer	Dr. Judith Daly	Mr. Iftikhar Jamil
HQ USCENTCOM/J3-PI	AFIWC/ISC	ADUSD(AD)	DDR&E(IT)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0603750D	P523	2.3	1.8	1.0	1.0	0	0
	Total	**2.3**	**1.8**	**1.0**	**1.0**	**0**	**0**

A.26 Information Assurance: Automated Intrusion Detection Environment ACTD

Objectives. This ACTD will develop a capability to address the question: Are our information systems under attack? This is an initial "cyber radar" to detect coordinated attacks on the military information infrastructure. The program will provide automated detection, correlation, warning, and reporting for Integrated Threat Warning and Attack Assessment (ITW/AA). Each year, the program will demonstrate the ability of various intrusion devices to detect, visualize, and report activities. Sensor devices such as Intrusion Alert, Enterprise Security Manager, Netranger, etc., at various locations will be targeted using attack scenarios collected from services and agencies, as well as those used during the Mitre flyoff. Sensor detection, local alerting (visualization), and reporting (two-tier reporting in FY98) to the GOSC will be assessed. The scenarios will include localized, regionalized, and global, with various skill (curious, moderate, expert) levels.

Payoffs. The program will provide data bridges to extract information from existing and planned sensors (such as firewalls, intrusion detectors, network management, audit, etc.), data analysis software, and network operational concepts. This integrated suite of capabilities will provide an initial capability to detect attacks at approximately 30 sites and provide data reduction, correlation and visualization software, and a network operational center.

Challenges. The major challenges are techniques to recognize coordinated attacks and filter out "normal" hacker intrusion attempts. Integrating this capability across service lines with a disparate set of sensors is also a challenge.

Milestones/Metrics

FY1998: Kickoff ACTD and demonstrate initial visualization capability. Anticipate having 10 sensors at seven locations, including CECOM, ACOM, and STRATCOM, reporting at a two-tier level during this fiscal year.

FY1999: Conduct annual demonstrations and periodic technology insertions.

FY2000: Conduct annual demonstrations and periodic technology insertions.

FY2001: Conduct annual demonstrations and periodic technology insertions.

FY2002: Conduct annual demonstrations and periodic technology insertions. Complete the program.

Customer POC	**Service/Agency POC**	**USD(A&T) POC**
Mr. David Ellis STRATCOM/J671	Mr. Jack Eller DISA/D25	Dr. Charles Perkins ADUSD(SP)
MAJ Joseph Means, USAF Joint Staff J6K	Mr. Brian Spink AFRL-IFGB	Mr. Marshall Potter DDR&E(IT)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
S&T Funding							
0603750D	P523	3.4	3.6	3.0	1.0	1.0	0
Total S&T		**3.4**	**3.6**	**3.0**	**1.0**	**1.0**	**0**
Non-S&T Funding							
0303140A		1.5	1.7	1.7	0	0	0
0303140N		1.1	0	0	0	0	0
0303112F	BIP	3.9	5.0	2.1	0.4	0	0
0303140K	465	9.3	7.8	12.8	8.0	7.8	0
Total Non-S&T		**15.8**	**14.5**	**16.6**	**8.4**	**7.8**	**0**

PRECISION FORCE

Defense Technology Objectives
for the Joint Warfighting Science and Technology Plan

Precision Force

B.01 Precision Rapid Counter Multiple Rocket Launcher ACTD I-34

B.03 Precision Signals Intelligence Targeting Systems ACTD I-35

B.05 Target Acquisition ATD I-36

B.06 Air/Land Enhanced Reconnaissance and Targeting ATD I-37

B.07 Joint Continuous-Strike Environment ACTD I-38

B.15 Powered Low-Cost Autonomous Attack System Program I-40

B.16 Concentric Canister Launcher I-42

B.17 Low-Cost Missile System ATD I-43

B.18 Low-Cost Precision Kill I-44

B.19 Cruise Missile Real-Time Retargeting I-45

B.21 Miniaturized Munition Technology Guided Flight Tests I-46

B.22 Hammerhead I-47

B.23 MLRS Smart Tactical Rocket I-48

B.24 Programmable Integrated Ordnance Suite I-49

B.25 Theater Precision Strike Operations ACTD I-50

B.26 Multifunction Staring Sensor Suite I-51

B.01 Precision Rapid Counter Multiple Rocket Launcher ACTD

Objectives. Develop and demonstrate a joint adverse-weather, day/night, end-to-end, sensor-to-shooter, precision, deep-strike capability to locate, identify, and kill high-value, short-dwell, time-sensitive targets and assess damage within tactically meaningful timelines. This ACTD demonstrated a significantly enhanced capability for U.S. Forces Korea to neutralize the newly deployed North Korean 240-mm Multiple Rocket Launcher System (MRLS). Because of the brief time in which these targets are expected to be exposed and vulnerable to counterfire, near-continuous surveillance and near-instantaneous target acquisition are required.

Payoffs. The Precision Rapid Counter Multiple Rocket Launcher (PRCMRL) ACTD started in FY95 and completed its demonstration in FY96; its sustainment phase of the interim capability ends in 4Q FY98. The ACTD demonstrated the capability to neutralize the 240-mm MRLS and 170-mm self-propelled guns deployed in North Korea in a matter of hours vice the substantial number of days currently required. The advanced capabilities and prototypes that were demonstrated, modeled, or simulated as part of the ACTD included development or integration of improved sensors, targeting, C^2, automation, communication, and weapon delivery into a seamless deep-strike capability. The FY96 ACTD OCONUS demonstration focused on the leave-behinds for targeting, command and control, automation, communication, weapon delivery, and joint Air Force and Navy fire support. In FY97, the interim capabilities—along with new tactics, techniques, and procedures that were developed by the user—enhanced the CINC's capability to defeat the 240-mm MRLS threats. These capabilities include tactical operations center automation and connectivity, automated weapon–target pairing, Improved Firefinder, terrain visualization capability, and automated request for fire connectivity with Air Force close air support (CAS) and naval fire support. This capability provides the CINC an improved warfighting capability to neutralize or destroy high-priority threats.

Challenges. This ACTD integrates fielded systems and advanced concepts for a coherent response that defeats the North Korean 240-mm MRLS. The sensors must be able to differentiate the 240-mm rockets from the other incoming warheads, determine the launch point, and transmit the coordinates to the shooters. All this must be done in sufficient time for the shooters to launch defensive weapons within the window of vulnerability for the MLRS.

Milestones/Metrics.

FY1998: ACTD is completed this year, and funding is for residual support of leave-behind assets.

Customer POC	Service/Agency POC	USD(A&T) POC
Col Sam Coffman, USAF D&SA Battle Lab	Maj Dan Folk, USAF Joint Precision Strike Office	Dr. C. W. Kitchens, Jr. DDR&E(WT)
LTC Charles Zaraba, Jr., USA USFK	Mr. Bruce Zimmerman SARD-TT	Dr. Charles Perkins ADUSD(SP)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0603238A	177	2.4	0	0	0	0	0
	Total	**2.4**	**0**	**0**	**0**	**0**	**0**

B.03 Precision Signals Intelligence Targeting Systems ACTD

Objectives. Develop and demonstrate a near-real-time, precision targeting, sensor-to-shooter capability using existing national and tactical intelligence resources. The Precision SIGINT Targeting Systems (PSTS) ACTD is a joint service and defense agency effort. The combination of tactical airborne and national SIGINT assets adds a new dimension to the role of intelligence in information warfare. The goal of the PSTS ACTD is accurate determination of potential enemy threat emitter positions and the rapid relay of those positions to forces that can engage and eliminate the threat. The PSTS concept of operations is being worked closely with USCINCPAC and USFK to ensure that warfighter needs are being met. This coordination will ensure multiservice compatibility during the development process. Army, Navy, and Air Force aircraft and sea-based units have participated in past demonstrations and will be included in future demonstrations.

Payoffs. The PSTS ACTD seeks to achieve an order-of-magnitude improvement in geolocation accuracy over any existing single-system SIGINT capability. The program goal is to determine threat position in a timeframe such that munitions may be rapidly delivered by friendly forces. This threat-positional data will be delivered via the Tactical Data Dissemination System (TDDS) and intradivisional Army communications systems. An early PSTS demonstration focused on the technical feasibility of combining tactical and national SIGINT assets to achieve geolocations of pulsed (i.e., ELINT) emitters. The program is evolving to develop geolocations on nonpulsed (i.e., COMINT) emitters as well. The FY98 demonstration is envisioned to be the final demonstration and will leave behind a limited operational capability with military forces.

Challenges. Technological hurdles include precision timing, navigational accuracy, and errors associated with geodesy and ephemeris.

Milestones/Metrics.

FY1998: Demonstration is envisioned to be the final demonstration and will leave behind a limited operational capability with military forces. The ACTD is completed this year.

FY1999–01: Funding supports ACTD interim capability.

Customer POC	Service/Agency POC	USD(A&T) POC	
LTC Ken Manfra, USA	CDR Dennis Sorensen, USN	Dr. C. W. Kitchens, Jr.	Dr. Charles Perkins
USCINPAC(STA)	ONR	DDR&E(WT)	ADUSD(SP)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0603750D	P523	1.0	0	0	0	0	0
0603794N	R2239	7.2	0.9	0.9	0.9	0	0
	Total	**8.2**	**0.9**	**0.9**	**0.9**	**0**	**0**

B.05 Target Acquisition ATD

Objectives. Provide the warfighter a system for night or poor visibility usage that will give him knowledge of the battlespace in real time. By FY98, the program will develop and demonstrate an extended-range, multisensor, target acquisition suite for future tank, cavalry, and scout vehicles. The multisensor suite will consist of a second-generation thermal imaging sight with an automated wide-field-of-view search capability coupled to aided target recognition/identification algorithms, a multifunction laser, and a low-cost moving target indicator (MTI) radar (growth to stationary target indicator (STI)).

Payoffs. The Target Acquisition ATD started in FY96 and completes its demonstration in 4Q FY98. The DTO developed and produced a demonstration multisensor suite for use on future combat vehicles. The unit consists of a second-generation thermal imaging sight with automated search capability, aided target recognition/identification algorithms, a multifunction laser, and a low-cost MTI radar. Enhanced target acquisition capabilities offer the user a more resilient, consistently performing sensor suite capable of better performance under adverse conditions in a fraction of the current timeline found in fielded systems. Fewer false alarms and increased sensor sensitivity lead to fewer missed targets and improved fire control hit probabilities, thus improving combat vehicle lethality and survivability. These capabilities also will lead to a decrease in fratricide and extended target identification ranges for exposed and partially obscured targets. Automation will reduce search timelines over manual search and thus streamline crew workloads for future combat vehicles. The Target Acquisition ATD will permit effective employment of weapon systems under all ambient light and atmospheric conditions, providing a means for the warfighter to gain full knowledge of the battlespace in real time.

Challenges. Technical barriers include optimizing forward-looking infrared (FLIR)/multifunction-aided target recognition fusion algorithms and developing a multifunction laser that fits the space constraints of the current M1 laser.

Milestones/Metrics.

FY1998: Develop and demonstrate an extended-range, multisensor, target acquisition suite for future tank, cavalry, and scout vehicles. Target identification ranges will be extended by 67% for exposed targets and 50% for partially obscured targets. Automation will reduce search timelines by 60%–80% over manual search.

Customer POC	Service/Agency POC	USD(A&T) POC
COL John Kalb, USA DFD, Ft. Knox Armor Center	Mr. Rob Saunders SARD-TT	Dr. C. W. Kitchens, Jr. DDR&E(WT)
	Mr. Timothy Watts CECOM, NVESD	Dr. Jasper Lupo DDR&E(SEBE)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0603710A	K87	1.9	0	0	0	0	0
	Total	**1.9**	**0**	**0**	**0**	**0**	**0**

B.06 Air/Land Enhanced Reconnaissance and Targeting ATD

Objectives. Exploit emerging developments in on-the-move automatic target recognition (ATR) algorithms, including long-range detection, target identification, scene-to-scan correlation, smart sensor management, and temporal FLIR processing for moving target indicator (MTI); and evaluate the additional benefit provided by enhanced laser rangefinder functionality. The fast pace of many engagement scenarios requires a significantly improved capability to find and service targets while improving survivability.

Payoffs. The goal of the Air/Land Enhanced Reconnaissance and Targeting (ALERT) ATD is to provide the helicopter pilot and gunner the ability to automatically acquire and identify stationary and moving targets from a high-speed, dynamic aerial platform such as a scout or attack helicopter. The net result will be a more efficient warfighting platform with greater survivability.

Challenges. Technical barriers include developing algorithms for motion compensation, optimizing FLIR/multifunction laser ATR fusion algorithms, and data imagery compression.

Milestones/Metrics.

FY1998: Collect in-flight, on-the-move data in support of constructive and virtual simulations.

FY1999: Demonstrate baseline on-the-move performance using second-generation FLIR and standard rangefinding modes.

FY2000: Integrate laser range mapping capability and enhanced on-the-move, search-and-detect algorithms.

FY2001: Automation to extend the safe ingress and egress rate of the platform by 50%–75% for full threat coverage over manual acquisition. Integrate a laser profiling capability to demonstrate target identification. The final demonstration will demonstrate the ability to provide on-the-move, long-range detection (in excess of 4,000 m).

Customer POC	Service/Agency POC	USD(A&T) POC
Mr. Mel Jackson PM Comanche	Mr. Rob Saunders SARD-TT	Dr. C. W. Kitchens, Jr. DDR&E(WT)
	Mr. Richard Wright CECOM, NVESD	Dr. Jasper Lupo DDR&E(SEBE)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0603710A	K86	2.5	8.6	4.3	2.5	0	0
	Total	**2.5**	**8.6**	**4.3**	**2.5**	**0**	**0**

B.07 Joint Continuous-Strike Environment ACTD

Objectives. Focus technology and concepts to enable the application of a joint weapon suite to neutralize time-critical, high-value targets. The product of the joint continuous-strike environment (JCSE) effort is an integrated system for joint, near-real-time attack operations based on distributed, cooperative engagement planning and execution. The JCSE ACTD will demonstrate four capabilities: semiautomated target prioritization, continuous weapon availability monitoring, optimized weapon target pairing, and near-real-time airspace deconfliction.

Payoffs. The warfighter payoffs arising from JCSE are (1) production of dynamic target lists that automatically prioritize actionable targets in accordance with the commander's guidance and their reprioritization to accommodate changes to that guidance; (2) cross-component awareness of current and projected weapon status and locations; (3) dynamic target ranking and strike asset status and location, combined to produce single and multiple weapon target tieups needed to prosecute emergent targets before they move with high P_k; and (4) for each weapon target pair or group of pairs, operators are informed of the need to deconflict airspace and given the means to accomplish it rapidly.

Challenges. The challenges for JCSE involve integration of JCSE software into service and joint legacy and migration systems in such a manner that it operates at the module or segment level with minimal impact to the users in terms of training and system footprint modification. These challenges involve technical issues of integration and programmatic issues of interface schedule development and management. The challenges are being addressed at the technical level through phased design, implementation, and testing of interface control documentation; and at the programmatic level through interlocking working-level integrated process teams between JCSE and each service/joint system program management office.

Milestones/Metrics.

FY1998: Demonstrate target prioritization incorporating target class and current situation; baseline weapons database incorporating near-real-time and projected status and location; single target/weapon pairings; deconfliction option generation for unmanned weapons.

FY1999: Demonstrate target prioritization incorporating future plans; bottom-up recovery of planning information; multiple target/weapon pairings for single target complex; deconfliction option generation for use of unitary manned aircraft (one on many).

FY2000: Demonstrate target prioritization incorporating enemy actions requiring plan modification; projected strike asset status based on planning information; multiple platform/weapon pairings on multiple target complexes; option generation for use of multiple manned aircraft (many on many).

Customer POC	**Service/Agency POC**		**USD(A&T) POC**
LCDR Michael Steed, USN EUCOM	LtCol Mike Clark, USMC USN	Mr. Bruce Zimmerman SARD-TT	Dr. Judith Daly ADUSD(AD)
	Ms. Rosanne Hynes OSD/C^{3}I	Col Buster McCrabb, USAF ASC^{2}A	Dr. C. W. Kitchens, Jr. DDR&E(WT)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0603750D	P523	1.0	1.6	1.3	0.4	0.4	0
	Total	**1.0**	**1.6**	**1.3**	**0.4**	**0.4**	**0**

B.15 Powered Low-Cost Autonomous Attack System Program

Objectives. Demonstrate an affordable, miniature, powered munition capable of locating, identifying, and destroying the entire spectrum of ground mobile targets. This program will demonstrate the feasibility and military utility of the Low-Cost Autonomous Attack System (LOCAAS) for the lethal suppression of enemy air defense (SEAD) theater missile defense attack operations and interdiction mission areas. The subsystem technologies to be integrated in the LOCAAS program include a laser radar (LADAR) submunition seeker with automatic target recognition (ATR) algorithms, multimode warhead, safe-and-arm fuzing, INS/GPS midcourse guidance, a compact high-lift-to-drag-ratio airframe, and a DARPA-developed miniature turbojet engine. The munition design will be compatible with both internal and external dispense concepts for Air Force and Army platforms. Additionally, the LOCAAS has affordability as a key objective with a unit production cost goal of $30,000 per munition.

Payoffs. The combination of the powered airframe, INS/GPS midcourse guidance, and high-resolution LADAR/ATR seeker allows the LOCAAS to search over very large areas to find relocatable and mobile targets. This wide area search capability will allow the LOCASS to counter large initial target location error and deny the advantage of mobility to the enemy. Further, the range of the LOCAAS will allow launch from outside the engagement range of surface-to-air missiles, thus increasing the survivability of the launch aircraft. The following operational needs will be addressed by the LOCAAS program: *Theater Missile Defense*—limited wide area search capability; limited ability to counter camouflage, concealment, and deception (CCD); and limited capability to kill time-critical targets. *Electronic Combat*—preemptive lethal SEAD; limited ability to find and engage nonemitting air defense targets; and stimulate/decoy/saturate enemy air defenses with unmanned systems. *Strategic Attack/Interdiction*—lack of off-boresight capability for target engagement; multiple kills per pass; limited ability to destroy targets from standoff ranges; minimize/negate collateral damage; lack of weapon effectiveness against area targets; and limited ordnance carriage.

Challenges. Technology being demonstrated as part of the LOCAAS program includes the multimode warhead and terminal guidance and pointing accuracy with LADAR/ATR. The primary challenges remaining on the Powered LOCAAS program are sustaining LADAR/ATR performance over large search areas, integrating all components into the tactical munition, and integrating the munition into the aircraft carriage and dispensing system. A further technical challenge is to develop a mission planning system that incorporates intelligence preparation of the battlefield and allows for rapid targeting and effective operational employment of the Powered LOCAAS system.

Milestones/Metrics.

FY1998: Complete multimode warhead testing; demonstrate high P_k vs. all ground mobile targets. Conduct guided glider flight test; demonstrate autonomous detection, track, and terminal pointing accuracy. Conduct captive seeker flight test—order of magnitude reduction in false alarm rate over glider LOCAAS.

FY1999: Mission planning/engagement simulation system developed and demonstrated in operational exercises.

FY2000: Conduct captive seeker flight test; demonstrated capability vs. countermeasures, robust performance with varying terrain.

Customer POC	Service/Agency POC	USD(A&T) POC	
Maj Charles Bowman	Maj David Jacques, USAF	Dr. C. W. Kitchens, Jr.	Dr. Jasper Lupo
ACC/DRPW	AFRL-MNAV	DDR&E(WT)	DDR&E(SEBE)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0603601F	670A	5.1	4.4	0.7	0	0	0
	Total	**5.1**	**4.4**	**0.7**	**0**	**0**	**0**

B.16 Concentric Canister Launcher

Objectives. Significantly lower the cost of launch systems over the entire life cycle while increasing operational flexibility. The launching system is an array of concentric cylinders; the inner cylinder supports the weapon and guides its initial flight, while the annular space between the inner and outer cylinders provides for gas management during the launch sequence.

Payoffs. The concentric canister launcher (CCL) requires little to no maintenance, permits unmanned operations, requires little to no specialized training, reduces manning, greatly simplifies and reduces logistic support, and is generic and broadly applicable to all Navy ships. CCL technologies enable plug-and-play capability for introduction of new weapons (and upgrades) without ordnance alterations to the ship, reduces cost and complexity of bringing weapon upgrades to the ship, and allows more flexibility to introduce non-Navy-developed weapons. CCL emphasis upon a flexible generic interface also enables "acquisition reform." The Navy can request or industry can volunteer the concept of a warranted all-up round that reduces the Navy's burden and provides the potential for increased industry incentive for product quality.

Challenges. The technical barriers that must be overcome in order to meet the objectives include (1) self-contained gas management—exit criteria: a restrained firing of a stressing missile (e.g., SM–2, Block IV) in a prototype-representative configuration and the associated predictive modeling capability to handle future growth missiles; (2) distributed electronic architecture—exit criteria: a single, survivable distributed launch system architecture (featuring smart canisters) capable of simultaneously supporting the launch of multiple weapon types from multiple weapon systems; and (3) manning and life-cycle cost benefits—exit criteria: independent validation of reductions in manning, production cost, simplified logistics and maximum compatibility, etc.

Milestones/Metrics.

FY1998: Demonstrate electronic architecture.

FY1999: SM–2, Block 4 restrained firing test.

FY2000: Develop and demonstrate technologies that result in 50% reduction in production costs, 66% reduction in manning, 50% reduction in maintenance costs, and 80% reduction in next-generation ship weapon integration cost.

Customer POC	Service/Agency POC	USD(A&T) POC	
CAPT Ray Pilcher, USN	Mr. James Chew	Dr. Donald Dix	Dr. C. W. Kitchens, Jr.
N864	ONR	DDR&E(AT)	DDR&E(WT)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0603217N	R0447	1.2	5.2	4.3	0	0	0
	Total	**1.2**	**5.2**	**4.3**	**0**	**0**	**0**

B.17 Low-Cost Missile System ATD

Objectives. Address common deficiencies in air superiority and defense precision strike thrusts that require extended-range, high-speed missile concepts. The Low-Cost Missile System (LCMS) ATD objective is to demonstrate the airframe and propulsion technology associated with flying a 700-lb warhead 700 nmi at Mach 4.0/70,000-ft altitude. The unique airframe technology uses a finless and wingless airframe with no external aerodynamic surfaces. Stability and control will be realized through thrust vector control (TVC) only, with the TVC joint ahead of the ramjet engine.

Payoffs. This DTO will demonstrate the enabling technology for a low-cost missile system that will solve the common deficiencies in air superiority and defense precision strike that require extended-range, high-speed missiles. This technology will provide for a tactical weapon with a capability of attacking hardened and time-critical targets—a capacity not existent in the Navy's present inventory. It will result in increased launcher survivability, reduced number of sorties per target, and improved lethality. These technologies are also applicable to other sized missile airframes with equivalent ranges and reduced target times. It will significantly reduce maintenance costs (standardized off-the-shelf equipment and simpler systems) and logistics costs (sensor/fusion commonality). Analysis shows that a weapon with this capability used in a Korean scenario would eliminate the need for over 240 aircraft sorties against time-urgent and buried targets, all in high-threat environments with a potential warfighting savings of over $250 million. Technology in this ATD will undergo transition to the Tomahawk Block 5 missile system. Major area defense programs that have indicated interest in this technology include Navy (PEO(CU), PEO(TAD), Aegis), Army (Corps SAM, Patriot), and Air Force.

Challenges. In this concept, the ramjet combustor and tandem booster are connected to the frontal missile airframe by an articulating TVC joint. This has never been demonstrated before. The technical challenges demonstrated by flight tests are a robust H-infinity-based bending body control system to provide dynamically stable flight without aerodynamic control surfaces, a self-starting annular inlet with 68% pressure recovery at Mach 3.0/60,000-ft altitude, and stable bent-body combustion during maneuvers and all flight regimes.

Milestones/Metrics.

FY1998: Conduct booster static firings, fabricate flight test hardware, perform HWIL and wind tunnel testing, and conduct a direct connect ground test of the propulsion system.

FY1999: Demonstrate a free-flight test of a bending annular missile body (BAMB) ramjet missile configuration with a 700-lb warhead, 700-nmi range at Mach 4.0/70,000-ft altitude. The ATD will culminate in two flight tests in the 3rd and 4th quarters of FY99.

Customer POC		Service/Agency POC	USD(A&T) POC
Mr. Edmund Anderson PEO(CU)	CAPT Dennis Army, USN PMA-280	Mr. David Siegel ONR	Dr. C. W. Kitchens, Jr. DDR&E(WT)
CAPT Gary Johnson, USN N864			

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0603792N	R1889	6.1	4.5	0	0	0	0
	Total	**6.1**	**4.5**	**0**	**0**	**0**	**0**

B.18 Low-Cost Precision Kill

Objectives. Demonstrate a very low cost (~$10,000), accurate (~1-m CEP) guidance and control retrofit package for the 2.75-inch Hydra–70 rocket. A standoff-range (greater than or equal to 6 km) capability will be provided against specified nonheavy armor point targets often engaged in large numbers in many operational scenarios.

Payoffs. The low-cost precision kill (LCPK) 2.75-inch guided rocket will support both aviation-specific and integrated future operational capabilities (FOCs). The FOCs and pertinent capabilities are (1) AV 97–006 weapons suite: rapidly destroy or neutralize targets with minimum exposure, minimum required rounds, optimized precision, increased hit probability, and day and night capability while minimizing collateral damage and fratricide potential; and (2) TR 97–040 firepower lethality: responsive weapon system overmatch, increased lethality, and superior range with minimal collateral damage.

Challenges. Technical barriers include unproven low-cost, producible-strapdown (solid-state) mechanisms for precision guidance; a requirement for accurate, robust control of a highly rolling free rocket; the lack of small, very low cost inertial components; weight and size minimization component packaging in the 2.75-in airframe; a limited understanding of structural, vibration, and shock considerations for guidance package retrofit to the 2.75-in Hydra–70 rocket; and lack of standoff range target acquisition and engagement techniques to address current free-rocket launch and flight dispersions.

Milestones/Metrics.

FY1998: Demonstrate in HWIL test a 1-m CEP accuracy at 6 km.

FY1999: Demonstrate in wind tunnel a 90% reduction in 2.75-in Hydra–70 guidance section spin rates.

FY2000: Demonstrate a 10X reduction in 2.75-in Hydra–70 rocket dispersions via control test vehicle flight tests.

FY2001: Demonstrate a 1-m CEP accuracy at 6 km via guided test vehicle flight tests.

Customer POC		Service/Agency POC	USD(A&T) POC
Mr. Joe Bower Air Maneuver Battle Lab	Mr. Pat McCartney Attack Battle Lab	Mr. Charles Lewis MICOM	Dr. C. W. Kitchens, Jr. DDR&E(WT)
Col Jesse Danielson, USAF ATZQ-CD	Col Richard Savage, USMC PM-AGMS	Ms. Irena Szkrybalo SARD-TT	

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602303A	214	1.2	0.5	0	0	0	0
0603313A	567	0	0	5.0	3.6	0	0
	Total	**1.2**	**0.5**	**5.0**	**3.6**	**0**	**0**

B.19 Cruise Missile Real-Time Retargeting

Objectives. Develop technologies for brilliant autonomous cruise missiles with onboard mission planning and control systems. The program will demonstrate, by FY01, a brassboard real-time guidance and control system with an associated LADAR sensor mounted on a T–39 aircraft to demonstrate (1) immediate launch-on-coordinates capability for weapons; (2) in-flight, onboard decision making to provide in-flight coordinated attack against fixed and mobile targets; (3) precise aimpoint selection for greater kill effectiveness; and (4) battle damage indication from the LADAR sensor. The LADAR seeker to be demonstrated in this program is being developed jointly with the Air Force under the Demonstration of Advanced Solid-State LADAR (DASSL) program.

Payoffs. Weapon systems affordability and effectiveness will be significantly enhanced by the transition of the technology demonstrated by this project. Specific payoffs include (1) the ability to retarget a weapon while it is in flight, (2) improved target and target aimpoint selection to improve weapon effectiveness via small CEP on fixed high-value and mobile targets, (3) a new ability to autonomously hunt for and kill critical mobile targets within a given search area, (4) reduced mission timeline for the destruction of time-critical targets, (5) development of reduced-cost LADAR seeker technology suitable for autonomous target identification in a high natural and manmade clutter environment, and (6) in-flight, onboard route replanning capability and onboard real-time autonomous decision-making capability to reduce the number of cruise missiles per target by one-third.

Challenges. There are three key technical challenges: (1) development of a higher power, lower cost LADAR seeker that is capable of rapid, high-resolution data collection rates, greater range capability, and better weather penetration; (2) development of algorithms and processing schemes necessary to accomplish in-flight, real-time adaptive strike planning; and (3) development of ATR algorithms to provide a precise aimpoint for both fixed and mobile targets in high-clutter backgrounds.

Milestones/Metrics.

FY1998: Deliver Lockheed-Martin Vought Systems (LMVS) LADAR seeker (6 W); conduct captive flight tests; develop real-time fixed high-value target (FHVT) ATR; demonstrate FHVT algorithms.

FY1999: Conduct captive flight tests; demonstrate weapon allocator/search path planner and in-flight route replanning.

FY2000: Conduct captive flight tests; deliver DASSL seeker (10 W); demonstrate critical mobile target algorithm tactical movement analyzer and sensor manager.

FY2001: Demonstrate a brassboard real-time guidance and control system with an associated LADAR sensor with a LADAR search rate of 12 km^2 per min.

Customer POC		Service/Agency POC	USD(A&T) POC
Mr. Edmund Anderson PEO(CU)	CAPT Gary Johnson, USN PMA-280	Mr. David Siegel ONR	Dr. C. W. Kitchens, Jr. DDR&E(WT)
CAPT Dennis Stokowski, USN N864F			Dr. Jasper Lupo DDR&E(SEBE)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0603217N	R0447	4.1	4.5	4.5	4.0	0	0
	Total	**4.1**	**4.5**	**4.5**	**4.0**	**0**	**0**

B.21 Miniaturized Munition Technology Guided Flight Tests

Objectives. By FY03, demonstrate the effectiveness of a small, 250-lb-class munition with extended range, an enhanced fragmentation/enhanced blast warhead, antijam Global Positioning System (GPS)/Inertial Navigation System (INS) guidance, and a laser radar (LADAR) terminal seeker. The goal is to demonstrate a small munitions capability to destroy a majority of fixed target threats.

Payoffs. The small package of a miniaturized munition will allow a threefold to fourfold increase in aircraft loadout, thereby increasing the number of targets destroyed on a single sortie. Given a fixed number of aircraft, this will increase the tempo of the war and allow more targets to be destroyed in a shorter amount of time, providing the potential to shorten the war. The smaller logistic footprint will allow airlifting of more munitions in a shorter amount of time. The smaller munition will also give future aircraft designers more flexibility in sizing their weapon bays and allow future stealth aircraft to carry more firepower in internal weapon bays and maintain their effectiveness against the majority of fixed targets. Several areas will be demonstrated, including (1) a range extension kit to increase standoff range substantially; (2) a penetrating warhead with an explosive 1.5X the energy in tritonal; (3) in conjunction with the hard target smart fuzes, the ability of the warhead to sense layers and voids and detonate at the appropriate location to ensure the warhead's effectiveness against theater targets; (4) GPS with a 120-dB jam-to-signal ratio (J/S) (50 dB better than commercial systems) effective up to 1 nmi from a 100-kW jammer; and (5) a less than 3-m accuracy using a LADAR terminal seeker.

Challenges. Technology barriers are aircraft integration of multiple smart munitions, including carriage systems (electrical and mechanical interface), and LADAR seeker integration within the prescribed munition length.

Milestones/Metrics.

FY1999: Demonstrate increased standoff range, 30-nmi flyout.

FY2000: design and fabricate miniaturized munition and dispenser.

FY2001: Sled/arena ground tests and initial flight tests.

FY2002: Demonstrate the effectiveness of a small, 250-lb-class munition with an enhanced fragmentation/enhanced blast warhead, antijam GPS/INS guidance, 120-dB J/S in tracking, and LADAR terminal seeker less than 3-m CEP.

Customer POC	Service/Agency POC	USD(A&T) POC
Maj Charles Bowman, USAF ACC/DRPW	Mr. Michael Flynn SAF/AQRT	Dr. C. W. Kitchens, Jr. DDR&E(WT)
Col Chris Caravello, USAF ASC/VX	Mr. Rick Moor AFRL-MNA	

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0603601F	670B	2.1	2.5	3.0	3.0	2.3	0
	Total	**2.1**	**2.5**	**3.0**	**3.0**	**2.3**	**0**

B.22 Hammerhead

Objectives. Demonstrate a Joint Direct Attack Munition (JDAM)-class SAR seeker for guided applications that has a capability to strike fixed targets obscured by cloudy or foggy conditions All seeker imaging, guidance, and other significant data will be recorded via an AMRAAM telemetry unit. Captive flight missions will be conducted under adverse-weather conditions, except when personnel safety is jeopardized, to assess the effects on seeker operation. These captive flight missions will also include an assessment of target location errors of at least 50 feet for a variety of targets.

Payoffs. The SAR seeker technology demonstrated under this DTO will provide a revolutionary air-to-surface precision guidance capability in adverse weather, allowing for the successful attack of fixed or stationary targets anytime, anywhere. A significant reduction in mission planning by a trained operator (15 minutes or less) is expected over current autonomous mission planning procedures (can take several days). Response to time-critical targets can be immediate. The precision guidance capability greatly reduces collateral damage to targets in heavily populated civilian areas and increases weapon lethality, thus requiring fewer aircraft sorties and reducing aircraft attrition. The autonomous capability improves shooter aircraft survivability through an increase in standoff range limited only by weapon kinematics, increases the aircraft's weapon capacity by one-third through the elimination of targeting or datalink pods, and allows carriage on single-seat aircraft by eliminating man-in-the-loop requirements.

Challenges. The key technical challenge is predicting the target characteristics in the SAR image at steep dive angles and in adverse weather. Several captive flight missions are planned to address this challenge; however, conducting these missions in adverse weather at steep angles without jeopardizing personnel safety will also be a significant challenge. Another challenge is to obtain trajectory scoring information, accurate to within 1 foot, to isolate seeker and weapon guidance errors in order to achieve weapon impact within 3 meters of the intended target aimpoint. A state-of-the-art, carrier-phase differential GPS scoring system will be used to address this challenge.

Milestones/Metrics.

FY1999: Demonstrate a threefold accuracy improvement over GPS/INS guidance systems performance at impact angles up to 60 deg from the horizontal ground plane and an angle of attack of 5 deg or less between the bomb velocity and the bomb roll axis against a fixed target under adverse-weather conditions (cloudy/foggy conditions over 10-mm-per-hour rain rate), with less than 3-m CEP. Plan missions in 15 min or less by a trained operator.

Customer POC	Service/Agency POC		USD(A&T) POC
Mr. Jim Galloway	Mr. Michael Flynn	Mr. Tim Jones	Dr. C. W. Kitchens, Jr.
ASC OL/YUP	SAF/AQRT	AFRL-MNA	DDR&E(WT)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0603601F	670B	3.0	2.6	0	0	0	0
	Total	**3.0**	**2.6**	**0**	**0**	**0**	**0**

B.23 MLRS Smart Tactical Rocket

Objectives. Develop a delivery system for packaging and dispensing multiple smart submunitions from a Multiple-Launch Rocket System (MLRS) rocket within the physical constraints of the current MLRS launch pod container (LPC) tube. This DTO will evaluate multiple candidate submunitions and select the system that provides the best performance and cost effectiveness meeting the MLRS Tactical Rocket (MSTAR) Operational Requirements Document.

Payoffs. This DTO will provide the ability to engage multiple ground targets with fewer rockets and carriers, thus improving the target kill ratio and reducing costs per kill.

Challenges. Technical barriers associated with the payload section separation, de-spin, stabilization, guided flight after separation, and dispense (axial) include the following problem areas: (1) the payload section will be spinning prior to and during separation, (2) the dispensing of smart submunitions from payload cross sections that may be elliptical, oversized cylindrical, and noncylindrical shapes, (3) use of the existing MLRS launch pod, and (4) use of planer fins for payload stabilization after separation. Dispense system design must provide a benign environmental condition for the smart submunition during the dispense operation.

Milestones/Metrics.

FY1998: Conduct payload section concept trade studies to define design attributes: motor separation mechanism, submunition deployment method, aerodynamic configuration, and stabilization mechanism. Fabricate prototype components for engineering tests.

FY1999: Conduct component testing. Develop detailed prototype dispenser/payload section. Fabricate prototype dispenser/payload section. Provide design requirements and exit criteria for the MSTAR ATD. Conduct side-by-side captive flight test of large footprint sensor technologies. Evaluate candidate sensor performance under identical test conditions. Develop draft system performance specification.

FY2000: Develop performance specifications. Detail design and engineering analyses. Update 6-DOF simulations. Conduct submunition dispenser design validation tests through airdrop tests. Validate simulation of submunition performance. Conduct candidate system performance evaluation. Conduct cost as an independent variable (CAIV) on system options.

FY2001: Complete dispenser validation tests. Initiate flight hardware fabrication and flight demonstrations. Evaluate system dynamics on payload configurations.

FY2002: Complete flight demonstrations. Initiate design integration of MSTAR with guided MLRS. Prepare for EMD milestone review.

Customer POC	Service/Agency POC	USD(A&T) POC
Mr. John Reynolds MLRS Project Office	Mr. Julian Cothran MICOM	Dr. C. W. Kitchens, Jr. DDR&E(WT)
COL Richard Svitak, USA TRADOC Sys. Mgr	Ms. Irena Szkrybalo SARD-TT	

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602303A	214	1.3	0.3	0	0	0	0
0603313A	380	0	2.5	6.8	7.5	7.1	0
0603004A	43A	0	2.5	5.0	0	0	0
	Total	**1.3**	**5.3**	**11.8**	**7.5**	**7.1**	**0**

B.24 Programmable Integrated Ordnance Suite

Objectives. Develop and demonstrate an integrated ordnance suite comprised of an imaging infrared (I^2R) target detection device (TDD), advanced initiation fireset, and directional warhead (being accomplished by U.K.) to maximize medium- and short-range missile counterair lethality. The Programmable Integrated Ordnance Suite (PIOS) is a joint U.S./UK program. The goal of the program is to show, through ground-based sled testing, the ordnance suite's capability to acquire a target, establish a vulnerable aimpoint, and project a focused, highly lethal payload onto the selected aimpoint under simulated high-speed encounter conditions. Funding shown in this DTO does not include U.K. funds.

Payoffs. The PIOS program will provide the warfighter with an air-to-air missile ordnance package that will enhance missile effectiveness against cruise missiles, fighter aircraft, and bombers; increase kills per sortie in air-superiority missions; and provide a one-missile/one-kill capability.

Challenges. Dual, side-looking fisheye lenses are used to collect imagery over missiles' forward hemisphere nonuniform window heating, stray light, ghost images, and fisheye image distortion, and this presents significant optical design challenges. High-speed image processing in excess of 1000-Hz frame rates is required to perform target acquisition, aimpoint selection, and burst-point selection and to provide burst-point decision for high closing rate encounters. Finally, multipoint initiation fireset requires accurate timing of detonation points sequencing to project warhead fragments in the preferred air direction at the proper time.

Milestones/Metrics.

FY2000: Lethality analyses prediction baselined against Advanced Medium-Range Air-to-Air Missile (AMRAAM). Fuze and warhead fabrication and laboratory testing.

FY2001: Integration of fuze and warhead as part of an integrated ordnance suite (IOS) static test set.

FY2002: Perform sled track demonstration tests. Project targets past static IOS test set. Exercise fuze detection and detection processes and warhead kill mechanism in a dynamic test environment. Performance metrics to be evaluated include fuze target type identification, fuze target aimpoint error, fuze warhead aim direction error, fuze point error, actual warhead fragmentation response versus design response, and probability of kill.

FY2003: Exit criteria for success is defined as (1) 90% P_k improvement over current AMRAAM vs. SS–N–22 (Sunburn) at nominal AMRAAM miss distances, and a 180% P_k improvement at twice the nominal AMRAAM miss distances; (2) 30% P_k improvement over current AMRAAM vs. advanced fighter at nominal AMRAAM miss distances; and (3) 20% P_k improvement over current AMRAAM vs. Tu–22M (Backfire) at nominal AMRAAM miss distances, and a P_k improvement at twice the nominal AMRAAM miss distance. Update fuze and warhead models using demonstration test results, and rerun lethality analyses.

Customer POC	**Service/Agency POC**		**USD(A&T) POC**
Col Dennis Miner, USAF	Mr. Aaron Brinson	Mr. Michael Flynn	Dr. C. W. Kitchens, Jr.
HQ, SAF/XOR	AFRL-MNM	SAF/AQRT	DDR&E(WT)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0603601F	670A	0	0.1	2.2	3.0	3.0	2.1
	Total	**0**	**0.1**	**2.2**	**3.0**	**3.0**	**2.1**

B.25 Theater Precision Strike Operations ACTD

Objectives. Develop and demonstrate a significantly improved capability for the ground component commander (GCC) to forecast, plan, and execute deep operations with an integrated joint and coalition force to detect volume of fires, plan collaborative targeting, and direct counterfire and precision engagements against all types of ground targets using joint/coalition assets.

Payoffs. Theater precision strike operations (TPSO) will enable the GCC to synchronize, coordinate, deconflict, and employ organic, joint, and coalition deep-strike assets, focused on the area between the forward line of own troops and the forward boundary, in near-real-time coordination with the air component commander, other component commanders, and coalition partners.

Challenges. TPSO is a system-of-systems program to integrate the precision strike functions of surveillance/reconnaissance, target acquisition, strike planning, weapons delivery, and battle damage assessment. The major challenges are to provide a new C^4I capability at the theater Army level—an enhanced deep operations coordination center (EDOCC) that does not currently exist—to provide shared situational awareness, a common operating picture, and an automated strike planning capability within the context of the end-to-end, sensor-to-shooter precision strike process. Additional challenges include the ability to rapidly detect volume of fires through new technical capabilities such as the networking of Firefinder radars and technology to support the seamless transition from unreinforced to reinforced situations.

Milestones/Metrics.

FY1998: Establish initial technical baseline.

FY1999: Conduct a DOCC exercise to baseline the equipment and capabilities of the theater (Korea).

FY2000: Conduct an unreinforced exercise scenario to prosecute the initial hours of a war.

FY2001: Demonstration to examine the issues associated with the transition from the unreinforced to reinforced fight. The TPSO ACTD and tactics, techniques, and procedures demonstrated should allow the JFLCC to defeat at least 50% more threat targets than the current capability.

FY2002–03: Interim capability support.

Customer POC		Service/Agency POC	USD(A&T) POC
Col Sam Coffman, USAF D&SA Battle Lab	LTC John Dunham, USA D&SA Battle Lab	Mr. Bruce Zimmerman SARD-TT	Dr. C. W. Kitchens, Jr. DDR&E(WT)
COL Paul Stuart, USA USFK		COL Paul Wolfgram, USA Joint Precision Strike JPO	Dr. Charles Perkins ADUSD(SP)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0603238A	177	5.1	9.5	19.0	22.4	14.0	10.0
0603750D	P523	1.4	4.8	4.5	4.0	0	0
	Total	**6.5**	**14.3**	**23.5**	**26.4**	**14.0**	**10.0**

B.26 Multifunction Staring Sensor Suite

Objectives. Demonstrate a sensor system capable of acquiring and identifying targets beyond the range of the host platform weapon systems. In addition to the target acquisition functions, the host platform must perform supplementary tasks such as sensing target range, acquisition of fleeting targets, and locating sources of sniper and mortar fires. The solution that accomplishes these functions requires the use of multiple sensors operating across the electromagnetic spectrum. The reconfigurable Multifunction Staring Sensor Suite (MFS^3) uses sensor fusion and integrates multiple advanced sensor components including staring arrays, a multifunction laser, and acoustic arrays.

Payoffs. MFS^3 will provide the capability to detect and identify active and passive targets in all battlefield conditions throughout the extended 360-degree, three-dimensional battlespace. The MFS3 will provide ground vehicles, amphibious assault vehicles, and surface ships with a compact and affordable sensor suite for long-range noncooperative target identification, mortar/sniper location, and air defense against low-signature targets.

Challenges. Technical challenges include the fusion of multiple advanced sensor components, the application of the aided target recognition algorithms to these advanced sensors, and the achievement of high probability of target detection and recognition with a low false alarm rate.

Milestones/Metrics.

FY1998: Demonstrate an ultra narrow field-of-view, long-range identification with a 3–5-μm staring FLIR.

FY1999: Conduct preliminary design review and critical design review; develop MFS^3 virtual prototype to assist in the design process; initiate fabrication on the MFS^3 backplane, staring thermal imaging sensor, and multifunction laser; collect 3–5-μm imagery of ground process to initiate ATR training; conduct an early user demonstration of the 3–5-μm Staring Thermal Imaging System.

FY2000: Integrate staring FLIR, multifunctional laser, and acoustic sensors with common backplane processor and automatic target recognition (ATR) algorithms.

FY2001: Demonstrate the capability of automated surface-to-surface, surface-to-air, and air-to-surface search, acquisition, and noncooperative identification. Identify ground targets at 2.5X the range of present Scout vehicles; provide a 10X increase in azimuth field-of-regard. The MFS^3 ATR will improve target detection timelines by 9X and maintain simultaneous track of multiple targets.

Customer POC	**Service/Agency POC**	**USD(A&T) POC**
COL John Kalb, USA	Mr. Paul Laster	Dr. C. W. Kitchens, Jr.
DFD, Ft. Knox Armor Center	CECOM, NVESD	DDR&E(WT)
	Mr. Rob Saunders	Dr. Jasper Lupo
	SARD-TT	DDR&E(SEBE)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0603710A	K70	4.6	9.7	9.6	9.6	0	0
0603710A	K87	1.5	0	0	0	0	0
	Total	**6.1**	**9.7**	**9.6**	**9.6**	**0**	**0**

COMBAT IDENTIFICATION

Defense Technology Objectives
for the Joint Warfighting Science and Technology Plan

Combat Identification

C.01 Battlefield Combat Identification ATD I-54

C.02 Combat Identification ACTD I-55

C.03 Advanced Air Target Identification ATD I-56

C.04 Advanced Surface Target Identification ATD I-57

C.05 Precision Targeting Identification ACTD I-58

C.07 Link–16 ACTD I-59

C.01 Battlefield Combat Identification ATD

Objectives. Solve some elements of the ground battlefield combat identification (CID) problem underscored by the lessons learned from Operation Desert Storm. The ATD supports the Combat ID ACTD (DTO C.02) by providing some of the Army-specific technologies as well as supporting the evaluation of technologies through virtual simulation. Efforts in this ATD address the dismounted soldier and evaluate CID close support (helicopter support) and ground-to-ground architectures that include the dismounted soldier.

Payoffs. The capabilities developed as part of this program will enhance the warfighter's combat effectiveness, especially in joint operations, while reducing the potential for fratricide incidents. This ATD was started in 1993 and became a DTO in 1995. These capabilities will be demonstrated for a number of different mission areas in the CID architecture. The results of the work performed under this ATD/DTO to date have already led to the Army decision to invest procurement funds for BCIS and CIDDS. This ATD/DTO has helped lay the groundwork for fusing CID with target acquisition functions and has demonstrated the effectiveness of applying CID technology.

Challenges. The barriers include ensuring interoperability across the battlespace while minimizing the exploitability of signatures, impact to firing sequence, required actions by crews, impacts to data latency/accuracy, and cost.

Milestones/Metrics.

FY1998: Analyze the different possible CID architectures as a function of cost, performance, and interoperability; demonstrate a 2-lb combat ID capability for Land Warrior-equipped soldiers interoperable with the Combat ID for Dismounted Soldiers (CIDDS) system; develop target ID concepts for soldier-to-vehicle, vehicle-to-soldier, and helicopter-to-soldier applications with 90% probability of ID for friendlies equipped with the system; extend the situational awareness through-the-sight effort to include an enhanced version of the Battlefield Combat ID System (BCIS), digital appliqué, and other acquisition and target ID systems; demonstrate GPS backup system using BCIS, appliqué, and Enhanced Position Location and Reporting System (EPLRS) with an accuracy of at least 50 m.

Customer POC	**Service/Agency POC**	**USD(A&T) POC**
COL Thomas Page, USA	Mr. Gerardo Melendez	Mr. Iftikhar Jamil
Hq TRADOC ATCD-Q	SFAE-IEW-CI	DDR&E(IT)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602120A	H15	3.3	0	0	0	0	0
0603772A	281	2.9	0	0	0	0	0
	Total	**6.2**	**0**	**0**	**0**	**0**	**0**

C.02 Combat Identification ACTD

Objectives. Demonstrate a joint air-to-surface and surface-to-surface combat ID (CID) capability, concentrating on close air support (fixed-wing aircraft support), close support (helicopter/rotary-wing support), and ground-to-ground mission areas. The ACTD will quantify the contributions of identification technologies for increasing combat effectiveness and reducing fratricide through assessment of measures of performance and measures of effectiveness from exercises and simulations. The ACTD will leverage the investment in the Digitized Battlefield initiative to explore synergism between situational awareness and target ID. It will also propose refinements to joint service CID tactics, techniques, and procedures and provide an interim capability period for operational forces. This FY96 ACTD will conclude in FY99.

Payoffs. The ACTD will provide the warfighter with an integrated surface-to-surface and air-to-surface CID capability to enhance combat effectiveness and reduce fratricide. Technologies demonstrated as part of this program that provide military utility will remain with the operational test units as leave-behind assets.

Challenges. Challenges include interoperability across joint/coalition battlespaces and multiservice systems with different requirements, system availability, operational concepts, technologies, and security levels. Other areas of concern are minimizing the detectability/exploitability of signals, minimization of timelines for ID, and minimizing the impacts on data latency/accuracy and cost.

Milestones/Metrics.

FY1998: C^4I Interoperability Demonstration at Ft. Huachuca is being developed to assess technologies within current C^4I and future tactical architectures; CID Exercise with elements of the 4th Infantry Division at Ft Hood; Virtual Integration Exercise will connect Ft. Rucker, Ft. Knox, and Air Force Research Lab (Armstrong Lab) using distributive interactive simulations with the technologies. Complete military utility assessment report.

FY1999: Residual support for leave-behind technologies.

Customer POC	Service/Agency POC		USD(A&T) POC
LTC John Arthur, USA	Mr. Gerardo Melendez	Mr. Bruce Zimmerman	COL John Fricas, USA
US Atlantic Command J–34T	SFAE-IEW-CI	SARD-TT	DUSD(AT)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
S&T Funding							
0603750D	P523	4.6	4.8	0	0	0	0
Total S&T		**4.6**	**4.8**	**0**	**0**	**0**	**0**
Non-S&T Funding							
0604817A	BCIS	1.2	0.6	0	0	0	0
Total Non-S&T		**1.2**	**0.6**	**0**	**0**	**0**	**0**

C.03 Advanced Air Target Identification ATD

Objectives. Develop and demonstrate advanced, long-range, all-aspect, high-confidence CID capabilities for air target identification for use on current and next-generation aircraft. The joint USAF–USN ATDs will leverage the investment already made in multiple science and technology programs. The intended resulting system will be a single, multifunction device incorporating at least two of these techniques.

Payoffs. Enhanced CID capabilities will provide long-range, high-confidence, all-aspect noncooperative identification capabilities that are jam resistant; render the flexibility to incorporate multiple sensor inputs that will provide the warfighter with timely and accurately fused ID solutions with an expanded target set; and will give the warfighter the ability to quickly, accurately, and confidently identify friends and hostiles for maximum mission/weapons effectiveness and economy of forces while significantly minimizing the potential for fratricide. Exit criteria for air target identification (20 classes) under this DTO are declaration probability of 85% and identification confidence probability of 99%.

Challenges. Technical challenges include computational limitations, registration errors between data sources, data latency between asynchronous information sources, handling ambiguous information, deception, and model fidelity.

Milestones/Metrics.

FY1998: Multisensor/multifeature fusion algorithm developments are being examined by the USAF Air Target Algorithm Development (ATAD) program for air targets and will be tested in the ATAD flight demonstration.

FY1999: Demonstration of the USN Noncooperative Air Target Identification program's all-aspect target classification ISAR imaging techniques for air targets via an adaptive-range Doppler imaging process. A Bayesian classifier combines tracking data, range profiles, and range-Doppler surfaces to provide target-class estimates.

FY2000: Demonstration of ATAD system for air-to-air identification.

FY2001: Demonstration of the Target ID for Tactical Application program's noncooperative aircraft identification at long ranges via acoustic background analysis techniques.

Customer POC	Service/Agency POC		USD(A&T) POC
MAJ J. Dunham, USA	Mr. Roger Cranos	Mr. William Miceli	Mr. Iftikhar Jamil
HQ ACC/DRAO	AFRL-SN	ONR	DDR&E(IT)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602232N		0.5	0.5	0	0	0	0
0603203F	69DF	1.7	2.0	1.6	4.0	0	0
	Total	**2.2**	**2.5**	**1.6**	**4.0**	**0**	**0**

C.04 Advanced Surface Target Identification ATD

Objectives. Develop and demonstrate advanced, long-range, high-confidence air-to-surface target ID capabilities for use on current and next-generation aircraft. The joint USAF–USN ATDs will leverage the investment already made in multiple S&T programs. The actual system that these efforts will produce will be a multifunction device, incorporating at least two different but complementary techniques.

Payoffs. Positive hostile ID is required for weapons employment. The USAF Enhanced Recognition and Sensing LADAR (ERASER) ATD is aimed at improving the airborne identification process for air and ground targets through the use of active laser technologies. Efforts for this program will concentrate on integrating ERASER laser and signal processing technology into a testbed aircraft for flight demonstration. ERASER-supplied target ID will complement other sources of ID from the warfighter's total ID suite. ERASER will incorporate 2D laser imaging technology and CID algorithms developed for ground target ID. The DARPA/USAF Moving and Stationary Target Acquisition and Recognition (MSTAR) program is developing model-driven ATR/ID SAR core technologies. The USN Littoral Surveillance/Moving Target Recognition program will provide a demonstration of imaging small craft. The USN Laser CID project uses laser vibrometry, high-range-resolution 1D profiling, 2D silhouette extraction, and techniques relying on unique target reflectivity characteristics when illuminated by optimized laser sources. Exit criteria for surface target ID under this DTO are declaration probability of 85% and identification confidence probability of 98%.

Challenges. Technical issues include the fact that shortwave IR cameras are new technology and that the ERASER program is employing 2.5 times the laser power of current designators. Other challenges include weather performance and eye-safe laser development.

Milestones/Metrics.

FY1998: Complete ERASER mission/operations analyses; initiate hardware modifications; flight demonstrate the USN Littoral Surveillance/Moving Target Recognition program; NATO (U.S.-hosted) field test 1.55-, 2.05-, and 10.6-μm vibration sensors in support of the USN Laser CID project; initiate sensor downselect and planning for airborne demonstration.

FY1999: Deliver and integrate ERASER shortwave IR camera.

FY2000: Tower test ERASER.

FY2001: Flight demonstrate ERASER technology at militarily significant ranges.

FY2002: Technology available for air-to-ground multimode application (i.e., APS–137/JSTARS).

FY2003: Complete USN Littoral Surveillance/Moving Target Recognition program.

Customer POC	Service/Agency POC		USD(A&T) POC
MAJ J. Dunham, USA	Mr. Roger Cranos	Mr. William Miceli	Mr. Iftikhar Jamil
HQ ACC/DRAO	AFRL-SN	ONR	DDR&E(IT)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602232N		2.1	4.3	4.5	1.5	1.0	0.8
0603203F	665A	0.7	2.4	1.2	0	0	0
	Total	**2.8**	**6.7**	**5.7**	**1.5**	**1.0**	**0.8**

C.05 Precision Targeting Identification ACTD

Objectives. Demonstrate the standoff aspect invariant classification of aircraft and surface targets with a low probability of intercept. Precision targeting identification (PTI) combines an advanced third-generation IR sensor together with a C^4I sensor fusion package and a target tracking and identifying laser radar (LADAR). The LADAR performs target ID by exploiting the return signal that contains the targets vibration spectrum (micro-Doppler signature).

Payoffs. The PTI ACTD will evaluate the potential to improve military capabilities to address critical military needs in three warfare mission areas: (1) joint surveillance/intelligence (positive ID of noncooperative air targets), (2) joint electronic warfare (over-the-horizon targeting (OTH-T)), and (3) battle damage assessment (BDA). Specific payoffs include (1) the sensor technology packaging can meet the needs of various transition sponsors (i.e., fighter/strike aircraft, ground combat vehicles, patrol/surveillance aircraft, and ships), (2) combat ID and precise tracking of small aircraft and ships at extended ranges, (3) real-time sensor-to-shooter updates for OTH-T and BDA, and (4) low probability of counterdetection.

Challenges. Technical objectives to be accomplished include the integrated C^4I sensor fusion package, stable laser transmitter, in-flight vibration compensation for LADAR, producibility of a low-cost common module LADAR unit for transition, and classification of aircraft and surface targets.

Milestones/Metrics.

FY1998: Develop stable laser transmitter (100 Hz/ms); integrate C^4I sensor fusion with third-generation IR, OTCIX, and radar.

FY1999: Classify airborne and surface targets; complete system integration with UK; complete conceptual designs for transition into production; full-capability-integrated C^4I sensor fusion with Link–16; improve aircraft vibration compensation to 1.0-g level.

FY2000: Achieve unit cost of less than $500,000 (targeting $370,000/unit for 270 units); improve aircraft vibration compensation to 2.0-g level.

FY2001: Complete PTI evaluation program.

Customer POC		Service/Agency POC	USD(A&T) POC
CAPT Michael Mathis, USN	RADM J. E. Shkor, USN	Mr. Chyau Shen	Lt Col Marty Meyer, USAF
PMS-422	JIATFE	NAWCAD 4.5.5.6	DUSD(AT)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
S&T Funding							
0603750D	P523	2.2	2.1	1.8	0.6	0	0
Total S&T		**2.2**	**2.1**	**1.8**	**0.6**	**0**	**0**
Non-S&T Funding							
0604221N		2.3	3.9	2.4	0	0	0
MOD/UK		1.5	1.5	0.5	0	0	0
Total Non-S&T		**3.8**	**5.4**	**2.9**	**0**	**0**	**0**

C.07 Link–16 ACTD

Objectives. Provide interoperability between the Link–16 and variable message format (VMF) networks. The ACTD will provide situational awareness between the networks and digital communications connectivity for air-to-ground and maritime-to-ground attack missions. (Air and maritime operations are migrating to Link–16, while ground operations are migrating to VMF.)

Payoffs. Disparate datalink message formats and communications media have resulted in untimely, incorrect, or incomplete delivery of crucial battlespace information due to the use of translators/gateways to make these systems "communicate" with one another. Currently, it is difficult to establish seamless information flow among diverse datalink units. A major goal of this ACTD is to begin standardizing C^4I messaging and data elements used to provide a seamless, flexible datalink environment. The objective is to demonstrate a joint integrated capability to pass tactical information seamlessly across Link–16 and VMF networks. This ACTD will be demonstrated by the military services and potentially some of our NATO allies.

Challenges. The barriers include platform integration of specific, standardized C^4I messaging and data elements for messages crossing the air-to-ground and maritime-to-ground seams. Since work has been underway for several years to do waveform/frequency conversion, that technology is maturing and should be easily incorporated into this effort.

Milestones/Metrics.

FY1998: Select and define standardized C^4I messaging and data elements for CAS and TMD; develop and test appropriate software.

FY1999: Demonstrate that common TADIL–J-based message sets can be imbedded into VMF message standards that are shorter than standard Link–16/TADIL–J messages; demonstrate Link–16/VMF waveform/frequency interface in near-real time at several operational test settings.

FY2000: Provide operational support and assist with field evaluations.

Customer POC		Service/Agency POC	USD(A&T) POC
Col John Edwards, USMC HQ DAMO-FD	LtCol David Garrard, USMC MCCDC	Mr. Steven Derganc PMW-159-2A	Lt Col Marty Meyer, USAF DUSD(AT)
CAPT William Elliot, USN USACOM, J-32	Capt Ben Rich, USAF ASC2A/C26		

Programmed Funding($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
S&T Funding							
00603750D	P523	1.3	0	0	0	0	0
	Total S&T	**1.3**	**0**	**0**	**0**	**0**	**0**
Non-S&T Funding							
0604771D	P775	0	0.3	0.7	0.1	0.1	0
0604754F	4749	0.8	0	0	0	0	0
0305188		0.1	0.4	0	0	0	0
0205604N	P2126	0	0.4	0	0	0	0
	Total Non-S&T	**0.9**	**1.1**	**0.7**	**0.1**	**0.1**	**0**

JOINT THEATER MISSILE DEFENSE

Defense Technology Objectives
for the Joint Warfighting Science and Technology Plan

Joint Theater Missile Defense

D.03	Discriminating Interceptor Technology Program	I-62
D.04	Advanced X-Band Radar Module Demonstration	I-64
D.05	Advanced Space Surveillance	I-65
D.08	Atmospheric Interceptor Technology	I-66
D.10	Airborne Lasers for Theater Missile Defense	I-68

D.03 Discriminating Interceptor Technology Program

Objectives. Develop and demonstrate, in laboratory tests and low-cost interceptor flight tests, the technologies necessary for interceptor discrimination. Advanced ballistic missile defense (BMD) interceptors must discriminate with high confidence between real targets and other objects such as decoys and debris for effectiveness in an ECM environment or against reentry vehicles accompanied by decoys. An interceptor employing these technologies, used in an architecture including ground-based radar and space-based infrared satellites, could potentially protect U.S. cities and fighting forces from ballistic missile attack. Simulation results show that, depending on the attack scenario, the single-shot kill probability (P_k) can increase by as much as a factor of nine after the addition of advanced interceptor discrimination capability (P_k increases from 0.1 to 0.95). An interceptor's mass and cost will increase; however, the overall system cost will decrease because of the increased P_k. The technologies necessary for interceptor discrimination include lightweight laser radar, simultaneous multispectral long-wavelength infrared (LWIR) focal plane arrays (FPAs), highly uniform FPAs, and data fusion techniques to combine the outputs of active and passive sensors providing a fourfold improvement in terms of GFLOP/watt and GFLOP/dollar, and a seventyfold improvement in packaging density (700 GFLOP/ft^3). Technology needs for multispectral and highly uniform FPAs are also being addressed by complementary technology efforts under DTO SE.33.01, Advanced Focal Plane Array Technology. Systems benefiting from this technology are the Exoatmospheric Kill Vehicle (EKV), Theater High-Altitude Air Defense (THAAD) System, and Navy Upper Tier Interceptor.

Payoffs. Milestones and demonstrations for the Discriminating Interceptor Technology Program (DITP) include building and bench testing prototype LADARs, and lab testing simultaneous two-color LWIR FPA at a sensitivity of 0.2–1.0 x 10^{12} Jones (4Q98); down-selection between competing solid-state and CO_2 LADAR designs (1Q99), lab testing a fusion processor and algorithms, and building and lab testing a 10-kg prototype LADAR (3Q98); integrating a two-color passive FPA and fusion processor into a prototype shared-optics fused seeker (4Q99); lab and field testing a fused seeker (3Q00); and flight testing a fused seeker in an EKV observation package (4Q01). The flight testing will take advantage of the flyalong bus in a BMD core program test. This test will observe the target, decoys, and debris and perform real-time discrimination between them.

Challenges. The development of simultaneous, large-format, highly uniform, multicolor, LWIR FPAs is required. A LADAR system, both transmitter and receiver, that is less than 5-kg and will withstand the interceptor environments must be developed. Passive and active sensor systems need to be integrated into an interceptor flyalong package using a shared optical path. Development of a fusion processor is required with the required speed and data throughput to perform discrimination in real time.

Milestones/Metrics.

FY1998: Build and bench test prototype 3D imaging LADARs to power levels defined in DITP Demonstration Requirements Document; lab test simultaneous two-color LWIR FPA at 0.2–1.0 x 10^{12} Jones with cold target acquisition range capability of 500 km to 800 km and less than 1% nonuniformity.

FY1999: Integrate a two-color passive FPA, LADAR, and fusion processor into a prototype shared-optics fused seeker; continue engineering development to reduce LADAR package from 10 kg to 5 kg.

FY2001: Flight test miniature active-passive-fused sensor package as a flyalong package on a BMDO-sponsored interceptor mission.

FY2002: Begin follow-on technology development for next-generation interceptor seeker upgrades. Second verification flight test of miniature active-passive-fused sensor package as a flyalong package on a BMDO-sponsored interceptor mission.

FY2003: Develop and test follow-on seeker technology in accordance with findings and limitations uncovered in previous flight tests.

Customer POC	Service/Agency POC		USD(A&T) POC
Mr. Keith Englander BMDO/JNE	Dr. Paul Levan AFRL-VSSS	Mr. Duane Stott USASMDC	Dr. C. W. Kitchens, Jr. DDR&E(WT)
	LCDR Chip Buckley, USN BMDO/TOS		

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0603173C	1161	0.9	0	0	0	0	0
0603173C	1270	18.2	17.8	22.5	23.2	27.7	28.9
	Total	**19.1**	**17.8**	**22.5**	**23.2**	**27.7**	**28.9**

D.04 Advanced X-Band Radar Module Demonstration

Objectives. By FY00, demonstrate a fivefold increase in output power of solid-state transmit/receive (T/R) monolithic microwave integrated circuits (MMICs) operating at X-band. Current gallium arsenide (GaAs)-based MMIC technology provides output power that can be significantly increased using advanced GaAs designs such as metal semiconductor field effect transistors (FETs), pseudomorphic high-electron mobility FETs, heterogeneous FETs, and wide-bandgap devices. Advanced MMIC module packaging technologies such as stack module designs can reduce the overall occupied volume of the MMIC T/R modules, improving the efficiency of the device and its manufacturability, as well as the transportability of the system using the MMIC chips.

Payoffs. The program will begin in the second quarter of FY98. Demonstration of the advanced module will take place in the fourth quarter of FY00, and candidate designs for the Theater High-Altitude Area Defense (THAAD) ground-based radar (GBR) and the National Missile Defense (NMD) GBR will be complete by the end of FY01. The radar module development program will produce form, fit, and function replacement T/R modules for the NMD GBR and potentially the THAAD GBR with greatly increased power, efficiency, and lifetime. The program will be completed in time for potential preplanned product improvement (P^3I) insertion into the THAAD GBR, to take place from FY02 to FY04. It will allow a significant increase in GBR range. The various MMIC technologies are targeted for use in the THAAD GBR and the NMD GBR, which are both X-band multielement radars. Advanced solid-state T/R modules for the THAAD and NMD GBRs will improve their target detection capabilities by roughly a factor of two, allow them to discriminate various threats from one another by improving their sensitivities by a factor of five, and allow them to operate in a burnthrough mode to overcome jamming and radio frequency interference.

Challenges. Less expensive and more dependable growth techniques for both the substrate materials and the epitaxial layers must be developed. Better mechanisms for growing atomic-level abrupt interfaces are needed, and improvement is needed in the area of lattice mismatch mitigation.

Milestones/Metrics.

FY1998–99: Develop design-to-achieve objectives of X-band operation, four times greater output power, twice the efficiency, four times the bandwidth, extended operating time at 250°C , and size suitable for placement into a fully populated X-band phased array.

FY2000: Fabricate a small quantity of modules with test data demonstrating objective performance and recurring performance and cost estimates.

Customer POC	Service/Agency POC		USD(A&T) POC
Col Anthony DiRienzo, USAF	CDR Rob Childs, USN	Dr. Dwight Duston	Dr. C. W. Kitchens, Jr.
SSAE/AMD/NMD/R	BMDO/TOS	BMDO/TO	DDR&E(WT)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602173C	1651	4.5	4.5	4.5	0	0	0
	Total	**4.5**	**4.5**	**4.5**	**0**	**0**	**0**

D.05 Advanced Space Surveillance

Objectives. Demonstrate advanced satellite technologies required to perform precision surveillance, acquisition, and tracking of sophisticated ballistic missile targets.

Payoffs. This program will develop and demonstrate a unique multimode (ultraviolet and infrared) sensor, data fusion concepts and algorithms, and innovative processing hardware to enable advanced onboard data processing. Also, this program will demonstrate a lightweight, low-power, 10-Gbps laser communication system for future satellite-to-satellite use; new high-power, high-efficiency, long-life solar arrays; and increased efficiency, long-life Hall Effect thrusters. For distribution of satellite data, this program will develop and demonstrate wavelength-division multiplexing (WDM) waveguide components for high-density, very large bandwidth supercomputer links and distributed massively parallel computer networks.

Challenges. To meet the challenges of BMD, future space surveillance systems will require increased communication/data rates (both in space and on the ground), multimode sensors, data fusion, onboard processing, increased power, longer life, and lower weight.

Milestones/Metrics.

FY1998: 3D neural network surveillance/tracking processor demonstration (VIGILANTE). Deliver Scarlet–2 solar cells (2.6 kW, 50 W/kg, 24%-30% efficient, 100-V array voltage) to NASA for New Millennium satellite. Demonstrate 1.5-kW Russian Hall Effect thrusters (RHETTs) (20 kg, 1600s Isp, 50% efficient, 5,000-hr lifetime) in space.

FY1999: Demonstrate advanced data fusion concepts and algorithms (Innovative Science and Technology Evaluation Facility (ISTEF) testbed). Demonstrate satellite-to-ground, high-data-rate laser communications—Space Technology Research Vehicle (STRV–2).

FY2000: Demonstrate terabit bandwidth communications with WDM components.

FY2001: UV/IR focal plane array available for testing. Deliver Scarlet–3 solar cells (70 W/kg, 24%–30% efficient, 500-V array voltage, 7-yr life).

Customer POC	**Service/Agency POC**	**USD(A&T) POC**
Col Kathy Roberts, USAF Space and Missile Center	Dr. Dwight Duston BMDO/TO	Dr. C. W. Kitchens, Jr. DDR&E(WT)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602173C	1651	7.5	7.5	7.0	7.0	0	0
0603173C	1161	0.9	0	0	0	0	0
	Total	**8.4**	**7.5**	**7.0**	**7.0**	**0**	**0**

D.08 Atmospheric Interceptor Technology

Objectives. Develop, integrate, and demonstrate lightweight kill vehicle technologies that can withstand high thermal stress environments, including intercepts at 25-km altitude with interceptor velocities of 4 km/s. Hypersonic hit-to-kill intercepts of TBMs within the atmosphere provide significantly expanded areas of protected coverage over current systems, take advantage of atmospheric stripping of decoys to reduce countermeasure discrimination requirements, provide a capability against TBMs whose trajectories remain in the atmosphere, and permit intercepts of TBMs in the boost phase of their trajectories. Lightweight technologies are critical for incorporating these kill vehicles in existing and planned theater missile defense (TMD) systems as block upgrades or preplanned product improvements to preserve service weapon system infrastructures. Atmospheric interceptor technologies (AITs) being developed are applicable to advanced Navy theater-wide defense, advanced THAAD, Medium Extended Air Defense System (MEADS), and unmanned aerial vehicle/boost-phase intercept (UAV/BPI). The technology development effort emphasizes cooled windows/forebodies, strapdown IR seekers, lightweight composite vehicle airframe structures, and solid divert and attitude control systems (DACSs). AIT is the only atmospheric kill vehicle technology program within BMDO.

Payoffs. Planned demonstrations will provide (1) new capabilities with reduced costs/risks compared with current interceptor weapon systems, and enhancements to other interceptors under development; (2) reduction of technical risks and costs in support of acquisition programs through direct technology insertions; and (3) technical solutions to provide TMD interceptor capabilities for contingencies not currently addressed by the TMD system programs. Component and subsystem technology development will continue through FY01. An integrated kill vehicle will be available for ground test in FY02 with hit-to-kill flight test demonstrations completed by FY05.

Challenges. Cooled forebodies have been demonstrated in ground testing to withstand the aerothermal loads of the hypersonic endoatmospheric flight regime. Aero-optic effects of a hypersonic flowfield on an externally helium-cooled forebody/window concept have been measured in ground testing under conditions duplicating the flight environment and have been consistent with analytical predictions. Strapdown seeker components have been demonstrated in ground tests, and a prototype seeker is planned for demonstration in ground tests in FY98. Thermal management challenges to withstand the thermal loads of the hypersonic endoatmospheric flight regime will be addressed with the use of cooled windows and advanced kill vehicle thermal protection systems. The primary strapdown seeker challenge is the stabilization of the target image in order to provide sufficiently accurate guidance for hit-to-kill intercepts. AIT seekers will incorporate both active motion stabilization through high-speed mirrors and passive electronic signal processing of the image to compensate for both rigid and flexible body motion and counter the effects of divert thruster firings. Solid DACS challenges relate to providing high divert thrust at the lowest possible weight to ensure high lateral acceleration to provide hit-to-kill capability against highly accelerating targets.

Milestones/Metrics.

FY1998: Flightweight 1,000-lbf thrust divert valve demonstration. Successful demonstration of a flightweight 1,000-lbf divert valve will enable significant reductions in system weight with concomitant higher kill vehicle divert acceleration to enable intercepts of maneuvering targets. Jet interaction aerodynamic and radiance effects measurements in hypersonic shock tunnel facility. The effects of full-scale, hot-gas, solid 1,000-lbf-class divert thruster firings on vehicle aerodynamics and on background radiance through the kill vehicle window will be measured and compared to analytical predictions to validate analysis codes. Strapdown seeker prototype demonstration with active motion

compensation, which enables the cancellation of the effects of both rigid and flexible body motion on the seeker's target line-of-sight measurements. Motion cancellation of <60 μrad will be demonstrated.

FY1999: Developmental flight test to measure divert thruster jet interaction radiance and aerodynamic effects in actual flight conditions. Flight test verification of jet interaction results obtained in shock tunnel testing in FY98 will validate that measurements are not influenced by tunnel wall effects.

FY2000: Solid DACS hot-fire test. System-level test of solid DACS of the 1,000-lbf-thrust class will enable the incorporation of solid DACS into atmospheric kill vehicles eliminating the toxicity and storage limitations of liquid propulsive DACSs.

FY2001: Flight test vehicle critical design review. Completion of critical design review of the flight test vehicle will permit fabrication of flight test vehicles for demonstrating hypersonic hit-to-kill intercepts of ballistic missile targets in the atmosphere.

FY2002: Dynamic tests using the ground test vehicle or equivalent tethered tests will demonstrate the interaction of the vehicle seeker, guidance, DACS, and airframe.

FY2003: Conduct a flight test of the AIT flight test demonstration vehicle to show that the vehicle can maintain stable flight with the attitude control thrusters in the presence of divert thruster firings and that the seeker can maintain track of a celestial object during the test.

Customer POC	**Service/Agency POC**	**USD(A&T) POC**
COL W. Hastie, USA	Maj Buford Shipley, USAF	COL J. E. O Pray, USA
BMDO/AQQ	BMDO/TOS	DDR&E(SA)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0603173C	A1270	14.3	13.4	18.2	19.1	24.1	27.1
	Total	**14.3**	**13.4**	**18.2**	**19.1**	**24.1**	**27.1**

D.10 Airborne Lasers for Theater Missile Defense

Objectives. Develop and demonstrate technology to reduce the risk and improve performance for the airborne laser (ABL) system acquisition program. This DTO addresses key risk-reduction issues for development of the ABL prototype during the preliminary design and risk reduction (PDRR) phase and demonstrates advanced technology at a level of maturity that will support transition to operational ABL system development during the engineering and manufacturing development (EMD) phase, which begins in FY03. Specific demonstrations include active tracking field tests against boosting missiles, and ground testing of integrated atmospheric compensation and tracking, scaled to replicate the propagation conditions expected in a theater missile engagement scenario. ABL technology objectives are to increase the atmospheric compensation and beam jitter strehl ratios (ratio of the beam intensity achieved compared to the ideal) by a factor of 2 and to increase the laser device efficiency by 10%–20%.

Payoffs. The Air Force separately funds the ABL system acquisition program to develop a warfighter capability to engage and negate theater ballistic missiles in the boost phase. The operational ABL system will be the boost-phase negation portion of the overall DoD theater missile defense (TMD) architecture, which also includes midcourse and terminal negation by kinetic kill intercept systems. Tracking, adaptive optics, and laser device technologies developed under this DTO pay off in performance growth and additional margin in the operational capability of the ABL weapon system. If objectives can be met and the technology transitioned to the ABL system, the ABL operational range could be increased by approximately 25%, and the available lasing time could be increased by 10%–20% without any changes in overall ABL laser system weight.

Challenges. Key technical challenges include development of laser device technology to meet the weight and volume constraints of the aircraft platform, and development of adaptive optics and beam control technology to substantially compensate for optical distortions and beam jitter introduced in the ABL propagation scenario. Chemical oxygen-iodine laser (COIL) device and adaptive optics beam control design concepts have been developed for the ABL system that are predicted to meet baseline performance requirements. To achieve and demonstrate further performance improvements, the challenges for COIL device technology are (1) to improve the detailed understanding of COIL device operation and performance for identifying and quantifying efficiency loss mechanisms, and (2) to develop and demonstrate new hardware and operational concepts for reducing losses and thus improving overall COIL device efficiency. For adaptive optics/beam control technology, the challenge is to further improve the ability to measure and compensate for the distortions caused by high-energy laser propagation over long horizontal paths with significant atmospheric turbulence. More specifically, the challenge is to develop and demonstrate advanced technology that will improve the ability to deal with scintillation effects in the sensing of track jitter and higher order phrase distortions caused by atmospheric turbulence and in determining and applying the correct compensation to the outgoing high-energy laser beam at high bandwidth (over 500 Hz) with fast steering mirrors and adaptive optics.

Milestones/Metrics.

FY1998: Meet active tracking, scaled tracking/atmospheric compensation, and atmospheric characterization risk-reduction goals by the ABL system ATP–1 milestone date.

FY1999: Complete first round of field testing of advanced tracking and atmospheric compensation concepts against static targets over a scaled, 50-km propagation range.

FY2000: Begin field testing of advanced tracking and atmospheric compensation concepts against a scaled dynamic target (an instrumented target board on an aircraft).

FY2002: Complete demonstration of technology to support ABL design updates for EMD phase.

Customer POC	**Service/Agency POC**	**USD(A&T) POC**
Col Mike Booen, USAF	Mr. Michael Flynn	Dr. C. W. Kitchens, Jr.
SMC/TM (ABL SPO)	SAF/AQR	DDR&E(WT)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0603605F	3647	10.0	9.4	9.7	9.0	8.2	0
	Total	10.0	9.4	9.7	9.0	8.2	0

MILITARY OPERATIONS IN URBAN TERRAIN

Defense Technology Objectives for the Joint Warfighting Science and Technology Plan

Military Operations in Urban Terrain

E.01 Small-Unit Operations TD I-72
E.02 Military Operations in Urban Terrain ACTD I-74
E.03 Objective Individual Combat Weapon ATD I-76
E.04 Nonlethal Weapons Technical Demonstration I-77

E.01 Small-Unit Operations TD

Objectives. By FY01, demonstrate the capability to provide (1) scaleable, nonhierarchical networks with robust communications to enhance decision making at all echelons involved in MOUT operations; (2) situation awareness for tactical-level combatants to enhance collaborative planning from the battalion level down to the individual soldier or marine; (3) tasking and control of multiple autonomous systems with multiagent tasking and planning algorithms, integrated reflective and reactive planning, and automated tasking decomposition strategies; and (4) an internetted and arrayed advanced sensor capability, dynamically linked with situational awareness and tasking capability, to extend the tactical local area awareness and provide a flexible precision targeting capability integrated into the communications and geolocation architecture.

Payoffs. Specific capabilities to be demonstrated include (1) wireless communications providing voice, data, video, and graphics (operating in a severe multipath environment) with a twofold to fivefold range increase and a greater than 40-dB process gain in a lightweight (less than 1 kg without battery) package integrated with geolocation and navigation technologies capable of better than 3-m location accuracy that operate reliably in built-up environments with intermittent or obscured GPS data; (2) distributed, interactive hubs to monitor and automatically update data, alerts, and warnings in a collaborative environment providing a moving bubble of the battlespace (8-30-km radius providing 8–10-min warning time) to teams subordinate to the battalion; (3) a precision clock with rapid startup (2–5 s) and high stability (1×10^{-12}) to provide precision geolocation and navigation for comprehensive situational awareness; and (4) sensor technology with volume of 1 in^3 to 1 ft^3, operating life from 1 day to 2 months, and coverage to 30 km to detect, locate, identify, and report targets.

Challenges. The enabling technologies to be exploited include enhanced packaging; forward error correction coding; advanced protocols; diverse antenna technologies; multichannel, variable bandwidth; advanced modulation techniques; intelligent software agents to aid in filtering, planning, and decision making; and precision GPS. Technology barriers that must be overcome are lightweight power sources, dynamically reconfigurable networks, RF propagation in restrictive environments, GPS acquisition in restrictive environments, and digital loran.

Milestones/Metrics.

FY1999: Five competing designs for SUO synthetic aperture sonar (SAS) advanced concepts and technologies developed by industry and evaluated. Define SUO SAS demonstration and evaluation program. Demonstrate sensor, tasking, and control brassboard.

FY2000: Design two competing detailed systems; demonstrate key technology areas in laboratory. Select objective SUO SAS system design. Complete concept evaluation and demonstration. Complete SAS component build to brassboard level; complete component integration.

FY2001: SUO will demonstrate tactical-level, real-time, essential information and communications, scaleable from the individual soldier to the battalion, operating in urban, forested, and mountainous environments: lightweight (<1 kg excluding batteries), low power (<5 W), precision geolocations (<3 m), situation awareness (8–10-min moving bubble of the battlespace for teams).

Customer POC		Service/Agency POC	USD(A&T) POC
COL Timothy Bosse, USA USA DBBL	LtCol Duane Schattle, USMC NAVSEA J8/LLD	Dr. Mark McHenry DARPA/TTO	COL John Fricas, USA DUSD(AT)
Col James Lasswell, USMC USMC/MCWL			

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0603764E	LNW-02	38.6	55.9	60.4	61.7	0	0
	Total	**38.6**	**55.9**	**60.4**	**61.7**	**0**	**0**

E.02 Military Operations in Urban Terrain ACTD

Objectives. Integrate COTS, GOTS, and service/DARPA/OGA developmental technologies, along with advanced operational concepts and tactics, techniques, and procedures (TTP), into a MOUT system of systems to improve the operational effectiveness of Army and Marine Corps infantry in urban or built-up areas at battalion and below in the areas of C^4I, engagement, force protection, and mobility.

Payoffs. The MOUT ACTD will include field experiments and simulations to demonstrate the interoperability and functionality of the integrated system of systems, with supporting TTP, including the following specific capabilities: non-line-of-sight communications; position and location, intelligence collection, and dissemination via advanced sensors; through-wall sensors mapping to the small-unit and advanced marking capabilities; nonlethal capabilities for controlling personnel and vehicles; advanced MOUT munitions and breaching capabilities; precision mortars; countersniper, combat identification, small arms protection, and booby trap detection/disarmament; advanced individual mobility; and mission rehearsal capabilities for leaders. The military utility of individual and aggregated technologies and advanced operational concepts/TTP will be quantified through distributed interactive simulation or high-level-architecture instrumentation and supporting suite of modeling and simulation tools. The ACTD will culminate in a battalion-level experiment at the Joint Readiness Training Center (JRTC). An interim capability will be provided for 2 years following the ACTD to units in the XVIII Airborne Corps and 2nd Marine Division.

Challenges. The most significant challenge is the integration of existing and emerging technologies while still ensuring optimum effectiveness in the restricted MOUT terrain. A MOUT ACTD systems architecture that is responsive to users' operational concept and mission threads will be developed and implemented as the blueprint to integrate the myriad of products that, in aggregate, will meet the 32 user requirements. It will also ensure appropriate connectivity with other organic assets and developing technologies that are external to the ACTD products per se, but with which ACTD products must interface in operational situations.

Milestones/Metrics.

FY1998: Develop MOUT ACTD systems architecture; complete MOUT Performance Predictor Tool; complete MOUT site instrumentation; establish baseline; initiate squad/platoon experiments.

FY1999: Complete squad/platoon experiments; complete two integrating experiments.

FY2000: Complete battalion-level culminating demonstration: 25% increase in lethality, 20% increase in force protection, 50% increase in C^4I, and 20% increase in mobility.

FY2002: Complete residual phase of ACTD.

Customer POC	Service/Agency POC	USD(A&T) POC
COL Timothy Bosse, USA USA DBBL	Ms. Carol Fitzgerald USA SSCOM	COL John Fricas, USA DUSD(AT)
Col James Lasswell, USMC USMC/MCWL	Mr. Bruce Zimmerman SARD-TT	

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0603001A	393	19.1	19.6	19.1	1.8	1.8	0
0603750D	P523	5.7	0	0	0	0	0
	Total	**24.8**	**19.6**	**19.1**	**1.8**	**1.8**	**0**

E.03 Objective Individual Combat Weapon ATD

Objectives. By FY99, demonstrate affordable, high-payoff individual weapon system technologies that yield significantly improved hit probability, lethality, and operational capability through the use of 20-mm air-bursting munitions, 5.56-mm kinetic energy projectiles, and opto-electronic fire control. FY99 testing will demonstrate the Objective Individual Combat Weapon's (OICW's) operational utility, technological maturity, and ability to affect decisively violent and suppressive target effects. The OICW dual-munition system provides the ability to effectively acquire, engage, and incapacitate personnel targets in all operational scenarios. The air-bursting munition will defeat defilade targets (targets the M16 cannot) in reduced visibility conditions (night/all-weather) and at extended ranges. The OICW concept will replace selected M16A2 rifles, M4 carbines, M16 Modular Weapon Systems, and M203 grenade launchers.

Payoffs. The OICW ATD will demonstrate affordable, high-payoff individual weapon technologies. Specific capabilities to be demonstrated include at least a 50% probability of incapacitation (P_i) against individual targets to 300 m, a 20% P_i against defilade targets, and detection of targets to 1,000 meters at night and in reduced visibility conditions. Enabling technologies to be exploited are advanced opto-electronic video sighting, target tracking/detection, computerized aimpoint displacement, precision laser rangefinding, modularized thermal sighting, electronic target handoff, and an efficient air-bursting munition.

Challenges. The OICW concept represents a system integration of emerging and existing technologies offering new capabilities and revolutionary operational benefits. Areas of technical concern include accurate laser ranging, efficient fragmentation, system ruggedness and integration, fuze robustness and miniaturization, and weight minimization.

Milestones/Metrics.

FY1998: Demonstrate OICW functionality from a benchtest, achieving P_i >0.5 at 300 m (point targets); system weight (fire control, ammo, weapon) <18 lb. Downselect to a single contractor.

FY1999: Complete hardware build for six OICW systems. Safety certify and man-fire OICWs, demonstrating P_i >0.5 at 300 m (point targets), P_i >0.2 at 300 m (defilade targets), area target suppression to 1,000 m, system weight <18 lb, and OICW operational utility and technological maturity.

Customer POC		Service/Agency POC	USD(A&T) POC
Col Eldard, USAF HQ USAF/SPX	CDR Huss, USN USN, PMS 340	Mr. Robert Stiegler NSWCDD	Dr. C. W. Kitchens, Jr. DDR&E(WT)
CAPT Laird Hail, USCG USCG/OCM	Col Rick Owen, USMC MARCORSYSCOM(CBG)	Mr. Matthew Zimmerman ARDEC	
COL Robert Hobbs, USA USAIC	Col D. Voorhees, USMC USSOCOM		

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0603607A	627	6.4	4.4	0	0	0	0
0603640M	C2223	1.2	0.6	0	0	0	0
	Total	**7.6**	**5.0**	**0**	**0**	**0**	**0**

E.04 Nonlethal Weapons Technical Demonstration

Objectives. Develop, demonstrate, and expedite fielding of antipersonnel and antimateriel nonlethal devices, munitions, and weapons. Mission areas of priority include crowd control; localizing or dispersing noncombatants; denying an area to personnel or vehicles; and disabling vehicles, aircraft, vessels, facilities, and equipment.

Payoffs. U.S. forces have few current options for conducting operations in the above mission areas in the MOUT environment within the stringent rules of engagement that often apply. Technologies from this program will lead to increased nonlethal options for the theater CINCs and field commanders.

Challenges. Technical challenges include development of acoustic, kinetic, and directed-energy technologies that will operate at sufficient ranges and be logistically supportable, along with generation and verification of bio-effects data to ensure system nonlethality.

Milestones/Metrics.

FY1998: *Acoustics*—determine specific acoustic frequencies that achieve noise interference level resonance bio-effects. *Delay/Denial Technology*—evaluate directed-energy technologies for area delay or denial. *Kinetics*—breadboard a nonlethal MK19 machinegun system retrofit with muzzle adapter and use blank rounds to generate vortex rings that will deliver nonlethal concussion or impact air pressure waves with greater than 75% of effects criteria. *Vehicle Stoppers*—for maritime vessels, downselect nonlethal options for disabling 90% of all target sets (small patrol craft) with diesel-powered inboard engines within 5 min; for ground vehicles, demonstrate engine shutdown within 25 s of electromagnetic frequency radiation using indoor dynametric facility.

FY1999: *Acoustics*—identify acoustic weapon design and performance requirements to achieve 100% of specific effects. *Kinetics*—measure concussion pressure waves to determine psi levels of vortex rings. *Delay/Denial Technology*—demonstrate selected directed-energy technologies for area delay or denial at 80% confidence level. *Vehicle Stoppers*—for maritime vessels, develop prototype of selected nonlethal option; for ground vehicles, conduct outdoor field test of prototype system.

Customer POC		Service/Agency POC	USD(A&T) POC
BG Clark, USA TRADOC	CAPT Robert Rieve, USN N851	Col A. F. Mazzara, USMC Joint Nonlethal Weapons	Dr. C. W. Kitchens, Jr. DDR&E(WT)
Col Miner, USAF XORBP	Maj Brian Wilhoite, USMC MCCDC/NL		

Non-S&T Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0603851M		6.2	10.6	8.1	8.3	8.6	0
Total Non-S&T		**6.2**	**10.6**	**8.1**	**8.3**	**8.6**	**0**

JOINT READINESS AND LOGISTICS AND SUSTAINMENT OF STRATEGIC SYSTEMS

Defense Technology Objectives
for the Joint Warfighting Science and Technology Plan

Joint Readiness and Logistics and Sustainment of Strategic Systems

F.01 Synthetic Theater of War ACTD I-80
F.02 Advanced Joint Planning ACTD I-82
F.05 MARITECH I-83
F.06 Joint Training Performance Assessment Technologies I-85
F.10 Joint Readiness Extension to Advanced Joint Planning ACTD I-87
F.16 Logistics Technologies for Flexible Contingency Deployments and Operations I-89
F.17 Advanced Amphibious Logistics and Seabasing for Expeditionary Force Operations ATD I-90
F.18 Joint Advanced Health and Usage Monitoring System ACTD I-92
F.19 Joint Logistics ACTD I-94
F.20 Joint Modular Lighterage System ACTD I-96
F.22 Battery Charger/Analyzer I-98
F.23 Modular Aircraft Support System I-99
K.01 Post-Boost Control System Technology I-100
K.02 Missile Flight Science I-101
K.03 Aging and Surveillance Technology I-102
K.04 Underwater Launch Technology I-103
K.05 Submarine Navigation Technology I-104
K.06 Missile Propulsion Technology I-105

F.01 Synthetic Theater of War ACTD

Objectives. Improve the quality of simulations by developing representations of combat actions resolved at the weapon system level, command and control behaviors, and high-resolution dynamic environments that include tactically significant environmental effects. Synthetic theater of war (STOW) will improve simulation training effectiveness and flexibility by interfacing simulations with operational C^4I systems. A goal is to reduce the overhead cost of simulation by developing knowledge-based synthetic forces, faster database builds, and improved information transfer among participants.

Payoffs. Payoffs include scaleability to support, in real time, 10,000 dynamic entities per simulation exercise; command forces at the battalion level or equivalent in all services; intelligent synthetic force platforms for rotary- and fixed-wing aircraft; new standardized representations of synthetic environment databases; optimized terrain representations for triangulated irregular networks and for large geographic regions; key agile encryption systems for asynchronous transfer mode (ATM) networks and dynamic multicasting software and hardware to support thousands of multicast groups; and prototype scenario generation and distributed exercise control technologies. Payoffs also include Joint Task Force (JTF) training and mission rehearsal capabilities; system support and enhancements for USACOM joint training and mission rehearsal; and the transition of lessons learned from warfighter use of STOW technology, along with STOW technology improvements, to Joint Simulation System (JSIMS) and service simulations. Other expected payoffs from the STOW ACTD include operational interfaces between the STOW synthetic battlespace and real-world C^4I systems, reductions in required exercise support personnel through the use of company- and battalion-level synthetic command entities, and new exercise generation and initialization techniques.

Challenges. Significant technical challenges for the STOW ACTD include scaleability of large, entity-based exercises; real-time, object-oriented-simulation, run-time infrastructure; security of distributed simulation over ATM multicast networks; simulation of robust synthetic force and command force behaviors; and correlated multiresolution databases.

Milestones/Metrics.

FY1998: Demonstration of the STOW synthetic battlespace as the driver for a JTF-level training exercise and a TMD exercise.

FY1999: Demonstration of the STOW synthetic battlespace as the driver for a JTF mission rehearsal exercise.

Customer POC	Service/Agency POC		USD(A&T) POC
CAPT Drew Beasley, USN JSIMS JPO	Mr. Larry Budge DARPA/ISO	CAPT Jay Kistler, USN NAVMSMO	Dr. Judith Daly ADUSD(AD)
LTC Bob Strini, USA USACOM J-7	COL Henry Ruth, USA USAMSO	Lt Col Doug Martin, USAF JWFC, USAF	
Col Michael Fallon, USMC MCCDC-OSI			

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
S&T Funding							
0603750D	P523	2.3	2.4	0	0	0	0
0603761E	CST-01	13.3	12.9	0	0	0	0
Total S&T		**15.6**	**15.3**	**0**	**0**	**0**	**0**
Non-S&T Funding							
UK		2.8	0	0	0	0	0
Total Non-S&T		**2.8**	**0**	**0**	**0**	**0**	**0**

F.02 Advanced Joint Planning ACTD

Objectives. Provide USACOM, Joint Staff, and other CINCs with an increased ability to rapidly plan, package, and deploy forces to multiple regional conflicts. The Advanced Joint Planning (AJP) ACTD will develop, demonstrate, and establish an enhanced C^4 planning capability. The program focuses on three primary areas: force readiness and deployment planning, force employment planning, and force rehearsal and evaluation. The program will adapt the technologies developed by the Joint Task Force ATD (e.g., architecture, application, servers, schema) and other DARPA initiatives for configuration into USACOM's C^4 environment. Emerging C^4 software tools will be tailored to primary areas of application and then integrated, employing a CONOPS developed as a part of this program. Close interaction among developers, sustainers, and users will enhance the utility and transition of the resulting capability. This new functionality will provide a supported leave-behind capability at USACOM before undergoing transition through the DISA Global Command and Control System (GCCS) Leading Edge Services (LES) into the GCCS core service for application with other users.

Payoffs. Overall performance goals are to reduce CINC planning cycles from weeks to days or hours for crises, and from several weeks to less than a week for major deployments. The warfighter will be afforded a set of user-defined, key automated planning functions providing rapid visibility to readiness; needed tools for force deployment; and employment planning, rehearsal, and evaluation. The implementation phase (FY94–97) focused on readiness and deployment analysis, force employment planning, and force rehearsal and evaluation initiatives. Currently, this ACTD is being transitioned to the GCCS LES as a leave-behind system.

Challenges. The system must be hardened before transition.

Milestones/Metrics.

FY1998: This effort will undergo transition to the GCCS LES subsequent to a period of leave-behind maintenance support for readiness and deployment analysis, force employment planning, and force rehearsal and evaluation tools.

FY1999: Continue transition to DII COE.

Customer POC	**Service/Agency POC**	**USD(A&T) POC**
LtCol Paul Gillis, USMC	Dr. Robert McWilliams	CAPT Thomas Radich, USN
USACOM	DARPA/ATS/JPO	DUSD(AT)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0603750D	P523	1.5	1.6	0	0	0	0
0603760E	CCC-01	1.4	0	0	0	0	0
	Total	**2.9**	**1.6**	**0**	**0**	**0**	**0**

F.05 MARITECH

Objectives. Support the future readiness of naval forces by preserving the shipbuilding industrial base during the current and projected downturn in military ship construction. The MARITECH program is the technology portion of the president's five-part plan to revitalize U.S. commercial shipbuilding. An equally important reason for revitalization is to put in place competitive commercial practices that can be applied for more efficient and affordable Navy ship construction in the future. The objective of MARITECH is to accelerate the change in culture of the U.S. shipbuilding industry from its past focus on military ship construction and that market's attendant inefficiencies to a highly competitive international commercial ship supplier through the development of international competitive ship designs, process rationalization, development and implementation of advanced shipyard management, ship design, and ship construction technologies.

Payoffs. The most significant benefit of the MARITECH program is the maintenance of the shipbuilding industrial base to be available in time of heightened need for naval vessels. The MARITECH program has three major thrusts with distinct payoffs in each area. (1) *Near-term technology application*: develop a portfolio of more than 30 commercial ship designs for international market opportunities and implement strategies for building these ships at competitive world prices by fostering commercial shipyard management practices to include market analysis, product development, proactive marketing, and development of competitive financing plans. Commercial process rationalization is a critical step before applying advanced technology. The objective for this area is for several shipyards to successfully break into the international market. (2) *Advanced technology development*: develop discrete and enterprise-wide advanced technologies that improve the performance and affordability of ship design offered by U.S yards or significantly improve ship design and construction processes. These technologies will be implemented by U.S. yards to leapfrog the competition and thereby sustain a U.S. presence in the international market. These technologies will be applied to improve the affordability and performance of Navy ships. The objective of this area is to reduce the time and manhours to build a commercial ship by more than 50%. (3) *Electronic commerce/computer-integrated enterprise*: establish a national shipbuilding electronic information infrastructure linking shipyards, suppliers, financiers, customers, and regulatory bodies for the U.S. shipyard industry to facilitate rapid response to all commercial and military market opportunities with competitive and affordable ship designs and build strategies. The objective of this area is to reduce the time to respond to customer inquiries for a new ship from 6 months to less than 4 weeks.

Challenges. The most significant challenges for the MARITECH program are the cultural difficulties that occur within a traditionally insular industry. Information technology (IT) challenges are the second important factor on which MARITECH is focusing. There are currently nine IT projects underway within the MARITECH program that are attempting to develop solutions within three project areas: infrastructure, tools, and content. These solutions will develop and implement advanced IT along the shipbuilding continuum of concept formulation and marketing, detailed design and construction, and life-cycle support.

Milestones/Metrics.

FY1998: Deliver two international commercial ships; 19 ships currently under commercial construction (the designs and construction strategies for all these ships developed under MARITECH). Transition MARITECH-developed technologies to the shipbuilding industry for use on Navy ship construction.

FY1999: Initiate additional advanced technology development efforts to support the design and construction of Navy ships. Continue transition of MARITECH-developed technologies to the shipbuilding industry for use on Navy ship construction. Transition MARITECH management from DARPA to the Navy.

Customer POC
Mr. Paul Schneider
NAVSEA

Service/Agency POC
Mr. Joseph Byrne
OSR MAR 750

Mr. Robert Schaffran
DARPA/TTO

Mr. Andrew Dallas
DARPA/TTO

USD(A&T) POC
Dr. Donald Dix
DDR&E(AT)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0603746E	MR-01	36.0	15.0	0	0	0	0
	Total	**36.0**	**15.0**	**0**	**0**	**0**	**0**

F.06 Joint Training Performance Assessment Technologies

Objectives. Develop and demonstrate new measurement methods to evaluate complex simulations for training and rehearsal by higher echelons and joint forces. The research will assess how well simulations support the procedures that joint forces need to communicate, coordinate, and synchronize resources to accomplish joint mission-essential tasks (JMETs).

Payoffs. The services will develop new measures that will then be validated in joint operational training exercises that leverage large investments in distributed synthetic environments, modeling, and simulation. The complex mission selected for the R&D is joint fire support (air, ground, sea, and C4I). Accurate measurement in this training will improve assessment, allow targeted training of tasks requiring added training, and enhance synchronization of joint fires.

Challenges. Existing measures, developed for individual services, are subjective and difficult to aggregate for joint use. Furthermore, simulation and modeling environments lack instrumentation for collecting and processing assessment data, particularly for measuring the mission planning performance of joint staffs. Finally, the theory of measurement for joint training performance and mission capability needs definition.

Milestones/Metrics.

FY1998: Measurement methods—define alternative methods to measure the complex performance of large organizations; measures represent more than 90% of JMETs for a fire support mission.

FY1999: Feedback methods—develop and evaluate measures of how well simulations support the planning and conduct of multisite, multiservice, multiechelon exercises. After-action reviews and in-process training reviews will result in 25% fewer errors in day-to-day training performance.

FY2000: Training integration—develop and test improved integration of simulations, JMETs, and performance measurement; demonstrate it by a 50% expansion in the number of warfighting tasks measured and assessed during exercises.

FY2001: Generalizability—test the generalizability of the measurement methods with training, other than joint fires operations, by demonstrating more than 90% coverage of JMET requirements in the areas of maneuver, intelligence, and logistics operations.

Customer POC		Service/Agency POC	USD(A&T) POC
LtCol H. J. Coble, USMC Joint Staff, J7 JETD	COL Robert Reddy, USA USA ATSC TRADOC	Dr. Beverly Harris ARI, SARD-TR	Dr. Anna Johnson-Winegar DDR&E(E&LS)
LTC William Diehl, USA Joint Warfighting Center		Dr. Robert Seidel ARI, PERI-II	

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
S&T Funding							
0602233N		0.2	0.2	0.2	0.2	0	0
0603007A	792	0.6	0.6	0.6	0.6	0	0
0602202F	1123	0.5	0.5	0.5	0	0	0
0603227F	2743	0.4	0.6	0.5	0	0	0
Total S&T		**1.7**	**1.9**	**1.8**	**0.8**	**0**	**0**
Non-S&T Funding							
0902298J	Joint Trng	1.6	1.6	1.6	1.6	0	0
Total Non-S&T		**1.6**	**1.6**	**1.6**	**1.6**	**0**	**0**

F.10 Joint Readiness Extension to Advanced Joint Planning ACTD

Objectives. Extend the Advanced Joint Planning (AJP) ACTD (DTO F.02) to include the Automated Joint Monthly Readiness Review (AJMRR) program. AJMRR is developing and will demonstrate an automated capability supporting the joint staff's Joint Monthly Readiness Review (JMRR) analysis and brief-building process. Its objective is an expedited and accurate JMRR product to support joint staff and OSD force management and procurement issue resolution and decision making. The chairman, JCS is tasked to ensure the readiness of forces. Until recently, the only defined process for evaluating readiness metrics was based on the service-derived Status of Readiness and Training System (SORTS) data. With the recent emphasis on joint operations and joint warfighting capability, new metrics have been identified in eight functional areas. These metrics are evaluated by the various CINCs and CSAs, describing the current status, 12-month projected state, and readiness state in response to prescribed two major theater war scenarios. CINC/CSA joint readiness, together with service readiness and training data, provides the basis for JMRR evaluations and recommendations. The JMRR focus on these three readiness reviews directly supports the national military strategy of peacetime engagement, deterrence/conflict prevention, and ability to fight and win wars.

Payoffs. Each quarter, representatives from the Joint Staff Readiness Division and five services brief the vice chairman of the Joint Chiefs of Staff on the overall readiness of the armed forces—the JMRR. Before each briefing, the joint staff, unified commands, services, and CSAs collect information from their numerous components and aggregate it into a single briefing. To collect this information, the readiness community uses a variety of methods, including secure fax, telephone, and e-mail. This collection process is slow and nonstandardized. The AJMRR system standardizes and automates the JMRR process by allowing the unified commands, services, CSAs, and joint staff to exchange readiness information over the SIPRNet. This greatly facilitates the exchange of messages and files among participants. The system is designed to reach to the lowest echelons of the readiness community, transmitting readiness data from action officers from remote component commands through headquarters to the Joint Staff Readiness Division. This extension of the automated process improves the accuracy of collected information, which is the basis on which commanders make their subjective evaluation of readiness.

Challenges. The AJMRR entails development of a common interface to readiness information across a readiness community consisting of CINCs, services, CSAs, OSD, and the joint staff. This interface will include developmental challenges such as AJMRR-specific processes incorporating distributed objects to include scenario specification screens and entry, aggregation, collaboration, and presentation of JMRR-reported information; establishment of client-server replication of objects; creation of automated screens for reporting functional area readiness levels, which allows readiness reports to be published on the fly; implementation of integrated Web-based technology to publish the briefings so any AJMRR participant can view them with a Web browser; and use of video teleconferencing (VTC), file transfer, and electronic whiteboard capabilities available in the common operating environment (COE) to enhance collaboration among readiness players.

Milestones/Metrics.

FY1998: Final implementation and interim phase; provides single briefing in Web format instead of 21 separate PowerPoint briefings, and collaboration (VTC, whiteboard, etc.) using DII COE core services. This the final year and interim period for the AJMRR extension to the AJP ACTD.

Customer POC	Service/Agency POC	USD(A&T) POC
LtCol Paul Gillis, USMC	Dr. Robert McWilliams	CAPT Thomas Radich, USN
USACOM	DARPA/ATS-JPO	DUSD(AT)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0603750D	P523	0.3	0	0	0	0	0
	Total	**0.3**	**0**	**0**	**0**	**0**	**0**

F.16 Logistics Technologies for Flexible Contingency Deployments and Operations

Objectives. (1) Develop, demonstrate, and field test a suite of advanced deployment planning and beddown resource prediction and analysis tools. (2) Develop and demonstrate new technologies and methods to improve both wing and theater-level deployment planning and execution processes to support flexible and rapid contingency deployments, prediction of support asset and airlift requirements, and beddown/operations at deployed locations. This work is focused on both deployment to and employment in theater and directly supports the operational objectives of two of the Air Force core competencies, Agile Combat Support and Rapid Global Mobility.

Payoffs. Warfighter benefits include reduced response time, logistics airlift requirements, and footprint for deployed units, and more timely and accurate planning data for more efficient and effective use of deployment resources. These planning and contingency deployment tools will reduce the time required to react to deployment tasking and accelerate the deployment process itself. Through better planning, it will also reduce the quantity and corresponding costs of initial airlift and materiel and support operations. Current planning for deployment and mobility exercises is largely a manual process relying on past experience and dated contingency plans. This suite of tools will provide a capability to rapidly assess deployment requirements by collecting and integrating the required information and making it instantly available to planners. The system will be demonstrated in direct support of several DoD agencies, including the Army and Marine Corps, joint operations, and numerous operating AF MAJCOMs, providing faster and more accurate integrated deployment planning and asset prediction and resulting in significant deployment and sustainment cost savings.

Challenges. Primary technical challenges are the identification and development of embedded rule-based planning support tools that capture the constraints, considerations, and implications of the service-specific and Joint Force Air Component Command planning process embedded in an easily used human interface design. Additional challenges are development of integrated methods to allow logistics planners to collect and store widely divergent data ranging from site survey analyses through the re-employment process.

Milestones/Metrics.

FY1998: Develop and demonstrate specific site survey capability tool and beddown assessment tools.

FY1999: Develop and demonstrate suite of tools to reduce unit deployment airlift requirements by 25% through improved planning accuracy; reduce contingency planning time by 50%.

Customer POC	Service/Agency POC	USD(A&T) POC
Lt Col Anthony Dronkers, USAF	Mr. James Brinkley	Dr. Anna Johnson-Winegar
AF/ILXX	AFRL-CF	DDR&E(E&LS)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0603106F	2745	1.0	1.0	0	0	0	0
	Total	**1.0**	**1.0**	**0**	**0**	**0**	**0**

F.17 Advanced Amphibious Logistics and Seabasing for Expeditionary Force Operations ATD

Objectives. Develop and demonstrate advanced seabase sustainment/combat service support (CSS) technologies supporting emerging operational concepts. Objectives include developing new warfighter and seabase interface concepts for enhanced joint force/allied interoperability; analyzing and documenting future seabasing platform concepts to support Naval Expeditionary Force and Amphibious Ready Group (ARG); developing and demonstrating technologies to improve seabase operational efficiency; reducing manpower requirements; increasing intermodal throughput capacity; and developing and integrating common tactical logistics (TACLOG) improvements for inter- and intra-seabase total asset visibility. The program will focus on enabling technologies to reduce the expeditionary footprint ashore while supporting the force from a seabase. The ATD will explore operational efficiency gains from advanced container handling, improved bulk liquid throughput, smart warehousing, mission tailoring of supply loads, and onboard modular suiting. It will assess the feasibility of reducing ARG/MPF operational support costs.

Payoffs. Expanded throughput model analysis of seabasing sustainment systems will be used to conduct systems engineering and sensitivity analyses on emerging amphibious ship and seabase concepts. System deficiencies, technology barriers, and technology insertion opportunities will be explored. Results will establish a focal point for technical analysis support to the Joint Naval Expeditionary Warfare Engineering IPT. Improvement in expeditionary force interoperability with future amphibious (LPD–17), MPF(E), MPF 2010, and other joint sea/airlift programs is expected. Onboard TACLOG (intra-seabase) and combat service support operations center (CSSOC) (inter-seabase) architectures and systems will result.

Challenges. The seabasing of expeditionary forces poses technical challenges in ship-to-objective bulk liquids transfer, packaging of CSS, shipboard mechanisms to support CSS, and new lift requirements. The minimization or elimination of footprints on shore will require solutions that allow (1) selective offload of equipment and supplies from surface platforms located over the horizon; (2) in-stream offload of personnel, supplies, and equipment over extended distances day or night and in higher sea states; (3) predictive maintenance technologies; (4) delivery of bulk fuel and water by air and surface transport to dispersed forces in the amphibious operations area; and (5) on-board TACLOG and CSSOC systems.

Milestones/Metrics.

FY1998: Bulk fuel distribution model for 30% reduced ashore footprint in staging areas through implementation of seabase design.

FY1999: Demonstration of logistics information systems and bulk liquid distribution concepts for reduced ashore footprint.

FY2000: Air delivery and unitized load packaging system demonstration for reduced footprint ashore; reduction in tare weight by 20%; reduction in cube by 25%.

FY2001: Transition mature warfighter-ship interface technologies to amphibious/Maritime Prepositioning Force ship platform PMs. Transition technologies for amphibious or expeditionary tactical logistics and C^2 interoperability to director C^4I and PM CSLE, MARCORSYSCOM.

Customer POC		Service/Agency POC	USD(A&T) POC
CDR Kenneth Butryn, USN OPNAV N853	LtCol James Schindler, USMC MCCDC	Mr. Carroll Childers MARCORSYSCOM(AWT)	Dr. Donald Dix DDR&E(AT)
Mr. Martin Fink NAVSEA, PMS 385	LtCol Dennis Sorrell, USMC MCCDC/ C^4I Requirement	Dr. Phillip Abraham ONR	

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602131M		1.2	1.0	1.0	0	0	0
0603640M	C2223	0.5	0.8	2.1	2.5	0	0
0602121N		0.5	0.4	0.5	0.5	0	0
	Total	**2.2**	**2.2**	**3.6**	**3.0**	**0**	**0**

F.18 Joint Advanced Health and Usage Monitoring System ACTD

Objectives. Improve in-flight safety and reliability of helicopters and reduce maintenance costs. This ACTD is a joint Navy–Army demonstration, with the Navy as the lead service and user sponsor. The participants will coordinate with industry, including the Rotorcraft Industry Technology Association (RITA), in defining common industry health and usage monitoring standards and architectures. The ACTD will evaluate technologies focusing on reducing life-cycle costs, improving system safety and performance, increasing operational availability, and streamlining maintenance and logistics processes in Army and Navy helicopter communities. The ACTD demonstration will evaluate the application of commercial health and usage monitoring systems (HUMS) and assess the military utility of advanced health and usage monitoring technologies developed by the government as well as presented by industry.

Payoffs. This ACTD provides the technology, user experience, and data required to support a change in maintenance philosophy that utilizes individual aircraft usage monitoring data and diagnostic data collected in-flight from an onboard HUMS. Presently, no military helicopters employ a comprehensive HUMS. This Joint Advanced HUMS ACTD supports a Navy mission needs statement for integrated mechanical diagnostics, an Army mission needs statement for digitization, and an Army ORD for a digital source collector. The ACTD also supports the Defense Science Board's recommendations for improving flight safety. The Joint Advanced HUMS ACTD will coordinate with the Navy's Integrated Mechanical Diagnostics COSSI program and with the OSD Open Architecture Systems JTF to ensure that the approach and technologies assessed can function within an open systems environment.

Challenges. Challenges include implementation and acceptance of HUMS technologies into the existing Army and Navy maintenance systems and the capability to host independent technology modules onboard the aircraft using an open systems architecture approach.

Milestones/Metrics.

FY1998: Phase I—award multiple contracts for preliminary concept designs; Phase II—system integration including detail and assembly and bench testing; acquire baseline HUMS.

FY1999: Phase III—system installation, ground and flight testing, and crew training.

FY2000: Phase IV—operational demonstration on six Navy H–60 and six Army H–47 helicopters; perform a cost/benefit analysis.

Customer POC	Service/Agency POC	USD(A&T) POC
LCDR David Spracklin, USN NAVAIR 41.1.2	Dr. David Haas NSWC	Mr. Daniel Winegrad DUSD(AT)
CDR Mike Darby, USN USACOM	Mr. J. Tansey AATRD-AMSAT-R-TL	

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
S&T Funding							
0603750D	P523	4.6	6.0	4.0	1.0	0	0
Total S&T		**4.6**	**6.0**	**4.0**	**1.0**	**0**	**0**
Non-S&T Funding							
0603801A	DB32/33	2.2	0	0	0	0	0
Total Non-S&T		**2.2**	**0**	**0**	**0**	**0**	**0**

F.19 Joint Logistics ACTD

Objectives. Develop interoperable joint logistics decision support tools and migrate existing tools to the Global Combat Support System (GCSS). These tools will be available to all users via a Web-based client server environment that complies with defense information infrastructure (DII) common operating environment (COE) architecture standards and requirements. Logistics will be interoperable with operations, intelligence, and other functional areas within the DII, the GCSS, and the Global Command and Control System (GCCS). Maturing technologies and tools will be tested for increased operational capability. This DTO is a multiphase effort: Phase I was completed April 1997; Phase II (Joint Decision Support Tools) is FY98–99; and Phase III (Real-Time Focused Logistics) is FY00–03.

Payoffs. This DTO provides the warfighter interoperable logistics decision support tools to reduce the logistics footprint, right-size inventories, and rapidly reprioritize and redirect combat support. It also provides a seamless interoperable information and decision support capability and one fused picture of the expanded logistics battlespace using one workstation on the DII COE.

Challenges. Technical challenges are shared operations and logistics C^2 schema; interconnection of models, simulations, and applications; access to high-quality, timely data, including integration of commercial data sources; collaboration, visualization, sentinels, and alert monitors; data security; adaptive workflow; and plan element dependency analysis.

Milestones/Metrics.

FY1998: In Phase II, provide methods to analyze and compare logistics supportability of alternative courses of action through continuous real-time collaboration in a common workspace; record actions taken for five or more participants with 90% system reliability.

FY1999: Provide logistics information displays and develop a common operating picture (COP) with operations in GCSS; refresh COP every 10 min with 95% reliability; monitor and graphically display unit status throughout deployment sequence and derive force capability estimates at specific nodes over time within 15 min of query initiation.

FY2000: In Phase III, demonstrate use of monitors and sentinels to collect and analyze logistics data; identify areas requiring management attention within 30 min of deviation from established standards.

FY2001: Estimate and source logistics force, sustainment, and capability requirements; identify potential shortfalls within 60 min of course-of-action selection.

FY2002: Automatically produce the logistics portion of OPORDs, OPLANs, and annexes within 4 hr of mission and combat force identification.

FY2003: Analyze and compare logistics supportability of alternative courses of action in 30 min.

Customer POC	**Service/Agency POC**	**USD(A&T) POC**
Col Philip Yff, USMC Joint Staff/J4	Mr. J. Brian Sharkey DARPA/ISO	Dr. Graham Law ADUSD(TSI)
CDR Mike Darbey, USN USACOM	Mr. Carroll Childers MARCORSYSCOM(AWT)	

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602702E	TT-11	10.2	10.0	10.0	10.0	10.0	10.0
	Total	**10.2**	**10.0**	**10.0**	**10.0**	**10.0**	**10.0**

F.20 Joint Modular Lighterage System ACTD

Objectives. Build and demonstrate a service-interoperable prototype causeway lighterage system to safely assemble and operate (in a loaded condition) through sea state 3. The Joint Modular Lighterage System (JMLS) addresses causeway connector technology in a sea state 3 environment, component material and fabrication methods for life-cycle O&S requirements, and system employment requirements. A government–industry team will develop the system.

Payoffs. The CINCs require a sea state 3 logistics-over-the-shore (LOTS)/joint LOTS (JLOTS) capability to support their expeditionary and theater sustainment logistics. These operations are conducted over unimproved shorelines, through damaged ports, or at ports not accessible to deep-draft shipping. As a critical component of LOTS/JLOTS operations, causeway lighterage systems involve the offload of warfighting and sustainment materiel from afloat prepositioning force, assault follow-on echelon, and surge sealift ships. Presently, Army and Navy LOTS/JLOTS systems are not fully interoperable and cannot provide safe, sustained operations in conditions higher than sea state 2. There are four significant payoffs: (1) The critical portion of CINC sea state 3 JLOTS capability requirement is satisfied 2 years earlier than possible without ACTD, throughput is increased in lower sea states, and JLOTS operational costs are potentially reduced. (Conditions above sea state 2 that preclude offload of essential equipment and sustainment materiel exist more than 50% of the time in many geographic regions.) (2) The Army and Navy will be able to acquire a single system, which will result in savings from economies-of-scale production and reduced total life-cycle costs. (3) Current sea state 3 causeway system initiatives will be leveraged to provide a cost-effective basis for making an informed acquisition decision. This will provide the means to evaluate use of composite materials in causeways and to significantly reduce life-cycle costs. Full interoperability in joint operations will be realized.

Challenges. The challenges include development, planning, and execution of military exercises that fully assess the integration of recently developed causeway connector, composite material, and fabrication technologies with operational requirements to operate in sea state 3 conditions.

Milestones/Metrics.

FY1998: Issue RFPs to industry; award contract; begin design and development of causeway system.

FY1999: Test and evaluate at component and system level; conduct fleet and joint exercises to demonstrate successful sea state 3 LOTS/JLOTS causeway system assembly and operations.

Customer POC	Performer POC	Service/Agency POC	USD(A&T) POC
CDR Bill Beary, USN PHIBCB 2	Mr. Gregory Walker NAVFAC	LCDR John Dettbarn, USN OPNAV N42	Mr. Daniel Winegrad DUSD(AT)
LTC James Chambers, USA 7th Transportation Group		LTC Tim Gannon, USA HQDA, ODCSOPS	

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
S&T Funding							
0603750D	P523	4.0	4.2	0	0	0	0
0602233N		8.0	0	0	0	0	0
Total S&T		**12.0**	**4.2**	**0**	**0**	**0**	**0**
Non-S&T Funding							
0408042	NDSF/RD	0	1.1	0	0	0	0
643804526	RJL4	0	9.1	0	0	0	0
Total Non-S&T		**0**	**10.2**	**0**	**0**	**0**	**0**

F.22 Battery Charger/Analyzer

Objectives. Develop and build a battery charger/analyzer system contained in one unit that will automatically identify, configure for analysis, and perform diagnostics and maintenance on rechargeable batteries and determine the state of charging on primary batteries. This will eliminate the need for separate unique chargers for each battery.

Payoffs. This DTO will reduce battery maintenance personnel, number of chargers, number of charger spare parts, number of batteries required to be carried aboard ship, and fleet maintenance costs and will extend the life of rechargeable batteries, leading to reduced battery procurement and disposal costs. The battery charger/analyzer is expected to reduce recharge times from 8 to 2 hours, determine the state of charge of primary batteries to eliminate disposal of at least 75% of good batteries, and replace four known and several unknown battery chargers currently in the fleet. It will give the fleet a needed capability to test primary batteries, leading to improved utilization and safety of fleet operations. Total annual cost avoidance with the new battery support system is estimated to be $35 million per year.

Challenges. The biggest risks associated with commercial applications are requirements definition and compliance, item/system integration, maintenance and support, and obsolescence. The technical risks are in the areas of battery diagnostics, advanced charging techniques, and primary battery test (i.e., determining the state of charge of primary batteries and reducing venting from one in three hundred batteries tested to zero because of nonintrusive testing).

Milestones/Metrics.

FY1998: Complete secondary battery diagnostics and charging techniques for silver-zinc, nickel-cadmium, and lead-acid batteries and primary battery diagnostics (state of charge) for Li/SOC_{l2}, Li/SO_2, Li/MnO_2, carbon-zinc, and alkaline batteries; place software in demonstrator hardware for complete evaluation before starting procurement of fleet hardware. Determine the state of charge within 5% of actual capacity; conduct hardware demonstration by performing side-by-side tests with new and old equipment to confirm that turnaround time on maintenance can be reduced from 8 to 2 hours and diagnostics from 3 days to 2 minutes.

FY1999: Complete laboratory demonstration, award final integration contract, and begin fleet demonstration on USS *Carl Vinson* and at selected shore stations; complete side-by-side demonstration test in the fleet to ensure that the predictions from the hardware demonstration still hold true.

Customer POC	**Service/Agency POC**		**USD(A&T) POC**
Mr. Patrick Weaver	Dr. Phillip Abraham	Ms. Mary Hart	Dr. Donald Dix
NAVSYSCOM, AIR 260C	ONR	DLA SAVE PM	DDR&E(AT)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
S&T Funding							
0603712N	R1910	1.2	1.1	0	0	0	0
Total S&T		**1.2**	**1.1**	**0**	**0**	**0**	**0**
Non-S&T Funding							
DLA-A-SAVE		1.3	0	0	0	0	0
NAVAIR	98-075	2.6	0	0	0	0	0
Total Non-S&T		**3.9**	**0**	**0**	**0**	**0**	**0**

F.23 Modular Aircraft Support System

Objectives. (1) Design, build, and demonstrate a proof-of-concept aerospace ground equipment (AGE) unit that supplies electricity, cooling air, nitrogen, hydraulic, and related utilities for aircraft maintenance in modular, multifunction carts. (2) Increase affordability and reduce the amount of space and weight on cargo aircraft that AGE displaces (also called the deployment footprint) through modular designs with advanced concepts and technologies.

Payoffs. Introduction of modular aircraft support system (MASS) equipment will reduce the logistics footprint in a direct, objective way. This reduction of the operational unit deployment footprint will result in increased operational capability. Making the support equipment multifunctional and modular allows for reduced numbers of ground support equipment items while maintaining flexibility. Modularity will be at two levels. Functional modularity allows for support functions (e.g., electrical power, cooling) to be logically combined on single frames, maintaining flexibility. Maintenance modularity allows for parts to be quickly removed and replaced to reduce downtime for repairs, increasing availability. At the same time, MASS machines will be more reliable and maintainable than current support equipment, resulting in reduced MASS ownership costs in manpower, spares, and training. Environmental implementations will also be a design consideration. Cost savings will span from initial acquisition through disposal. This AF program has tri-service IPT membership and is an Air Force Research Laboratory pilot affordability demonstration program using integrated product process development tools and methods.

Challenges. Challenges that face the MASS program include defining technologies and system concepts that meet the maintenance requirements of all the services' aircraft. Also, an open architecture for the MASS units must be defined, and a mechanical or electrical bus must be developed that is robust enough to handle plug-and-play and the flightline environment, while maximizing the use of existing components.

Milestones/Metrics.

FY1998: Develop concept.

FY1999: Complete detailed engineering design and analysis.

FY2000: Demonstrate and evaluate the technology demonstrators; design, update, and transition the technology to the field; reduce deployment footprint of AGE by 50%; reduce life-cycle costs by 25%.

Customer POC	Service/Agency POC		USD(A&T) POC
CMSGT James Converse, USA	Mr. Chris Reyman	Mr. James Brinkley	Dr. Anna Johnson-Winegar
ACC/LGMS	NAWC-AC	AFRL-CF	DDR&E(E&LS)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0603106F	2745	1.6	1.9	1.3	0.5	0	0
	Total	**1.6**	**1.9**	**1.3**	**0.5**	**0**	**0**

K.01 Post-Boost Control System Technology

Objectives. (1) By FY03, develop and demonstrate solid-propellant post-boost control system (PBCS) component technologies that use readily available materials, which will reduce hardware costs. (2) By FY02, develop nonpermeable materials compatible with liquid-propellant PBCS environments.

Payoffs. Achieving the objectives will permit cost-effective, solid-propulsion PBCS design choices that are not dependent on the unique high-temperature (refractory) metals and manufacturing processes currently used, and will result in a 90% reduction in hydrazine leakage during storage—an environment concern—and a 5X increase in service life for liquid-fueled PBCSs.

Challenges. The most significant technology challenge is to identify cost-effective materials that can be used in the manufacture of PBCS replacement components, are compatible with existing or modified propellants, and do not erode in a high-temperature environment yet maintain current weight, Isp, and thrust levels.

Milestones/Metrics.

FY1999: Identify candidate replacement materials and processes for gas generator cases, valves, and fittings that are compatible with selected propellant formulations and have potential for low cost and high availability.

FY2001: Conduct gas-generator, valve, and subscale manifold tests to demonstrate potential for achieving objectives.

FY2003: Complete scale-up and testing of propellant integrated with replacement components (valves, fittings, injectors, tanks, etc.) in a full-scale demonstrator; demonstrate 25% reduction in the cost of PBCS components; complete aging tests on nonpermeable materials.

Customer POC	**Service/Agency POC**	**USD(A&T) POC**
Capt David Hearding, USAF USSTRATCOM	Mr. James Chew ONR	Dr. Donald Dix DDR&E(AT)
Col Dayton Silver, USMC S&TS/MW	Mr. Drew DeGeorge AFRL/PR	
Mr. Phillip Spector SSP 2020	Dr. Walter Jones SAF/AQR	

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602111N		1.0	1.0	1.0	0	0	0
0602601F	1011	3.0	2.9	2.9	1.5	1.5	1.8
0603302F	6340	0	0	0	1.5	1.5	1.5
	Total	**4.0**	**3.9**	**3.9**	**3.0**	**3.0**	**3.3**

K.02 Missile Flight Science

Objectives. Capture critical aspects of ballistic missile flight science and analytic capability by improving and merging physics-based models to produce an integrated design and analysis tool for submarine-launched ballistic missiles (SLBMs) and intercontinental ballistic missiles (ICBMs). The focus of the effort is in three areas: drag reduction devices, nuclear survivability, and solid motor ignition response.

Payoffs. Achieving the objective will reduce the risk and life-cycle costs to the existing and possible follow-on fleet ballistic missile program by (1) transferring missile flight science knowledge from experts to all users, (2) reducing the resources required to operate models by one-third, and (3) understanding the capabilities and limitation of COTS technology.

Challenges. The major technical challenges to developing drag reduction models are that no validated, fully analytic computational fluid dynamics (CFD) tools exist and that the applicability of nonlinear first-order methods and tools to complex aeroelastic phenomena have yet to be validated. The challenges for developing a nuclear survivability model are linking the current analysis tools and techniques, the availability of a complete database to perform high-fidelity analysis, and producing realistic results without underground testing verification and validation. The challenges for developing the solid-rocket ignition response and effects tool are characterizing the motor grain structure behavior to motor ignition.

Milestones/Metrics.

FY1999: Develop first-order CFD methodology for drag reduction devices model.

FY2001: Integrate survivability models and database; validate motor response model with static test firing.

FY2003: Validate survivability, final drag reduction CFD aeroelasticity prediction, and coupled motor structural/gas dynamic response models.

FY2004: Demonstrate one-third reduction in resources required for model operation by linking and validating survivability, drag reduction, and motor response tools.

Customer POC	**Service/Agency POC**	**USD(A&T) POC**
Ms. Shiela Young	Mr. James Chew	Dr. Donald Dix
Navy Strategic Systems Program Office	ONR	DDR&E(AT)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602232N		1.0	3.0	3.0	3.0	3.0	2.0
	Total	**1.0**	**3.0**	**3.0**	**3.0**	**3.0**	**2.0**

K.03 Aging and Surveillance Technology

Objectives. Predict remaining solid-rocket motor life to 10 years with a 90% confidence level; develop techniques that permit individual motor predictions, as well as motor population predictions; and reduce the time and cost for nondestructive evaluation (NDE) data processing by 50%.

Payoffs. Achieving the objectives will maximize force availability by providing sufficient time (up to 10 years as compared to the current look-ahead window of 5 years) to replace components without degrading mission effectiveness, and by avoiding the current necessity of condemning an entire population of motors when only a few are unacceptable. The costs of surveillance will be significantly reduced.

Challenges. The major technical challenges include (1) understanding the linkage between aging chemistry and mechanical properties, (2) accurate characterization of the generalized loads of rocket motors and the development of physics-based constitutive laws to predict the response, (3) identification of the coupling between computational fluid dynamics and structural modeling to better understand the effect of the pressure and flow of combustion gases on the propellant during motor operation, and (4) the automated collection and analysis of multiple modes of NDE.

Milestones/Metrics.

FY2000: Demonstrate 10% reduction in analysis uncertainties through the use of physics-based constitutive laws.

FY2001: Demonstrate 50% reduction in NDE processing time through use of automated defect modeling methods; identify chemical aging mechanisms.

FY2002: Demonstrate 50% decrease in NDE processing cost through implementation of improved NDE methods; demonstrate initial individual and population service-life prediction capability with incorporation of chemical aging mechanisms.

FY2003: Demonstrate 10-year life prediction with 90% confidence through augmentation with improved fracture mechanics methods for predicting remaining motor life.

Customer POC	Service/Agency POC	USD(A&T) POC
Capt David Hearding, USAF USSTRATCOM	Mr. James Chew ONR	Dr. Donald Dix DDR&E(AT)
Col Dayton Silver, USMC S&TS/MW	Mr. Drew DeGeorge AFRL/PR	
Mr. Phillip Spector SSP 2020	Dr. Walter Jones SAF/AQR	

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602601F	1011	1.3	2.3	2.3	3.0	4.0	2.4
0603302F	4373	1.7	1.7	1.7	0.9	0	0
	Total	**3.0**	**4.0**	**4.0**	**3.9**	**4.0**	**2.4**

K.04 Underwater Launch Technology

Objectives. By FY03, develop underwater-launch modeling and simulation tools that permit effective design and analysis of current and future submarine-launched ballistic missile (SLBM) designs, and develop options for new low-cost underwater test facilities for future SLBMs.

Payoffs. Achieving the objectives will preserve, to a significant extent, the industrial capability to design and develop underwater launch systems by producing an historical compendium of knowledge and a smart user interface that captures critical underwater launch technology and expertise that will guide future designers to the relevant test data, reports, validated models, and lessons learned. This will reduce the knowledge ramp-up time for new employees and reduce reliance on testing, which will either not be available or be prohibitively expensive, thereby reducing the time and costs associated with underwater missile launch design and analysis.

Challenges. The major technical challenges in developing the tool are the compatibility of underwater launch electronic database with future Strategic Systems Program connectivity standards, determining the proper database architecture, dealing with classified data, and verifying and validating the tool in the absence of new testing.

Milestones/Metrics.

FY1998: Develop system architecture.

FY2000: Develop electronic database; define future test facility requirements.

FY2001: Validate initial launch model.

FY2003: Validate integrated model; develop user manuals; document future launch facility requirements and launch facility designs.

Customer POC	**Service/Agency POC**	**USD(A&T) POC**
Ms. Shiela Young	Mr. James Chew	Dr. Donald Dix
Navy Strategic Systems Program Office	ONR	DDR&E(AT)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602232N		5.0	6.0	6.0	6.0	6.0	5.0
	Total	**5.0**	**6.0**	**6.0**	**6.0**	**6.0**	**5.0**

K.05 Submarine Navigation Technology

Objectives. Adapt fiber-optic gyroscope technology (fiber-optic gyros and thermally stable instrument mounts), develop associated thermal control to meet SSBN navigation requirements, and develop accelerometer technology suitable for SSBN applications.

Payoffs. Achieving the objectives will (1) permit the development of modern navigation systems (and the retrofit of existing systems) with components that do not rely on the obsolete- and out-of-production-components characteristic of current systems and that can be manufactured without dependence on ozone-depleting substances; and (2) reduce O&M costs of existing systems.

Challenges. The major technical challenges are (1) obtaining in-depth knowledge of factors affecting interferometer fiber-optic gyroscope (IFOG) temperature sensitivity and identifying materials and components to reduce IFOG thermal sensitivity; (2) understanding, characterizing, and reducing the magnetic sensitivity of the IFOG; (3) developing a high-power IFOG light source with very stable wavelength over long periods of time; (4) developing accelerometers with extremely accurate short-term (10^{-11} g) and long-term (10^{-6} g) stability; and (5) achieving an accurate thermal model and thermal control techniques for instrument mount thermal control to reduce temperature-induced gyro drifts to less than 10^{-6} degrees per hour.

Milestones/Metrics.

FY1998: Fabricate breadboard IFOG.

FY1999: Demonstrate 3X reduction in thermal sensitivity, 5X reduction in magnetic sensitivity, and 4X improvement in wavelength long-term stability over ONR ADM I IFOG.

FY2000: Demonstrate high-power light source operation in breadboard IFOG.

FY2001: Complete thermal, magnetic, and wavelength control characterization of IFOG; demonstrate SSBN performance requirements.

Customer POC	Service/Agency POC	USD(A&T) POC
Ms. Shiela Young	Mr. James Chew	Dr. Donald Dix
Navy Strategic Systems Program Office	ONR	DDR&E(AT)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602232N		3.0	4.0	4.0	3.7	0	0
	Total	**3.0**	**4.0**	**4.0**	**3.7**	**0**	**0**

K.06 Missile Propulsion Technology

Objectives. Develop a multiuse, less-detonable (Class 1.3) solid propellant that meets all ballistic missile requirements; develop component technologies (e.g., nozzles, cases, insulation systems) that both are compatible with the new propellant and reduce hardware costs by 25%; and increase mass fraction by 1% and Isp by 4% to sustain current performance levels.

Payoffs. Achieving the objectives will eliminate the current dependence of SLBMs on unique propellant formulations, materials, and processes, thereby ensuring the future availability of needed propellants and motors. A 25% reduction in missile propulsion system cost is expected.

Challenges. The major technical challenges include tailoring the burn rate with a new propellant oxidizer, controlling stress levels in the case dome area, controlling nozzle throat erosion with advanced materials, and adapting rapid processing techniques to refractory materials.

Milestones/Metrics.

FY1999: Downselect to one propellant formulation candidate.

FY2000: Complete characterization of final propellant formulation; demonstrate 13% reduction in propellant costs.

FY2001: Complete case material characterization; conduct large subscale or full-scale case tests to demonstrate 23% reduced cost, 14% reduced weight, and 1.5% increased Isp.

FY2003: Conduct large-scale test of the propellant and nozzle/insulation system to demonstrate 25% cost reduction, 1% increased mass fraction, and 4% increase in delivered Isp.

Customer POC	**Service/Agency POC**	**USD(A&T) POC**
Capt David Hearding, USAF USSTRATCOM	Mr. James Chew ONR	Dr. Donald Dix DDR&E(AT)
Col Dayton Silver, USMC S&TS/MW	Mr. Drew DeGeorge AFRL/PR	
Mr. Phillip Spector SSP 2020	Dr. Walter Jones SAF/AQR	

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602601F	1011	1.7	1.7	1.7	2.3	1.5	1.3
0603302F	4373	2.3	2.3	2.3	1.6	2.0	2.3
	Total	**4.0**	**4.0**	**4.0**	**3.9**	**3.5**	**3.6**

FORCE PROJECTION/DOMINANT MANEUVER

Defense Technology Objectives for the Joint Warfighting Science and Technology Plan

Force Projection/Dominant Maneuver

G.01 Mine Hunter/Killer ATD I-108
G.02 Vehicular-Mounted Mine Detector ATD I-109
G.04 Joint Countermine ACTD I-110
G.05 Rapid Battlefield Mine Reconnaissance I-112
G.06 Rapid Sea Mine Neutralization I-113
G.07 Autonomous Shallow-Water Influence Sweeping I-114
G.08 In-Stride Amphibious Breaching I-115
G.09 Advanced Mine Reconnaissance/Minehunting Sensors I-116
G.11 Advanced Mine Detection Sensors I-117
G.12 Lightweight Airborne Multispectral Countermine Detection System I-118
G.13 Electro-Optic Mine Identification I-120
G.14 Automatic/Aided Technology for Detection of Unexploded Ordnance Clearance I-121
M.01 Offboard Augmented Theater Surveillance ATD I-122
M.02 Extending the Littoral Battlespace ACTD I-124
M.04 Line-of-Sight Antitank System ACTD I-126
M.05 Rapid Force Projection Initiative ACTD I-128
M.06 Precision-Guided Mortar Munitions ATD I-130
M.07 Guided MLRS ATD I-131
M.08 Enhanced Fiber-Optic Guided Missile ATD I-132
M.09 High-Mobility Artillery Rocket System I-134

G.01 Mine Hunter/Killer ATD

Objectives. Demonstrate the capability to neutralize individual mines and other unexploded ordnance from a mounted platform at maneuver speeds by integrating advanced mine detection and mine neutralization technologies with automated targeting and fire control mechanisms. This capability increases the operational tempo by avoiding time delays due to mines and enhances force survivability by avoiding direct and indirect fire kills resulting from minefield delays. This DTO encompasses the neutralization component of the Mine Hunter/Killer (MH/K) ATD, specifically, 98% probability of kill (P_k) of metallic and nonmetallic mines, both surface-laid and buried, at speeds up to 20 mph and standoff ranges up to 15 m.

Payoffs. Specific demonstrated capabilities to achieve the MH/K neutralization goals include demonstration of multiple standoff neutralization concepts and selection of a baseline with the potential for near 100% P_k of mines. Specific concepts include bursting munitions, advanced propulsion schemes, and directed energy for incorporation into a two-stage process to remove or penetrate any overburden and then to destroy the mine. The ATD, which began in FY93 as an Army Science and Technology Objective (STO), will demonstrate (1) that the baseline design for the explosive neutralizer can penetrate soil overburdens and can destroy mines at 98% P_k, and (2) that integrated neutralization and detection components with automated targeting and fire control can achieve a delivery accuracy at 15-m standoff and 98% P_k. The program will integrate MH/K components onto a surrogate platform and demonstrate the ability to kill mines at up to the ATD goals of 15-m standoff, 10-mph ground speed, and 98% P_k. To date, all sensor options listed in the FY97 plan were tested and demonstrated—80% P_d at 2 mph was achieved. The plus-up in funding in FY98 will enable an increase in array size from 1 m to 3 m, teleoperation, marking, and extensive additional testing that will permit direct transition from Tech Base to EMD in FY99.

Challenges. Technical barriers include accurate, high-coverage-rate mine detection with real-time sensor processing; logistically efficient explosives that allow point destruction of mines; and real-time automated targeting and fire control with high accuracy at up to 15-m standoff and ground speeds of 5–20 mph.

Milestones/Metrics.

FY1998: Complete the design; confirm the performance of baseline neutralizer at 98% P_k.

FY1999: Integrate MH/K components; demonstrate 15-m standoff.

FY2000: Conduct the MH/K ATD using a surrogate platform operating at 10-mph average speed.

Customer POC	Service/Agency POC		USD(A&T) POC
COL C. M. Ferguson, USA	Mr. Rob Saunders	Mr. Dennis Van Derlaske	Dr. Jasper Lupo
U.S. Army Engineer School	SARD-TT	CECOM, NVESD	DDR&E(SEBE)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602712A	H24	5.1	4.8	0	0	0	0
0603606A	608	7.5	9.1	9.6	0	0	0
	Total	**12.6**	**13.9**	**9.6**	**0**	**0**	**0**

G.02 Vehicular-Mounted Mine Detector ATD

Objectives. Demonstrate the capability to detect surface-laid and buried mines and other unexploded ordnance from a vehicle-mounted platform through development of new sensors and integration of sensor fusion and automatic mine recognition techniques. Specifically, the goals for the vehicular-mounted mine detector (VMMD) are 2–5-mph detection speed, 80%–90% probability of detection (P_d), and a 0.15–0.04 false alarm rate (FAR) per meter of advance.

Payoffs. The VMMD effort began in FY93 as an Army STO. Specific capabilities for the VMMD include demonstrating three down-looking, ground-penetrating radar variants, two electromagnetic inductive coils (metal detector), and two forward-looking infrared (FLIR) sensors (3–5 and 8–12 μm). In FY97, it demonstrated an 80% P_d at 2-mph detection speed; and demonstrating selected sensors, sensor fusion, automatic mine detection and marking capabilities, and full-width arrays linked to tele-operation to achieve 5-mph detection speed, 90% P_d, and 0.04 FAR. Milestones for the VMMD ATD include selecting the most promising multiple sensor options and conducting the VMMD ATD with integrated components on a tele-operated platform. In addition, a forward-looking radar will be assessed for its ability to detect mines at standoff distances of up to 25 m. The plus-up in funding in FY98 will enable the completion of development for a wider array (from 1 m to 3 m), implementation of tele-operation, development of a marking system, and extensive additional testing. These additions will permit direct transition from Tech Base to EMD in FY99.

Challenges. Technical barriers for VMMD include mechanisms to distinguish mines from clutter and requirements to operate in diverse environments, terrains, and soils at maneuver speed.

Milestones/Metrics.

FY1998: Conduct the VMMD ATD with integrated components on a tele-operated platform to demonstrate 90% P_d at 5 mph.

Customer POC	Service/Agency POC		USD(A&T) POC
COL C. M. Ferguson, USA	Mr. Rob Saunders	Mr. Dennis Van Derlaske	Dr. Jasper Lupo
U.S. Army Engineer School	SARD-TT	CECOM, NVESD	DDR&E(SEBE)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0603606A	608	5.6	0	0	0	0	0
	Total	**5.6**	**0**	**0**	**0**	**0**	**0**

G.04 Joint Countermine ACTD

Objectives. Evaluate utility of new countermeasure (CM) technologies, individually and collectively, that enhances a Joint Task Force (JTF) mission to conduct seamless amphibious mine countermeasures operations from sea to land, with an emphasis on clandestine reconnaissance and surveillance. The Joint Countermine (JCM) ACTD integrates 13 novel systems, some which find minefields and others which breach and clear minefields. The integration umbrella includes a JCM C^4ISR architecture, JCM common operational picture software, and a JCM operational simulation system. Novel demonstration systems are further integrated with currently fielded Army, Navy, and Marine Corps systems to develop an overall JCM system of systems. ACTD objectives include conducting two demonstrations during JTF exercises and providing a set of interim CM capabilities to operating forces for 2 years.

Payoffs. This DTO will enhance a commander's ability to maintain freedom of maneuver and control the battle tempo, a necessary prerequisite of battlespace dominance. Related payoffs will facilitate rapid transition of advanced CM technologies to the services; achieve early user assessment of military utility; allow development of new doctrine and employment concepts; provide the services with interim/residual CM capabilities, supply tools to share CM information, and maintain a common CM operational picture; provide a CM simulation capability to perform training and course-of-action analysis; and potentially provide the sensors and tools to allow mine avoidance.

Challenges. Mines are cheap, available worldwide and, along with obstacles, can be used to restrict maritime, amphibious, and ground operations. The challenge is to allow rapid movement of maneuver forces to achieve their objectives in the face of a mine threat. Specific technical challenges include rapid, reliable mine detection across air–sea, air–sea–bottom, and air–land interfaces using mechanical and multispectral techniques; rapid, reliable minefield breaching/clearing using mechanical or explosive techniques; rapid, reliable mine detection using EM, acoustic, and IR techniques; fine remote control of unmanned vehicles; rapid information retrieval, display, and correlation; geopositional reporting accuracy for small-unit operational safety; dissimilar system-level and service-level C^4I interfaces and architectures; and better than real-time simulation capability to enable course-of-action analysis.

Milestones/Metrics.

FY1998: Conduct Demo II, with emphasis on clandestine surveillance/reconnaissance.

FY1999: Provide interim novel system CM capabilities for field use and evaluation.

FY2000: Complete JCM ACTD.

Customer POC	Service/Agency POC		USD(A&T) POC
CDR Peter Morford, USN USN	Mr. Bruce Zimmerman SARD-TT	CAPT Tom Vecchiolla, USN OASN RD&A	CAPT Thomas Radich, USN DUSD(AT)
	Mr. Michael Jennings CECOM, NVESD	Col T. J. Singleton, USMC ONR	

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0603606A	608	5.5	2.1	1.0	0	0	0
0603750D	P523	7.0	1.4	0.3	0	0	0
0603782N	R2226	7.0	2.7	1.5	0	0	0
	Total	**19.5**	**6.2**	**2.8**	**0**	**0**	**0**

G.05 Rapid Battlefield Mine Reconnaissance

Objectives. Demonstrate coastal area reconnaissance (beach, craft landing zone, and inland areas) using advanced sensors in an unmanned aerial vehicle. The DTO focuses on coastal battlefield reconnaissance and analysis (COBRA). COBRA incorporates advanced multispectral sensors and optics in a Pioneer UAV for daylight countermine reconnaissance. The system uses dual, advanced multispectral video cameras (adjacent field of view with overlap), forward-looking video, and video downlink; a ground station processor with real-time tracking and map overlay; and near-real-time processing using advanced target recognition algorithms. Enhanced COBRA optics (tunable camera, active illuminator, and passive millimeter wave imaging) are being developed in the Joint Mine Detection Program (6.2).

Payoffs. COBRA will permit a commander to conduct rapid minefield reconnaissance of a coastal area using a highly survivable UAV—the Pioneer flew over 300 missions and 1,300 hours during Operation Desert Storm with only one operational loss. This information will significantly aid in planning for amphibious operations, allowing commanders to avoid heavily defended areas where possible and, as necessary, to optimize allocation of mine neutralization assets to best counter the threat. Work on the COBRA ATD began in 1993 and became part of DTO G.04, Littoral Mine Obstacle Detection, in FY96. In FY97, it was recognized as its own DTO G.05. In FY97, the COBRA ATD successfully completed an early operational assessment showing tactical utility by operating in a Pioneer UAV. The COBRA system also participated in the JCM ACTD Demo I.

Challenges. Technical challenges include high-rate coverage, high-resolution imaging, and real-time image processing to support automatic target recognition.

Milestones/Metrics.

FY1998: Participate in Joint Countermine ACTD Demo II; demonstrate enhanced/refined capabilities in all areas (0.8 probability of detection and 0.3 probability of false alarm at 60–100-kn airspeed), including significant improvements in near-real-time ground station processing. Transition technology to acquisition program.

Customer POC	Service/Agency POC		USD(A&T) POC
Maj Brian Wilhoite, USMC	Mr. Greg Chambers	CAPT Tom Vecchiolla, USN	Dr. Jasper Lupo
MCCDC/Action Office	MARCORSYSCOM(AWT)	OASN RD&A	DDR&E(SEBE)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0603640M	C2223	2.0	0	0	0	0	0
	Total	**2.0**	**0**	**0**	**0**	**0**	**0**

G.06 Rapid Sea Mine Neutralization

Objectives. Demonstrate the in-stride mine clearance capabilities of the Rapid Airborne Mine Clearance System (RAMICS). RAMICS will employ a light detection and ranging (LIDAR)-based targeting system and supercavitating projectiles fired from a conventional 20-mm gun mounted on a helicopter to rapidly neutralize near-surface mines.

Payoffs. RAMICS will provide a joint force commander with an in-stride capability to rapidly target and destroy near-surface mines with minimum risk to personnel and equipment. Currently, the only means to positively destroy near-surface mines requires the use of mine-countermeasures-dedicated, underwater, remotely operated vehicles or explosive ordnance disposal personnel, which greatly impedes the tempo of joint countermine operations.

Challenges. Technical challenges for RAMICS include targeting through the modulating air–sea interface, aerodynamic and hydrodynamic stability of projectile, minimization of gun and projectile flight dispersion, and terminal ballistics to ensure confirmed mine destruction.

Milestones/Metrics.

FY1998: Finalize antimine projectile (AMP) and payload design; complete integrated system design; demonstrate lethality and effectiveness against key mine types.

FY1999: Complete integration of system components; demonstrate integrated RAMICS (LIDAR targeting/fire control, 20-mm gun, and AMP) operation from static platform. Demonstrate neutralization of moored contact mines to a maximum depth of 20 ft below air–sea interface.

FY2000: Demonstrate in-flight (airborne platform) operation of the integrated RAMICS against mine targets.

Customer POC		Service/Agency POC	USD(A&T) POC
CAPT Hubert Broughton, USN N852	CAPT William Shannon, USN COMINEWARCOM N8	CAPT Tom Vecchiolla, USN OASN RD&A	Dr. Jasper Lupo DDR&E(SEBE)
Col Randy Norton, USMC PEO-MIW M		Dr. Doug Todoroff ONR	

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0603792N	R1889	3.0	4.5	7.5	0	0	0
	Total	**3.0**	**4.5**	**7.5**	**0**	**0**	**0**

G.07 Autonomous Shallow-Water Influence Sweeping

Objectives. Demonstrate the ability to successfully conduct remote influence sweeping of magnetic and acoustic influence mines targeted against amphibious assault craft in shallow and very shallow waters (as shallow as 10-foot depth). The DTO focuses on the neutralization capabilities of the Advanced Lightweight Influence Sweep System (ALISS) and its participation in the JCM ACTD. ALISS will utilize conductively cooled, low-temperature, superconducting magnet and plasma-discharge, pulse-power technology.

Payoffs. ALISS will allow a commander to conduct remote high-speed influence minesweeping (50 knots compared to 27 knots maximum for current helicopter-towed sweeping equipment) of the intended amphibious assault lanes in shallow and very shallow water. ALISS' lightweight and reduced power technologies (150 kW vs. 500 kW for current systems) will allow deployment from a variety of manned or unmanned platforms (helicopter, ship, landing craft air cushion (LCAC), or remote/autonomously controlled boat). This technology addresses influence sweeping of current and emerging threat mines and will result in a decrease in the number of platforms required for amphibious assault sweeping and increase of personnel and equipment survivability during landings. The ALISS ATD began in 1993. In FY96, it was included in DTO G.08, Sea Mine Clearance; in FY97, it was recognized as an independent DTO G.07. High-speed operation, high-output magnetic influence sweep, cryocooler operation in a high-shock/-vibration environment, and acoustic pulse power sweep have been successfully demonstrated. The integrated ALISS will participate in JCM Demo II in FY98. Transition to the High-Speed Remote Influence Sweeping (HSRIS) Program under the management of PEO–MIW is planned.

Challenges. Technical challenges include development of a conductively cooled, low-temperature superconducting magnet for operation in a high-shock/-vibration environment; spectral shaping of plasma discharge acoustic source for emulation of ship-like acoustic signatures; electrode life; and low-drag/high-efficiency operations.

Milestones/Metrics.

FY1998: Integrate magnetic (magnetic dipole output 100X existing sweeps; 300% increase in cryocooler capacity) and acoustic (1,000% increase in electrode life since start of development) subsystems on high-speed, remote-controlled test platform. Demonstrate operation of integrated ALISS technologies (acoustic and magnetic subsystems) within the JCM ACTD Demo II.

Customer POC	Service/Agency POC	USD(A&T) POC
CAPT Hubert Broughton, USN N852	Dr. Doug Todoroff ONR	Dr. Jasper Lupo DDR&E(SEBE)
CAPT William Shannon, USN COMINEWARCOM N8	CAPT Tom Vecchiolla, USN OASN RD&A	

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0603782N	R2226	4.4	0	0	0	0	0
	Total	**4.4**	**0**	**0**	**0**	**0**	**0**

G.08 In-Stride Amphibious Breaching

Objectives. Demonstrate the accurate deployment of improved explosive neutralization systems from extended ranges to counter mines in the surf zone and beach zone.

Payoffs. This DTO will provide a joint force commander with an ability to deploy explosive line charges and arrays to neutralize surf- and beach-zone mines in support of in-stride amphibious assault operations. Accurate safe-standoff placement of explosive arrays and line charges with sufficient explosive effectiveness to confidently render anti-invasion mines inoperative will greatly improve in-stride breaching capabilities, reducing current clearance time while significantly improving the standoff and survivability of launch platforms and personnel. The Explosive Neutralization (EN) ATD was begun in FY93. In FY96 it was included in DTO G.08, Sea Mine Clearance; in FY97, it was recognized as an independent DTO G.08. Extended-range rocket motors, improved explosive line charges, improved explosive arrays, and landing craft air cushion (LCAC) fire control system were successfully demonstrated. The EN ATD participated in the JCM ACT Demo I in FY97 and will participate in Demo II in FY98. The EN automated fire control system and explosive line charges and arrays will transition as a P^3I in the PMS 407 SABRE and DET Programs in FY98. The airborne deployment for the Beach Zone Explosive Array is planned for transition to PMS 407 in FY99.

Challenges. Technical challenges include (1) accurate deployment of explosive line charges and arrays from an LCAC, via unguided rocket motor at 1,000-foot range; operation in high sea states and high wind conditions; and reliable expansion of explosive arrays in the surf zone; (2) accurate deployment of arrays of explosvely driven shaped charges from an unmanned, GPS-guided glider deployed from either a rotary- or fixed-wing aircraft, deployed from over the horizon (25-mile range), reliable expansion of arrays on the beach, and reliable orientation of shaped-charge munitions.

Milestones/Metrics.

FY1998: Demonstrate integrated LCAC breaching system (fire control for line charge, and explosive array subsystems) operation as a part of the JCM ACTD (Demo II); demonstrate scale deployment of the beach-zone array using an unmanned glider.

Customer POC	Service/Agency POC	USD(A&T) POC
CAPT Hubert Broughton, USN N852	Dr. Doug Todoroff ONR	Dr. Jasper Lupo DDR&E(SEBE)
Col Randy Norton, USMC PEO-MIW M	CAPT Tom Vecchiolla, USN OASN RD&A	

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0603782N	R2226	6.5	0	0	0	0	0
	Total	**6.5**	**0**	**0**	**0**	**0**	**0**

G.09 Advanced Mine Reconnaissance/Minehunting Sensors

Objectives. Demonstrate sensing and processing technologies for remote mine reconnaissance and minehunting from underwater vehicles. Technologies include toroidal-volume search sonar (TVSS) for high-coverage-rate detection of mines in deep water; side-looking sonar (SLS) for detection and classification of bottom mines in shallow water; synthetic aperture sonar (SAS) for detection and classification of bottom mines (included buried) in very shallow water; superconducting gradiometer for detection and classification (when fused with SAS information) of buried mines; underwater EO imaging for mine identification; and signal, image processing, and fusion technologies for automated detection, classification, and data reduction.

Payoffs. This DTO will provide technologies for detection, classification, and identification of all sea mines (including buried) from small-diameter UUVs in deep, shallow, and very shallow water. This capability will enable rapid mine reconnaissance of naval operating areas, sea logistics lanes, and amphibious operating areas in support of joint dominate rapid force protection.

Challenges. Technical challenges include high-area-coverage operation in deep water; rejection of clutter in high-clutter, littoral environments; operation of acoustic, EO, and magnetic sensors in very shallow water (dynamic, high-reverberation, high-turbidity, multipath environment); acoustic penetration in sediments at low-grazing angles; real-time processing; automated detection and classification; and data fusion of multisensor information.

Milestones/Metrics.

FY1998: Integrate acoustic, EO, and magnetic sensors into active towbody with embedded processing; demonstrate operational utility of multisensor packages towed by a remotely operated semisubmersible vehicle to perform remote high-speed sea mine reconnaissance (6 nmi^2/hr in deep water, 0.36 nmi^2/hr in very shallow water) during the JCM ACTD.

FY1999: Quantify enhanced mine detection, classification, and identification versus false detections through the use of multisensor fusion. Transition matured acoustic/optical sensor technologies to Remote Minehunting System (RMS) Program Version 4.

Customer POC	Service/Agency POC	USD(A&T) POC
CAPT Hubert Broughton, USN N852	CAPT Tom Vecchiolla, USN OASN RD&A	Dr. Jasper Lupo DDR&E(SEBE)
CAPT William Shannon, USN COMINEWARCOM N8	Dr. Doug Todoroff ONR	

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602315N		7.6	1.5	0	0	0	0
0603782N	R2226	0.4	0.4	0	0	0	0
	Total	**8.0**	**1.9**	**0**	**0**	**0**	**0**

G.11 Advanced Mine Detection Sensors

Objectives. Demonstrate advanced mine-detecting sensors for integration in current developmental systems to improve the maneuver commander's and individual soldier's ability to detect land mines from a safe distance with a high rate of accuracy at maneuver speeds. The DTO is investigating various technologies including passive millimeter wave, eddy-current-time-domain analysis, high-dynamic-range radar, acoustic/laser vibrometer, and giant magneto resistive sensor arrays. Specifically, the goals of the Advanced Mine Detection Sensor (AMDS) are 98% probability of detection (P_d) for antitank and antipersonnel mines, false alarm rate (FAR) of less than 0.2 per meter of forward progress, and ability to operate in all weather conditions.

Payoffs. The overall program objective of improving FAR, increasing P_d for small antipersonnel mines, and increasing standoff detection distances will be incrementally achieved. The standoff detection ranges achievable using a passive millimeter-wave approach will be determined, and applicability of this approach to the handheld mine detector will be assessed. The decreased FAR will be achieved by the eddy current decay analysis project that will be demonstrated.

Challenges. Technical barriers include algorithms to distinguish mines from clutter; requirements to operate in diverse environments, terrain, and soils at maneuver speed; excessive FAR; detection of small, nonmetallic mines; and detection at standoff distances greater than 5 m.

Milestones/Metrics.

FY1998: Demonstrate and baseline passive millimeter-wave approach.

FY2000: Complete acoustic/laser vibrometer testing with demonstrated mine detection at standoff distances of 15–20 m.

FY2001: Field demonstrate mine detection using high-dynamic-range radar with a P_d equal to or greater than 90% and lowering the FAR by 20%.

Customer POC	Service/Agency POC		USD(A&T) POC
COL C. M. Ferguson, USA	Mr. Rob Saunders	Mr. Dennis Van Derlaske	Dr. Jasper Lupo
U.S. Army Engineer School	SARD-TT	CECOM, NVESD	DDR&E(SEBE)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602712A	H24	1.8	1.5	1.9	1.8	0	0
	Total	**1.8**	**1.5**	**1.9**	**1.8**	**0**	**0**

G.12 Lightweight Airborne Multispectral Countermine Detection System

Objectives. Demonstrate an airborne detection system integrated into the tactical unmanned aerial vehicle (UAV) to provide route reconnaissance, point detection, and minefield detection that supports operational planning and tactical maneuvering on the battlefield. The DTO will focus on exploring new focal plane array (FPA) technologies, multi-/hyperspectral imaging active illumination, passive-polarization, and electronic stabilization. The work within DTO SE.67.02, Hyperspectral Terrain and Target Classification Technology, supports this DTO. In part, this DTO will continue the work completed by DARPA in FY97 for mine detection using hyperspectral technology and integrate sensor/processor efforts of the USMC Joint Mine Detection Technology Program.

Payoffs. The goal is to develop a lightweight sensor payload for the tactical UAV as a complement to the current Airborne Standoff Minefield Detection System (ASTAMIDS), which is being configured for operation on a UH–60 helicopter for operations-other-than-war scenarios and for contingency operations. In FY98, the Lightweight Airborne Multispectral Countermine Detection System (LAMIDS) will explore concepts and technology to support a lightweight, airborne standoff mine detection capability for point detection, route reconnaissance, and detection of minefields. The program will investigate a variety of new component and FPA technologies such as 3–5-μm staring FPA, passive polarization, multi-/hyperspectral imaging, and electronic stabilization. In FY99, the goal is to complete study efforts and initiate critical component development; in FY00, to complete development of sensors, mine detection algorithm, and processor modification; and in FY01, to complete integration on a tactical UAV and conduct a demonstration of the system. The major milestone for LAMIDS is to complete a proposed ATD in FY01.

Challenges. Technical barriers include minimizing sensor weight, detection of mines, discrimination of mines from clutter, and data compression.

Milestones/Metrics.

FY1998: In-house and contractual efforts to acquire mine signature image data and to baseline current sensor size/weight. Baseline the current algorithm minefield detection performance.

FY1999: Initiate efforts to fabricate prototype sensor that is under 65 lb; increase algorithm detection performance by 50% through algorithm enhancement effort.

FY2000: Integrate algorithm enhancements and prototype sensor; demonstrate an increase to 60% in detection performance for buried mines and to 75% for surface mines.

FY2001: Conduct system flight tests; demonstrate buried mine target detection of 80% and surface mines of 90%. Initiate Joint ATD between USMC/USA (new DTO) and complete LAMIDS ATD.

FY2002: Initiate sensor fusion effort with USMC/USA-developed sensors. Initiate algorithm development for the multisensor system.

FY2003: Initiate sensor hardware integration and bench testing. Begin integration with chosen UAV platform.

Customer POC	Service/Agency POC		USD(A&T) POC
COL C. M. Ferguson, USA U.S. Army Engineer School	Mr. Rob Saunders SARD-TT	Mr. Dennis Van Derlaske CECOM, NVESD	Dr. Jasper Lupo DDR&E(SEBE)
Col Michael Fallon, USMC MCCDC-OSI	Mr. Greg Chambers MARCORSYSCOM(AWT)		

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602131M		0.5	1.0	1.0	1.2	0.8	0.5
0602712A	H24	0.8	1.5	1.5	0	0	0
0603606A	608	0	3.0	5.9	4.0	0	0
0603640M	C2223	0	0	0	0.4	0.9	1.0
	Total	**1.3**	**5.5**	**8.4**	**5.6**	**1.7**	**1.5**

G.13 Electro-Optic Mine Identification

Objectives. Develop and demonstrate electro-optic sensor technologies to rapidly identify volume, bottom, and partially buried sea mines at extended ranges in highly turbid environments. Mine identification is the last stage in mine hunting prior to neutralization. Current neutralization assets (explosive ordnance disposal (EOD) divers, SLQ–48) are extremely slow (typically 1 hour per mine-like object) and it is imperative that they not be deployed against false targets. Further, identification of mine types enables them to be deployed more effectively. This DTO pursues a variety of laser-based imaging systems (Streak Tube Imaging LIDAR (STIL), Laser Line Scan) and associated image processing. They are being developed with either helicopter-tow or remote vehicles.

Payoffs. Underwater mine identification eliminates operational delays associated with unnecessary asset allocations or diversions around objects that are later not proven to be mines. These delays, dependent on clutter density, are quite significant. In one system study, the amphibious operating area took 14 days to clear with current assets, but only 3 days with mine identification assets in place. This dramatic improvement in sea-based mine countermeasure operations will enable quicker force projection and amphibious beach assaults.

Challenges. Laser line scan technology has shown excellent resolution (e.g., used in the TWA Flight 800 recovery effort); however, mine identification issues remain regarding operations in high-ambient-light conditions and in automated data processing. Challenges include maintaining sufficient resolution for identification in all three dimensions, the optimal display of 3D images in real time, and the development of computer-aided detection and identification algorithms to assist the human operator or monitor.

Milestones/Metrics.

FY1998: Lab demonstrate the ruggedized, compact receiver, transmitter, and data acquisition systems. Finalize mechanical design of STIL into helo-towed package.

FY1999: End-to-end demonstrate STIL in the helo-tow package at dockside.

FY2000: Demonstrate STIL from ship-based and helo-based tow.

FY2001: Transition to Airborne Mine Countermeasures and Surface Mine Countermeasures Program offices.

Customer POC	Service/Agency POC	USD(A&T) POC
CAPT Hubert Broughton, USN N852	CAPT Tom Vecchiolla, USN OANS RD&A	Dr. Jasper Lupo DDR&E(SEBE)
CAPT William Shannon, USN COMINEWARCOM N8	Dr. Doug Todoroff ONR	

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0603782N	R2226	4.0	4.2	4.5	0.6	0	0
	Total	**4.0**	**4.2**	**4.5**	**0.6**	**0**	**0**

G.14 Automatic/Aided Technology for Detection of Unexploded Ordnance Clearance

Objectives. Develop unexploded ordnance (UXO) technology to improve the ability of clearance personnel to detect, locate, access, identify, evaluate, neutralize, recover, and dispose of UXO. This DTO emphasizes the automation technologies needed to support UXO clearance and will provide scientific understanding, analysis, methodology, and theory to aid in the detection of UXO.

Payoffs. This program will provide improved automatic/aided target detection and recogntion algorithms to accomplish robust search, detection, and neutralization of UXO in support of countermine, humanitarian demining, explosive ordnance disposal (EOD), and environmental remediation programs. The fusion of information from existing and new sensors to aid in the detection process will be addressed. This effort will focus on improving algorithms, establishing the standards for testing, modeling of UXO data, defining metrics, and evaluating technologies for UXO detection and clearance. Work will leverage ATR efforts for detecting tactical and strategic targets and existing work being performed under DTO SE.19.03, Affordable ATR via Rapid Design, Evaluation, and Simulation. This DTO will also build on the work started by the DoD integrated product team working groups and integrate DoD UXO clearance technology activities with other government agencies and international efforts.

Challenges. Current sensors and processing algorithms cannot reliably distinguish UXO targets from background clutter. When viewed with current sensors, locations that are "clean" do not look very different from contaminated sites. This assessment is statistical and is based on actual cleanup data as well as controlled experiments. Even for objects with ample signal strength, the background clutter prevents distinguishing these objects from UXO targets. There is also tremendous variability in the clutter at different sites, and the clutter densities for objects with large strength signals can be very high. These factors mean that the UXO problem requires much better ablity to discriminate targets from clutter in order to achieve acceptable probabilities of detection and false alarm rates.

Milestones/Metrics.

FY1998: Demonstrate test–fix–test performance evaluation procedures and methods; standardize evaluation metrics, methods, benchmarks, and procedures; establish a common performance database and the capability to disseminate results via the ATR Virtual Distributed Laboratory; reduce false alarm rates by 2X while improving probability of detection of surface and buried mines by 2X.

FY1999: Demonstrate multisensor fusion algorithms in minefield technology; incorporate new sensor technology for improved performance; increase performance of buried mine detection by 4X.

FY2000: Continue to incorporate multisensor fusion algorithms for humanitarian demining to improve probability of detection; increase performance of surface and buried mine detection by 10X.

Customer POC	**Service/Agency POC**	**USD(A&T) POC**
COL C. M. Ferguson, USA	Ms. Lynda Graceffo	Dr. Jasper Lupo
U.S. Army Engineer School	NVESD	DDR&E(SEBE)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602712A	H24	1.5	0.5	0.5	0	0	0
0603232D	P232	0	0.5	0.5	0	0	0
	Total	**1.5**	**1.0**	**1.0**	**0**	**0**	**0**

M.01 Offboard Augmented Theater Surveillance ATD

Objectives. Demonstrate intelligence, surveillance, and reconnaissance (ISR) multiplatform fusion and sensor resource management concepts during flight tests onboard the Joint STARS T–3 test aircraft and the Hughes Aircraft Global Hawk A3 emulator. During the ATD, the offboard augmented theater surveillance (OBATS) architecture nodes will be placed onboard each platform, and improved battlefield situational awareness to both the JSTARS operator and the battlefield commander will be demonstrated. This demonstration will specifically show how the use of tactical adjunct UAVs can aid in the detection, tracking, and identification of dynamic time-critical ground targets that may be either screened or beyond the range of a JSTARS platform. The demonstration will technically quantify coverage improvements gained through the use of OBATS-generated onboard cueing tipoff information, demonstrate system-level management of sensor platform advanced processing resources, and demonstrate the coordinated use of tactical UAVs.

Payoffs. A real-time flight demonstration will quantify the tactical battlefield commander's situational awareness through the use of a common multisource integrated fusion concept. DARPA advanced tracking technologies will be implemented concurrently on both JSTARS and the Global Hawk emulator along with unique moving target indicator (MTI) exploitation algorithms, including convoy detection, force formation detection, target evidence accrual, and movement analysis features. In addition, several new radar modes, including enhanced synthetic aperture radar (ESAR), inverse SAR, and high-range-resolution MTI will be demonstrated and their use in supporting real-time automatic target identification on JSTARS will be showcased. These advanced technologies will be used to demonstrate how regions that provide difficulty for JSTARS because of masked terrain and dense foliage can be handed off to an adjunct UAV. Sensors onboard the UAV will collect, fuse, and send the data back to JSTARS via OBATS protocols for target identification and handoff to a "shooter."

Challenges. The key challenge is to effectively integrate advanced technologies onboard dissimilar platforms while quantifiably demonstrating improved situational awareness to the commander. An existing detailed simulation of the concept must run the actual onboard algorithms in real time, and the algorithms must then be seamlessly ported onto the airborne test platforms. Although the risk is high, the payoff of providing a platform-independent, multisource fusion architecture is high.

Milestones/Metrics.

FY 1998: Modify OBATS, DARPA moving target engagement, and ATR algorithms to run in real time and be portable to existing platform computer assets; quantify situational awareness in improvements for JSTARS.

FY 1999: Revisit algorithm performance based on Air Combat Command (ACC)/DRR input, and modify and test as required. Initiate porting to JSTARS and UAV emulator, ground testing, and flight testing.

FY 2000: Conduct real-time flight demonstration of time-critical target detection, tracking, identification, and handoff to a shooter using OBATS architecture-based criteria. Quantify effectiveness of multisource/multiplatform fusion and sensor resource management OBATS capabilities for JSTARS/UAV and improvements achievable with additional nodes.

Customer POC		Service/Agency POC	USD(A&T) POC
COL Debusk, USA	Col Michael Gentrup, USMC	Mr. Jon Jones	Dr. C. W. Kitchens, Jr.
ACC/DRR	ACC/DRA	AFRL-IFEA	DDR&E(WT)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0603789F	4072	2.0	2.2	2.0	0	0	0
	Total	**2.0**	**2.2**	**2.0**	**0**	**0**	**0**

M.02 Extending the Littoral Battlespace ACTD

Objectives. Demonstrate an enhanced integrated communications, C^2, sensors, and fires and targeting capability to enable rapid employment, maneuver, and fire support from the sea of dispersed units operating in an extended littoral battlespace (ELB).

Payoffs. This DTO will provide situation awareness, integrated sensors, responsive fires and targeting, and OTH connectivity through a dynamic information network; enable dispersed units and rapid operations by conventional forces; deal with contingencies; and serve as precursor force to deter and halt attacks, secure areas, and prepare for follow-on forces.

Challenges. This is a system-of-systems ACTD, relying on mature COTS and GOTS components. Consequently there are no S&T barriers. However, selection and integration of components into a seamless, functioning architecture with associated tactics, techniques, and procedures is a significant challenge.

Milestones/Metrics.

FY1998: Prepare for Major System Demo I; finalize open system architecture.

FY1999: Demonstrate (1) flattened OTH communications with narrowband voice and data services for 100–200 lightweight handheld terminals (HHTs), and at least 1.5-Mbps data services to support 2–3 distributed C^2 sites; (2) virtual workspace for C^2 demonstration—common operational picture/common tactical picture; planning and decision aid; reach-back capability; scaleable across afloat, transportable, and mobile CC variants; pull and push information; filtered push; multicast audio; and intelligent workflow; (3) flexible, integrated, distributed, near-real-time targeting from TACAIR platforms, partially automated 4D deconfliction of fires; and (4) limited coordination of sensor plans at all echelons and link from sensor to shooter.

FY2000: Prepare for Major System Demo II; refine open system architecture for preliminary evaluation.

FY2001: Demonstrate (1) OTH dual-mode (commercial cellular with militarized alternate) communications network supporting 200–300 HHTs, six distributed C^2 sites, extended LAN capability for four to six sites providing multimedia support over the wideband feeder links at rates of at least 10 Mbps, 100-mile radius footprint, demonstration hardware with improved LPI/LPD/LPE/AJ-hardened capability; (2) conduct of C^2 functions using distributed assets and personnel, all levels of information management architecture consistent across all ELB C^2 components; (3) automated 4D weapons deconfliction; and (4) dynamic sensor tasking, targeting-quality reports direct to shooter platform.

FY2002–03: Provide support for ACTD residuals.

Customer POC	Service/Agency POC	USD(A&T) POC
COL Chuck Cardinal, USA PACOM, J-36	Mr. Fred Belen ONR	CAPT Thomas Radich, USN DUSD(AT)
	Ms. M. T. Conner ONR	Dr. Ann Miller DDR&E(IT)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602315N		0	5.0	5.0	0	0	0
0603217N	R0447	7.0	0	0	0	0	0
0603238N	R2145	1.0	10.0	10.0	15.0	1.0	1.0
0603640M	C2223	10.0	0	0	0	0	0
0603640M	C2362	0	9.8	9.8	9.8	1.0	1.0
0603782N	R2226	2.0	0	0	0	0	0
0603750D	P523	2.3	6.0	5.0	5.0	5.0	5.0
	Total	**22.3**	**30.8**	**29.8**	**29.8**	**7.0**	**7.0**

M.04 Line-of-Sight Antitank System ACTD

Objectives. Develop and demonstrate the military utility of a lightweight kinetic energy missile system that provides dedicated long-range antitank fires and high-value, hard-target defeat in support of close combat by light forces during and after forced entry operations. The Line-of-Sight Antitank (LOSAT) ACTD encompasses the development and man-rating of the missile and fire unit; a three-phase battle lab warfighting experiment, consisting of a deployability demonstration, survivability demonstration, and lethality demonstration that will be conducted by the user; and a 2-year extended user evaluation by the 82nd Airborne Divison.

Payoffs. LOSAT will provide enhanced lethality and survivability to early entry forces as an assault support weapon during and after forced entry operations. Given the cancellation of the Armored Gun System and the standdown of the 3rd Battalion Armored in the 82nd Airborne, our early entry forces now have very limited long-range line-of-sight assault capabilities. LOSAT will help fill that gap. Tactical deployability of LOSAT can be by low-velocity airdrop for C–130 or larger aircraft and slingload by CH–47, V–22, and UH–60L helicopters, which will allow it to go in with initial early entry forces during forced entry operations. Survivability is increased over current antiarmor systems because of its long engagement range (beyond tank gun range), short time of flight, and increased mobility. High rate of fire and overwhelming lethality will permit LOSAT to serve as a long-range assault weapon to quickly defeat all known and projected threat tanks, including those protected by active protection systems and high-value targets such a bunkers. These capabilities mean that LOSAT can be used to fix the opposing force and permit effective maneuver of shorter range systems, as well as help ease the transition from the initial entry forces to the later arriving heavier forces.

Challenges. Technical challenges are related to system integration and affordability. The weight constraints imposed by the stated user requirement of a fire unit slingload by UH–60L (9,000 lb maximum) while maintaining sufficient survivability will be the primary challenge. Affordability issues also restrict the use of exotic lightweight materials to meet this challenge. Further challenges include assuring hardware durability in forced entry environments, including airdrop, and optimizing the missile guidance concept to incorporate an IMU into the guidance scheme to allow off-axis launch capability to account for loss of a turret on the fire unit.

Milestones/Metrics.

FY1998: Initiate ACTD.

FY1999: Complete component and HIL testing of missile electronics and IMU.

FY2000: Finalize the fire unit and missile hardware designs and begin prototype fabrication.

FY2001: "Stand up" LOSAT company in the XVIII Airborne Corps and conduct training and limited operational experiments.

FY2002: Demonstrate XX% probability of kill at YY meters [actual numbers are classified]. Demonstrate low-velocity C–130 airdrop with man-rated system.

FY2003: Complete user assessments of deployability, survivability, and lethality.

FY2004: Complete residual support phase of ACTD.

Customer POC	Service/Agency POC		USD(A&T) POC
COL Timothy Bosse, USA	Mr. Richard Paladino	Mr. Bruce Zimmerman	Mr. Tom Perdue
USA DBBL	PM-Tactical Missiles	SARD-TT	DUSD(AT)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
S&T Funding							
0603654A	460	4.9	20.1	40.4	55.9	61.2	28.5
0603750D	P523	5.7	8.3	10.0	0	0	0
	Total S&T	**10.6**	**28.4**	**50.4**	**55.9**	**61.2**	**28.5**
Non-S&T Funding							
SSN H09100	LOSAT MSL	0	0	0	0	10.0	19.0
	Total Non-S&T	**0**	**0**	**0**	**0**	**10.0**	**19.0**

M.05 Rapid Force Projection Initiative ACTD

Objectives. Demonstrate a highly lethal, survivable, and rapidly air-deployable enhancement to an airlift-constrained early entry task force. The Rapid Force Projection Initiative (RFPI) is based on a system-of-systems (SOS) concept, consisting of sensors (hunters) and weapons (standoff killers) connected by a robust digital command, control, communication, computers, and intelligence (C^4I) system. The hunters are equipped with advanced sensor packages capable of detecting targets well forward of friendly forces. The standoff killers are advanced, long-range precision weapon systems designed to engage and kill enemy armor forces at ranges beyond their ability to counter with direct fire. The integrated C^4I system, which is compliant with Army digitization initiatives, relays near-real-time situational awareness and targeting information from the hunters through battlefield computer networks to the standoff killers. The RFPI ACTD demonstrates reduced timelines for target acquisition, real-time target data transfer, improved situational awareness, enhanced weapons/target pairing, and standoff engagement of targets. The benefits of a lightweight combined hunter/standoff killer (HSOK) force arrayed against heavy armor will be examined in a large-scale, free-play field experiment in 4QFY98.

Payoffs. The RFPI ACTD concept emphasizes the integration of all RFPI technologies into an overall SOS architecture, integration of the RFPI SOS with the legacy organic systems of the ACTD experiment force, digital augmentation of the FORSCOM experiment brigade tactical operations center (TOC), baselining of the new HSOK operational concept, and live/virtual integration. Digital communications will be enhanced by the use of the Army's Enhanced Position Location Reporting System. The RFPI ACTD management plan measures of success are (1) increased situational awareness of the size and location of the threat array, applying integrated sensor orientation and sensor interconnectivity across the battlefield by 50% improvement over the base case (minimum) and 100% improvement over the base case (goal); (2) destruction of the inital threat array beyond 3 km by a 50% improvement over the base case (minimum) and a 75% improvement over the base case (goal); and (3) an increase in the survivability of the brigade by a 20% improvement over the base case (minimum) and a 45% improvement over the base case (goal). Payoffs also include military assessment of a light forces digital TOC leave behind, light force digitization lessons learned, and early user evaluation of other emerging Army systems and technologies. The RFPI ACTD HSOK operational concept demonstrates reduced timelines for target acquisition, real-time target data transfer, improved situational awareness, enhanced weapon/target pairing, and standoff engagement of targets. The benefits of a lightweight combined HSOK force arrayed against heavy armor will be examined in a large-scale, free-play field experiment in 4QFY98.

Challenges. Technical barriers include the nonavailability of advanced digital communications hardware and software, integration of participating elements into the RFPI SOS, integration of RFPI SOS with organic material of the FORSCOM experiment unit, and live/virtual integration.

Milestones/Metrics.

FY1998: ACTD field experiment (4 Qtr).

FY1999: Extended user evaluation, post-experiment simulations and evaluations, and acquisition decision support.

FY2000: Extended user evaluation; ACTD final report; TRAC final simulation; OPTEC final ACTD.

Customer POC	Service/Agency POC	USD(A&T) POC
COL Timothy Bosse, USA USA DBBL	Mr. Bruce Zimmerman SARD-TT	Dr. C. W. Kitchens, Jr. DDR&E(WT)
Mr. Phil Maughan XVIII ABN Corps	Ms. Emily Van Diver USA AAMCOM	Dr. Charles Perkins ADUSD(SP)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0603313A	486	7.9	5.1	0	0	0	0
0603313A	493	28.4	27.9	13.7	0	0	0
	Total	**36.3**	**33.0**	**13.7**	**0**	**0**	**0**

M.06 Precision-Guided Mortar Munitions ATD

Objectives. Demonstrate through simulation and testing of the 120-mm Precision-Guided Mortar Munitions (PGMM) the ability to engage, detect, and defeat high-value targets such as earth-and-timber bunkers (ETBs), command posts, and logistic sites. The 120-mm PGMM will demonstrate a range of 12 km while maintaining a weight of no more than 40 lb.

Payoffs. The PGMM will provide the infantry with a new capability: the defeat of high-value point targets at ranges beyond 7.2 km. PGMM will be a critical tool for use in stability and support operations (SASO, formerly OOTW). PGMM will allow commanders to conduct precision strikes while minimizing collateral damage. In addition, PGMM is ideal for use in military operations in urban terrain (MOUT). The mortar's high angle of fire makes it an ideal system to destroy point targets while reducing friendly exposure and casualties.

Challenges. The challenges include strapdown guidance, false target density less than five per square kilometer, and extended-range accuracy and performance.

Milestones/Metrics.

FY1998: Demonstrate extended-range capability by firing two rounds (without seeker and warhead) and executing a controlled glide to 12 km.

FY1999: Demonstrate precision capability by firing two rounds (without warheads) that will acquire and hit a laser-designated target located 8 km from gun.

FY2000: Integrate GPS/INS into an 18-in^3 volume available in the PGMM design; develop prototype hardware for HWIL demonstration.

FY2001: Demonstrate delivery accuracy required for 12-km extended-range precision by measuring 118-m CEP using GPS/INS via an HWIL test.

Customer POC	Service/Agency POC		USD(A&T) POC
LTC A. Litavec, USA	Mr. John Appel	Mr. Matthew Cilli	Dr. C. W. Kitchens, Jr.
U.S. Army Infantry School	SARD-TT	ARDEC	DDR&E(WT)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0603004A	43A	4.9	2.0	2.8	1.8	0	0
	Total	**4.9**	**2.0**	**2.8**	**1.8**	**0**	**0**

M.07 Guided MLRS ATD

Objectives. Develop guidance and control (G&C) package integrated with the current Multiple-Launch Rocket System (MLRS) extended-range rocket. The Phase I G&C package consists of an inertial measurement unit (IMU), a flight computer, and canards driven by electromechanical actuators housed in the nose section of the rocket. Phase II integrates GPS technology into the G&C package. The guidance package is designed to be compatible with various rocket payloads such as bomblets, precision-guided submunitions, mines, and earth penetrator/unitary warheads.

Payoffs. Improvements in rocket delivery accuracies will reduce (1) the number of rockets required to defeat the target by as much as sixfold at extended ranges, (2) the required number of launchers per fire mission, (3) the logistical burden, (4) the duration of the fire mission, and (5) possibly, the minimum safe distances to avoid fratricide and collateral damage. The goal of the IMU design is to provide the system with a 2–3-mil delivery accuracy at all ranges. The goal of the GPS-aided G&C package is to provide the system with a 10-m CEP delivery accuracy at all ranges. System benefits are evaluated through ongoing Rapid Force Projections Initiative (RFPI) force-on-force modeling, analysis, and simulation during the RFPI ACTD field experiment in FY98. Milestones for the guided MLRS include five flights tests (FY98) in support of the RFPI ACTD. System benefits are being evaluated through ongoing RFPI force-on-force modeling and analysis.

Challenges. No technical barriers are identified.

Milestones/Metrics.

FY1998: Five flights tests in support of the RFPI ACTD.

Customer POC	Service/Agency POC		USD(A&T) POC
COL Richard Svitak, USA TRADOC	Mr. Allan Gamble USA MC, RDEC	Ms. Irena Szkrybalo SARD-TT	Dr. C. W. Kitchens, Jr. DDR&E(WT)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0603713A	380	4.5	0	0	0	0	0
	Total	**4.5**	**0**	**0**	**0**	**0**	**0**

M.08 Enhanced Fiber-Optic Guided Missile ATD

Objectives. Develop and confirm a precision standoff capability against high-priority ground and airborne (helicopter) targets under day, night, and adverse weather conditions out to a range of 15 km. The Enhanced Fiber-Optic Guided Missile (EFOGM) ATD will demonstrate, during the Rapid Force Projection Initiative (RFPI) ACTD, a remotely directed missile system that can operate from defilade to engage targets also in defilade. The seeker incorporated into the missile provides for friendly force recognition, which, coupled with the gunner in the loop, contributes to fratricide avoidance and, under most conditions, positive hostile identification. The EFOGM capability will be a killer element of the composite hunter/standoff killer concept identified in the RFPI. The RFPI addresses the challenge of providing light, highly lethal and survivable technologies to an early entry force, within airlift constraints. The EFOGM also will participate in the RFPI large-scale field experiment (FY98). Exit criteria for the EFOGM include availability of short-range (1–15-km) firepower against ground and air targets for early entry forces; engagement of non-line-of-sight targets by forces deployed in defilade; provision of a means of assisting in battlefield management by automating the presentation of situation awareness information to the EFOGM gunner as well as automating the receipt/transmission, processing, and display of C^2 information; tactical deployability (C–130); missile seeker imagery exploitation; conduct of precision strike; and domination of the maneuver battle.

Payoffs. The current EFOGM ATD schedule is a two-phase development effort. EFOGM will deliver one mobile and two stationary simulators; a fire unit load of simulated missiles; and 12 fire units, three platoon leader vehicles, and 300 missiles to support a series of three demonstrations to be conducted during the performance of the ATD. The program incorporates the integrated product team (IPT) concept in the acquisition structure to significantly lower the unit cost of the missiles while providing sufficient hardware to conduct the demonstrations. These demonstrations include an RFPI field demonstration in FY98 and a 2-year extended user evaluation beginning in FY99. These remaining activities will be conducted by XVIII Airborne Corps, Ft. Benning, GA. The day. night, and adverse-weather seeker is considered the single most costly component of the missile assembly. It is intended that leveraging on focal plane array efforts currently underway by the DARPA will be maximized. Consideration will be given to manufacturability as well as effective array size and seeker sensitivity.

Challenges. The challenges of the EFOGM are C^3 interoperability with the Army Battle Command System (ABCS), soldier-machine interface, and seeker nonuniformity correction.

Milestones/Metrics.

FY1998: RFPI field demonstration.

FY1999: Conduct user evaluation as part of DTO M.05, RFPI ACTD.

FY2000: Complete user evaluation.

FY2001: Prepare for possible EMD start in FY01 or FY02.

Customer POC	Service/Agency POC		USD(A&T) POC
COL John Caldwell, USA TRADOC	Mr. Michael Rithmire SARD-SM	Ms. Irena Szkrybalo SARD-TT	Dr. C. W. Kitchens, Jr. DDR&E(WT)
	COL Roy Millar, USA PM-NLOS		

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0603313A	496	23.8	30.0	13.6	3.9	0	0
	Total	**23.8**	**30.0**	**13.6**	**3.9**	**0**	**0**

M.09 High-Mobility Artillery Rocket System

Objectives. Develop and demonstrate a lightweight, C–130-transportable version of the M–270 Multiple-Launch Rocket System (MLRS). Mounted on a 5-ton family-of-medium-tactical-vehicles (FMTV) truck chassis, it will fire any rocket or missile in the MLRS family of munitions. The High-Mobility Artillery Rocket System (HIMARS) will use the same C^3 and the same crew as the MLRS launcher, but it will carry only one rocket or missile pod.

Payoffs. By the third quarter of FY98, HIMARS will demonstrate a man-rated cab to protect its crew from rocket exhaust gases and launch debris. It will be fully C–130 transportable, both in weight and in cubage, and will fire rockets and missiles in the MLRS family of munitions. Its automated onboard reload capability and quicker aiming platform movement will provide accelerated mission timelines, enabling greater survivability for the warfighter.

Challenges. Technical barriers include developing an accurate aiming platform within weight and height constraints, integrating MLRS line replaceable units (LRUs) (fire control system, radios, air filtration, etc.) into the space available in the FMTV 5-ton truck cab, and developing a robotic reload system for rocket and missile pods.

Milestones/Metrics.

FY1998: Begin live firings at WSMR; deliver the tactical vehicles to 3–27 Field Artillery; conduct new equipment training for 3–27 Field Artillery; participate in RFPI field exercise.

FY1999: Conduct user evaluation as part of DTO M.05, RFPI ACTD.

FY2000: Complete user evaluation and prepare to start EMD in FY00 or FY01.

Customer POC	Service/Agency POC		USD(A&T) POC
COL Richard A. Svitak, USA	Mr. Robert Neighbors	Ms. Irena Szkrybalo	Dr. C. W. Kitchens, Jr.
TRADOC	MLRS Project Office	SARD-TT	DDR&E(WT)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0603313A	380	4.1	5.9	1.6	0	0	0
0603313A	496	6.6	5.8	1.5	0	0	0
	Total	**10.7**	**11.7**	**3.1**	**0**	**0**	**0**

ELECTRONIC COMBAT

Defense Technology Objectives
for the Joint Warfighting Science and Technology Plan

Electronic Combat

H.02 Multispectral Countermeasures ATD I-136
H.04 Miniature Air-Launched Decoy Program ACTD I-137
H.05 Large-Aircraft Infrared Countermeasures ATD I-138
H.06 Advanced Electronic Countermeasures Transmitter ATD I-139
H.07 Enhanced Situation Awareness Demonstrations I-140
H.08 Onboard Electronic Countermeasures Upgrade ATD I-142
H.10 Precision EW Situation Awareness, Targeting, and SEAD Demonstrations I-143
H.11 High-Power Microwave ACTD I-145

H.02 Multispectral Countermeasures ATD

Objectives. Develop and test advancements in laser technology, energy transmission, and jamming techniques for an all-laser solution to infrared countermeasures (IRCMs) as a preplanned product improvement (P^3I) to the Advanced Threat IRCM/Common Missile Warning System (ATIRCM/CMWS) program. The major goal is to eliminate noncoherent sources via a tunable, multiple-line laser with a fiber-optic (FO) transmission line.

Payoffs. The advanced laser/FO line technologies, in conjunction with advanced detection and jamming algorithm work, will be live-fire tested using the ATIRCM testbed. At the system level, these improvements will demonstrate a significant increase in jam-to-signal ratio (J/S), an equivalent reduction in laser jam head volume, a significant decrease in ATIRCM/CMWS prime power consumption, and an overall reduction in system weight. From the perspective of the warfighter, such improvements will provide the lighter, more robust capability of countering both present and future multicolor imaging focal plane array and nonimaging missile seekers.

Challenges. Technological challenges to this program include adapting advanced laser technology as a multiline source for IRCM while meeting the stringent size and power requirements for rotary-wing attack platforms. This process involves advancements in semiconductor lasers that promise a 2X increase in output power relative to the ATIRCM laser and the energy propagation thereof (via efficient optical couplers and advanced FO cables) in order to transmit this broadband energy with greater than 90%-per-meter efficiency. In concert with tri-service DTO WE.47, IIR Seeker CM Technology, the remaining challenge lies in the development of imaging seeker CM algorithms suitable for the self-protection of rotary-wing assets.

Milestones/Metrics.

FY1998: Integrate laser, FO coupler, and advanced jammer algorithms and begin lab testing. Metric goals of 6X increase in J/S and 4X reduction in laser jam head volume.

FY1999: Conduct live-fire cable car tests to demonstrate affordable IRCM retrofit capability. In addition to the performance metrics above, system metrics of 1.2-kW/50% reduction in prime power and 35-lb system weight reduction against advanced imaging IR missiles/surrogates and secondary rotary-wing threats (e.g., antitank guided missiles).

Customer POC	Service/Agency POC	USD(A&T) POC
Mr. Jack Van Kirk	Mr. Rob Saunders	Dr. C. W. Kitchens, Jr.
PM-AEC Huntsville	SARD-TT	DDR&E(WT)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0603270A	K16	5.0	7.0	0	0	0	0
	Total	**5.0**	**7.0**	**0**	**0**	**0**	**0**

H.04 Miniature Air-Launched Decoy Program ACTD

Objectives. Develop and demonstrate an affordable ($30,000 average unit flyaway price (AUFP)) decoy system for air-launched applications in the lethal suppression of enemy air defense (SEAD) mission.

Payoffs. The Miniature Air-Launched Decoy (MALD) is an expendable decoy and has a primary military utility in offensive operations against enemy air defense systems by diluting and confusing surface-based and airborne defenses with realistic tactical target characteristics. The MALD program will demonstrate a low-cost, realistic tactical decoy with an advanced decoy payload. Current capability is typified by the Tactical Air-Launched Decoy (TALD)/Improved TALD (ITALD) heavy-glide/-boosted family of passive and active decoys. MALD will be physically smaller (one-fourth the weight), faster, and less expensive (one-fourth the cost). A secondary operational payoff to be demonstrated will be MALD's simultaneous EW self-protection capability to protect the launching fighter/group of fighters. At the end of the ACTD, 32 MALD systems will remain with the operational user for continued testing and contingency operations. An expected long-term tertiary payoff is one of MALD expansion into additional roles and missions using the existing basic vehicle and engine design with other payloads.

Challenges. Critical to the ACTD's success is the tradeoff of affordability of the total MALD package versus its target realism in all mission scenarios (i.e., the minimum set of electronic payload complexity such as frequency response, antenna form factors, coherent exciter techniques, and amplification technology). The MALD concept involves the integration of previously developed, advanced small-engine technology (4-inch-diameter turbojet) into a missile form factor. Thus, startup and operation of the small turbojet engine over the full flight regime is one of the two major challenges of the MALD ACTD. The second challenge is miniaturization of the complex decoy payload, its integration with the vehicle's avionic systems, and the overall life-cycle reliability expected (15-year shelf life "wooden" round concept).

Milestones/Metrics.

FY1998: Flight test demonstration of MALD's separation and flight/maneuvering characteristics (90-in vehicle/sub-100-lb gross weight).

FY1999: Demonstrate operational effectiveness of a $30,000 AUFP MALD decoy in a multithreat, open-air environment. Residual leave-behind of 32 MALD systems.

Customer POC	Service/Agency POC	USD(A&T) POC
Maj Jim Avrit, USAF	Lt Col Walter Price, USAF	Lt Col Marty Meyer, USAF
HQ ACC/DRAS	DARPA/TTO	DUSD(AT)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602702E	TT-06	17.3	7.0	0	0	0	0
0603750D	P523	0.8	0	0	0	0	0
	Total	**18.1**	**7.0**	**0**	**0**	**0**	**0**

H.05 Large-Aircraft Infrared Countermeasures ATD

Objectives. Design, develop, and demonstrate an advanced laser-based infrared countermeasure (IRCM) capability suitable for self-protection of high-IR-signature, large Air Force aircraft (e.g., C–17, C–5, C–130, C–141).

Payoffs. The central program to the ATD, Laser IRCM Flyout Experiment (LIFE), will demonstrate closed-loop IRCM (CLIRCM) capability for transition to engineering development and P^3I. The coupling of advanced, higher power laser source technologies (solid state, advanced solid state, or semiconductor) with active aimpoint tracking of inbound threat missiles shows promise of a hundredfold increase in jam-to-signal ratio and a significant reduction in missile engagement times. Such figures are necessary to protect large multiengine aircraft throughout their range of mission profiles from the proliferated IR missile threat. This advanced capability can result in a robust IRCM system that will protect large transport, signature, and special forces aircraft well into the 21st century. The bottom-line benefit to the warfighter will be increased survivability of those platforms and the ability to successfully prosecute the mission.

Challenges. Currently fielded and developmental IRCM systems are designed to protect lower signature and suppressed platforms using a combination of coherent or noncoherent sources and an open-loop IRCM capability against a limited threat list. The increased signature of large aircraft requires that the intensity of the IRCM source(s) be increased and more efficient jam codes be implemented. CLIRCM techniques offer an increased capability by protecting larger signature aircraft from a wide variety of threats. Technical risks and challenges associated with a CLIRCM system include long-range missile warning in the presence of IR clutter to enable threat engagement at long ranges, pointing and tracking stability consistent with the narrow laser beams used in CLIRCM, development of all-band laser capability to reduce pointer/tracker size, and demonstration of CM timelines consistent with real-world scenarios (single- and multiple-threat launches) that will protect the full range of large aircraft missions.

Milestones/Metrics.

FY 1999: Demonstrate laser-based jamming using CLIRCM technique during live-fire SAM flyouts at WSMR cable car. Demonstrate sufficient laser intensity to protect large aircraft IR signature (10X–100X greater than suppressed helicopter and SOF aircraft).

FY 2000: Demonstrate effectiveness during live-fire air-to-air missiles against LIFE testbed. Demonstrate real-time CM effectiveness and 5:1 reduction in engagement timeline.

FY2001: Validate effectiveness of CLIRCM via M&S correlation with live-fire data.

Customer POC	**Service/Agency POC**	**USD(A&T) POC**
Col Ryan Dow, USMC	Mr. Michael Flynn	Dr. C. W. Kitchens, Jr.
HQ AMC/XPR	SAF/AQR	DDR&E(WT)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0603270F	691X	7.8	1.9	0.9	0.9	0	0
	Total	**7.8**	**1.9**	**0.9**	**0.9**	**0**	**0**

H.06 Advanced Electronic Countermeasures Transmitter ATD

Objectives. Develop and demonstrate a broadband RF ECM jammer/transmitter capable of defending surface ship combatants against modern antiship missiles and related threat weapon systems from surveillance/targeting through terminal missile run-in phases of an engagement.

Payoffs. This ATD will demonstrate a brassboard state-of-the-art planar array aperture fed by advanced, solid-state monolithic microwave integrated circuit (MMIC) power modules and a novel photonic beam formation and steering subsystem. This approach is central to an affordable system implementation required by the Navy's Advanced Integrated Electronic Warfare System (AIEWS). An AIEWS COEA confirmed the need to resolve surface EW shortfalls, among them being the capability to engage and counter multiple, advanced antiship cruise missiles in a shortened timeline response scenario. These collective ATD improvements will yield significant ship self-protection capabilities against multiple threat weapon systems (particularly in a multishot engagement) and in both at-sea and littoral mission scenarios. Upon the planned integration with the ongoing advanced electronic support (ES) 6.4 effort, the advanced ECM transmitter will provide an affordable solution to the growing problem of obsolescent ship EW systems.

Challenges. The major challenge involves the unique integration of a tunable laser and microwave-coupled, electro-optic modulator source—with 2D fiber-optic, true-time-delay, dispersive/non-dispersive fiber components into a prism beamformer architecture—feeding a high-gain, MMIC-based RF/microwave phased array. Associated with this challenge are the related, critical issues of multiple threat handling per quadrant aperture face; aperture element design for polarization diversity; achieving sufficient isolation for simultaneous jamming and transmit and receive in a high-EMI-ship environment; and integration with and maintenance of a low overall ship radar cross section while achieving the necessary high transmitter antenna gains.

Milestones/Metrics.

FY1998: Coastal/field test demonstration of 90-deg coverage array (quadrant) with four time-coincident transmissions, a 2.5X increase in effective radiated power, and a 4X increase in beams per quadrant.

Customer POC	Service/Agency POC	USD(A&T) POC
CAPT Raymond Donahue, USN	CDR Robert Boyd, USN	Dr. C. W. Kitchens, Jr.
N865	ONR	DDR&E(WT)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0603792N	R1889	4.5	0	0	0	0	0
	Total	**4.5**	**0**	**0**	**0**	**0**	**0**

H.07 Enhanced Situation Awareness Demonstrations

Objectives. Design, develop, and demonstrate hardware and software approaches and techniques to provide aircrews (tactical, strategic, airlift, and special operations) timely, enhanced threat alert (TA) and situation awareness (SA) (defensive) and retargeting and retasking (offensive) capabilities.

Payoffs. The emphasis of this DTO is on direct application of previously developed, automated, decision-making algorithms—hosted by COTS real-time symmetric multiprocessing (RTSMP) computer/open architecture—and integration with onboard sensor and offboard information (data, C^2, imagery) correlation techniques. Enhanced situation awareness (ESA) demonstrations will show automated aircrew defensive TA/SA and real-time retargeting; a hundredfold increase in processor throughput and associated reduction in pilot workload; and a significant acceleration of automatic, en-route correlation of all available offboard and onboard aircraft mission information (e.g., threat emitter laydown, mission tasking, precision targeting, defensive response/EW management). This DTO achieves initial real-time information in and out of the cockpit (RTIC/RTOC) capabilities.

Challenges. During mission execution and engagement phases, aircraft survival and successful weapon delivery depend on aircrew SA, which hinges upon timely and accurate information. Currently, threat and target information is primarily supported by pre-mission planning functions, yet is often colored by aged or inaccurate intelligence and battle damage assessments. Updates to the cockpit are relayed by voice communications (if and when permitted by mission OPSEC/COMSEC). Aircrew TA/SA is limited by existing onboard sensor ranges and is further constrained by current weapon systems with very limited capabilities for both over-the-horizon targeting and real-time mission updates from offboard information sources. The critical challenge of this DTO is to assimilate onboard sensor reports (both defensive and offensive) with all available, in-theater battlespace information and subsequently, automatically advise the aircrew with the timely defensive situation, response options, and updates to offensive mission posture, profiles, and priorities.

Milestones/Metrics.

FY1998: Demonstrate ESA in large aircraft flight environment (C–130): 100X increase in processor throughput; 3X–4X acceleration of automatic information correlation functions.

FY1999: Demonstrate ESA in fighter avionics HWIL or cockpit simulation configuration (F–16 or JSF): same as metrics above. Conduct F–117 flight demonstration of fused ESA/LO autorouter functions.

FY2000: Demonstrate F–117 RTOC with RTSMP and mission management system using low probability of detection (LPD) waveform.

FY2001: Demonstrate F–15E fusion of onboard SAR/FLIR data with offboard JSTARS imagery via ESA RTSMP.

FY2002: Ground demonstration of multiship, multisource/multisensor (two offboard and two onboard) defensive and offensive ATR data.

FY2003: Multiship tactical flight test demonstration of internetted RTIC/RTOC capabilities.

Customer POC		Service/Agency POC	USD(A&T) POC
Lt Col Mike Kemerer, USAF	Mr. Jeff Stanley	Mr. Michael Flynn	Dr. C. W. Kitchens, Jr.
HQ AFSOC/XPQE	AFRL-SNZ	SAF/AQR	DDR&E(WT)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0603270F	2432	3.9	0.9	0	0	0	0
0603203F	69DF	0.7	2.6	1.2	1.5	3.0	2.5
	Total	**4.6**	**3.5**	**1.2**	**1.5**	**3.0**	**2.5**

H.08 Onboard Electronic Countermeasures Upgrade ATD

Objectives. Maximize the defeat of the threat in the acquisition and track phases of target tracking radar engagement prior to missile launch. This ATD focuses on the first of a two-tiered goal to increase survivability of friendly aircraft against the RF guided missile threat: (1) prevent hostile forces from launching RF guided missiles, and (2) effectively counter those missiles that are launched. To "keep the missiles on the rail," the ATD will develop and demonstrate two advanced, affordable, monopulse-radar, angle-breaklock techniques. First, a specific, high-payoff, single-aircraft, low-effective radiated power (ERP) jamming technique has been pursued at the 6.2/6.3 levels and will proceed with ATD risk reduction. Since this low-ERP solution entails risk, the second approach emphasizes less risky, single- and dual-platform, high-ERP techniques.

Payoffs. The parallel development of angle CM techniques and architectures will maximize the probability of the successful implementation of an affordable, robust solution to the monopulse threat. ATD metrics to be demonstrated via flight tests are significantly reducing threat missile launch opportunities and reducing kill probability given launch. The resulting high (95%) probability of survival against the modern monopulse radar-directed weapon systems translates into aircraft survivability and continuation of the warfighter's mission. Applicability to existing systems include the AN/ALQ–131, –135, –172, and –184 and the B–1B DSUP (defensive system upgrade program).

Challenges. The main challenge is to develop a wideband architecture that successfully implements the first low-ERP technique (the monopulse angle jamming integrated countermeasure (MAJIC)). Concurrently, significant hardware miniaturization effort will be needed in order to make MAJIC fit within the size and weight constraints of existing RF self-protection systems. The higher ERP techniques foster the challenges of effective wideband RFCM technology and affordable integration of advanced transmitter and array technologies into the aforementioned examples of existing systems (e.g., the microwave power modules (MPM)-based architectures being pursued under DTO WE.46, Coherent RFCM Technology).

Milestones/Metrics.

FY1998: Effectiveness/affordability assessments of DSEAT (demonstration of selected electronic attack techniques) electronic architectures: 80% reduction in threat missile launch opportunities; 80% reducion in kill probability given launch ("80/80" metric).

FY1999: MAJIC flight test demonstration.

FY2000: DSEAT/MAJIC architecture designs and down-selections: 80/80 metric.

FY2001: DSEAT/MAJIC fabrication.

FY2003: Final DSEAT/MAJIC flight test demonstrations: 80/80 metric.

Customer POC	Service/Agency POC	USD(A&T) POC
Lt Col Mike Kemerer, USAF	Mr. Michael Flynn	Dr. C. W. Kitchens, Jr.
HQ AFSOC/XPQE	SAF/AQR	DDR&E(WT)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0603270F	431G	0.3	3.0	2.4	4.7	6.1	0.8
0603270F	691X	0.5	0	0	0	0	0
	Total	**0.8**	**3.0**	**2.4**	**4.7**	**6.1**	**0.8**

H.10 Precision EW Situation Awareness, Targeting, and SEAD Demonstrations

Objectives. Provide ground vehicles and rotary-wing, tactical, and special operations aircraft with the precision location of emitters for situation awareness and targeting. A coordinated multiservice program will develop and demonstrate those technologies needed for the uniquely different flight characteristics and missions of the subject air platforms plus ground vehicles.

Payoffs. By increasing the number of electronic support (ES) sensors in the tactical-level battlespace—via the networking of platforms equipped with passive detection, and accurate space-time reference (STR) systems—the warfighter will be provided with an unambiguous and unified picture of the battlefield to unprecedented targeting fidelity. The Army's Integrated Sensors and Targeting (ISAT) program pursues the modular integration of the RF, IR, and EO spectrums to produce that picture for the "low/slow" movers (rotary-wing and ground). ISAT will enable reduced decision timelines for defensive/offensive actions, target acquisition and identification, and antifratricide and is intended for future upgrade programs (ALQ–211, –212, AVR–2A, and VVR–1). From the "high/fast" EC SEAD perspective, missions today are accomplished in the face of new electronic order-of-battle and enemy air defender tactics and with a reduced U.S. force structure that has all but eliminated dedicated SEAD aircraft. The AF Precision Location and Identification (PLAID) program capability (unambiguous radar warning/threat geolocation (e.g., ALR–69, –56 C/M)) will feed an advanced SEAD targeting (AST) effort to pursue ES-based precision targeting. Intended for existing multimission/multirole airframes, AST will specifically enable the use of shoot-to-coordinate PGMs, thereby negating emitter shutdown tactics.

Challenges. A flyable, low-cost, wide-field-of-view, multiband, precision-line-of-bearing, off-axis laser location subsystem will be the principal challenge for the multispectral sensor low/slow applications. The sensors must operate under all battlefield atmospheric and environmental conditions (rotary-wing/ground vehicle). Receiver architectures capable of the precision TOA/TDOA and the required fine frequency measurements stress the limits of sub-nanosecond digital receiver parameter measurement technology. Unconstrained air engagement geometries dictate high-sensitivity approaches in order to conduct missions in emitter sidelobes. STR and precision clock technologies for real-time data alignment are critical to the 7D (time, position, and velocity) registration of the air battlespace. Finally, C^3 datalink techniques are critical to minimizing latencies in distributed ES collection management and coordination of receiver dwells among multiple platforms.

Milestones/Metrics.

FY1998: PLAID flight demonstration of hardware/software capabilities: global ID in ≤4 s; location to ≤5% of range within 10 s; and line of bearing to 1-deg azimuth.

FY1999: Validate PLAID technology design implementation for large aircraft (C–130)/large antenna baseline design and unique, low-latency/emitter ID requirements for ALR-69 FSRS (Frequency Selective Receiver System) insertion. Integrate ISAT digital and HITL models into CECOM Survivability Integration Lab Digital Integration Laboratory.

FY2000: Demonstrate AST critical component capabilities to resolve high-priority ambiguities greater than or equal to 95%. Conduct real-time ISAT DIS experiments: 10X increase in target location accuracy under operations on the move.

FY2001: AST demonstration of emitter geolocation to 50 m in ≤10 s at 50 nmi.

FY2002: Conduct ISAT rotary flight test and ground vehicle testing: geolocate radars to 1% range out to 20 km, with off-axis detection accuracy ≤1 deg over 75-deg field of view.

Customer POC	Service/Agency POC	USD(A&T) POC
Mr. Jack Van Kirk PM-AEC Huntsville	Mr. Michael Flynn SAF/AQR	Dr. C. W. Kitchens, Jr. DDR&E(WT)
Maj Don Lundie, USAF HQ ACC/DRAS	Mr. Rob Saunders SARD-TT	

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0603270A	K16	0	1.0	8.0	8.5	5.5	0
0603203F	69DF	0.2	2.4	3.7	4.0	0	0
0603270F	431G	5.7	0	0	0	0	0
	Total	**5.9**	**3.4**	**11.7**	**12.5**	**5.5**	**0**

H.11 High-Power Microwave ACTD

Objectives. Develop and demonstrate high-power microwave (HPM) technology to disrupt, degrade, or destroy electronics in specific information operations scenarios. In conjunction with development of a CONOPS, a microwave system will be integrated into a suitable delivery platform and transported to a realistic site for demonstration of capabilities. Following the successful technology development test in FY97, the HPM system will be reengineered into a fieldable configuration for use by operational personnel in August 1998. (Specific program, system design, and system effectiveness details are classified.)

Payoffs. Adversaries will be denied the use of electronic information collection, processing, and communications equipment through a judicious application of high-peak-power microwave sources. HPM technology will provide a means of electronic attack that is not only nonlethal but also nonhazardous to humans and causes minimal or no collateral damage. Only electronic systems will be affected by the device(s).

Challenges. The major challenges are integration of the technology into an operational system, development of concept of operations, and testing and evaluation in a realistic environment.

Milestones/Metrics.

FY1998: Field demonstration.

FY1999–00: Projected maintenance support. (Specific milestones/metrics are classified.)

Customer POC	**Service/Agency POC**	**USD(A&T) POC**
COL Jerry DeMoney, USA USA INSCOM	Mr. Michael Flynn SAF/AQR	Dr. Charles Perkins ADUSD(SP)
MAJ Larry White, USA USEUCOM	LtCol Mike Rowell, USMC JC2WC/OTI	

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
S&T Funding							
0603750D	P523	0.6	0	0	0	0	0
0603605F	3152	1.2	0.1	0.1	0	0	0
	Total S&T	**1.8**	**0.1**	**0.1**	**0**	**0**	**0**
Non-S&T Funding							
28021	LOSAT MSL	2.0	0	0	0	0	0
	Total Non-S&T	**2.0**	**0**	**0**	**0**	**0**	**0**

CHEMICAL/BIOLOGICAL WARFARE DEFENSE AND PROJECTION AND COUNTER WEAPONS OF MASS DESTRUCTION

Defense Technology Objectives for the Joint Warfighting Science and Technology Plan

Chemical/Biological Warfare Defense and Protection and Counter Weapons of Mass Destruction

I.02 Joint Biological Remote Early Warning System ACTD I-148

I.03 Airbase/Port Biological Detection ACTD I-150

I.04 Integrated Biodetection ATD I-151

I.05 Chemical Enhancement to Airbase/Port Biological Detection ACTD I-152

J.03 Counterproliferation I ACTD I-153

J.04 Counterproliferation II ACTD I-154

I.02 Joint Biological Remote Early Warning System ACTD

Objectives. Evaluate the military utility of remote early warning for biological warfare (BW) attacks against U.S. forces, and develop the operational procedures and doctrine associated with that capability by FY99. An additional objective, by FY99, is to provide the CINCs an interim residual capability to detect and provide automated warning and reporting to promptly alert only those forces that may be exposed to biological warfare agents. The ACTD will leverage advanced biological detection technologies (e.g., ultraviolet (UV) laser particle sizer, immunoassay fiber-optic wave guide) from the DoD counterproliferation initiative and technology base community. The ACTD will demonstrate several remote early warning platforms, including artillery-delivered remote detectors, man-emplaced detectors, detectors mounted on remotely piloted vehicles, and standoff active laser detectors. All the remote detectors will be connected to a warning and reporting system that enables the CINC to promptly alert forces (less than 15 minutes) who are downwind of biological warfare agents. Extensive simulation will be conducted in parallel to evaluate the operational utility of the remote early warning system for employment during early entry, buildup, defensive, offensive, and consolidation phases. Preliminary modeling of BW attack against U.S. forces during a proposed buildup phase shows that an early warning system could reduce casualties by up to 95%.

Payoffs. By FY99, the system will demonstrate in CONUS networked (Joint Warning and Reporting Network (JWARN)) remote early warning systems against point and long-line source BW attacks. Data fusion of remote detectors into a JWARN is the key to providing early warning of potential BW attacks; this capability may eliminate nearly all (95%) casualties from a biological attack.

Challenges. Technical barriers include the demonstration of a UV particle sizer, sufficiently miniaturized detection technologies for deployment on a remotely piloted vehicle, and effective active laser biodetection technology. Demonstration of a simulation capability for operational use is needed that enhances warning and reporting capabilities.

Milestones/Metrics.

FY1999: Demonstrate in CONUS networked (JWARN) remote early warning systems against point and long-line source BW attacks.

FY2001: Provide sustainment of demonstrated equipment at selected locations for operational use.

Customer POC		Service/Agency POC	USD(A&T) POC
LtTC Ken Manfra, USA USCINPAC(STA)	LTC Mike Urban, USA CENTCOM	Mr. Brian David JPO Biological Defense	Dr. Judith Daly ADUSD(AD)
LTC Robert Neumann, USA USEUCOM			

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
S&T Funding							
0603750D	P523	0	0	2.0	2.0	0	0
Total S&T		**0**	**0**	**2.0**	**2.0**	**0**	**0**
Non-S&T Funding							
0603884BP	CP4	17.9	37.1	5.0	5.0	0	0
Total Non-S&T		**17.9**	**37.1**	**5.0**	**5.0**	**0**	**0**

I.03 Airbase/Port Biological Detection ACTD

Objectives. By FY98, develop and demonstrate a biological local warning capability and operational procedures to detect, alarm, warn, dewarn, identify, protect, and decontaminate large areas against a biological warfare (BW) attack on an airbase or port facility. In FY97, a system was demonstrated that provided rapid detection (5 min versus 15 min), semiautomated versus manual warning and reporting of a BW attack using RF links, protection (collective protection and commercial oronasal masks), identification (20 min versus 30 min) and sample handling of eight high-threat agents versus four, and large-area decontamination.

Payoffs. This ACTD will demonstrate for the first time the capability to detect and protect high-value, fixed-site assets during point and long-line source BW attacks.

Challenges. Technical barriers include the ability to rapidly identify all BW threat agents. Both a dewarning capability and concepts or capabilities to decontaminate large areas without significant degradation in operational tempo need to be demonstrated.

Milestones/Metrics.

FY1998: Develop and demonstrate a biological local warning capability and operational procedures to detect, alarm, warn, dewarn, identify, protect, and decontaminate large areas against a BW attack on an airbase or port facility.

FY2001: Provide sustainment of demonstrated equipment at selected locations for operational use.

Customer POC		Service/Agency POC	USD(A&T) POC
LTC Ken Manfra, USA USCINPAC(STA)	LTC Mike Urban, USA CENTCOM	Mr. Brian David JPO Biological Defense	Dr. Judith Daly ADUSD(AD)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
S&T Funding							
0603750D	P523	1.1	2.4	1.0	1.0	0	0
Total S&T		**1.1**	**2.4**	**1.0**	**1.0**	**0**	**0**
Non-S&T Funding							
0604384BP	BJ5	1.0	2.0	1.0	0	0	0
Total Non-S&T		**1.0**	**2.0**	**1.0**	**0**	**0**	**0**

I.04 Integrated Biodetection ATD

Objectives. Demonstrate two technologies: one that provides a pre-exposure warning for a biological attack, and another that provides an order-of-magnitude increased sensitivity to agents while adding a first-time virus identification capability with significantly reduced logistics. These logistical improvements include automated operation, fivefold reduction in size and weight, reduced storage requirements, and reduced consumables.

Payoffs. In FY97, a demonstration of a remote biological aerosol warning capability using micro-UV-fluorescent, laser-based particle counting technology was completed. This technology will provide pre-exposure warning of biological agent attacks for protection of personnel and high-value battlespace assets. The FY98 goal is to demonstrate a point biosensor capability that incorporates an automated DNA diagnostic technology to identify biological agents with the highest known degree of reliability and sensitivity. By FY99, products will be demonstrated separately and as an integrated force protection suite in future battle lab warfighting experiments.

Challenges. Technical barriers include developing a passive long-range (2-km) standoff biodetection and identification capability, especially one that is not limited by path losses (e.g., atmospheric absorption) and the natural background. The development of a DNA diagnostic technology that is reliable is also needed.

Milestones/Metrics.

FY1998: Demonstrate a point biosensor capability that incorporates an automated DNA diagnostic technology to identify biological agents with the highest known degree of reliability and sensitivity.

FY1999: Products will be demonstrated separately and as an integrated force protection suite in future battle lab warfighting experiments.

Customer POC	Service/Agency POC	USD(A&T) POC
LTC Don Buley, USA	Dr. John Ferriter	Dr. Sal Bosco
JPO-BD	ERDEC (TPCBD)	DATSD(CP/CBD)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0603384BP	CB3	7.1	6.1	0	0	0	0
	Total	**7.1**	**6.1**	**0**	**0**	**0**	**0**

I.05 Chemical Enhancement to Airbase/Port Biological Detection ACTD

Objectives. In FY98, demonstrate an integrated biological and chemical detection and warning capability at two sites within the designated areas of operation associated with the current Airbase/Port Biological Detection ACTD (DTO I.03).

Payoffs. The chemical add-on capability will use mature and available technology (passive IR spectrometry and ion trap spectroscopy) to automatically detect and identify chemical threat agents in near real time (less than 30 sec). In addition, a Joint Warning and Reporting Network (JWARN) with hardware and software interfaces between three or four different biological and chemical detectors for the automatic generation of NBC 1 and 3 reports will be demonstrated by FY98. This ACTD will also develop the concept of operations and doctrine associated with the add-on capability at fixed-site assets. This chemical enhancement ACTD will provide the CINCs with a first-time capability to network legacy and emerging biological and chemical detectors and produce automated warnings and reportings for enhanced battlefield visualization and force protection as defined in *Joint Vision 2010.*

Challenges. Technical barriers include the development of detection and simulation capabilities that integrate chemical and biological detection sensor data.

Milestones/Metrics.

FY1998: Demonstrate a JWARN with hardware and software interfaces between three or four different biological and chemical detectors for the automatic generation of NBC 1 and 3 reports.

FY2000: Provide sustainment of demonstrated equipment at selected locations for operational use.

Customer POC		Service/Agency POC	USD(A&T) POC
LTC Ken Manfra, USA	LTC Mike Urban, USA	Mr. Brian David	Dr. Judith Daly
USCINPAC(STA)	CENTCOM	JPO Biological Defense	ADUSD(AD)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0603384BP	CP3	1.0	0.5	0	0	0	0
0603750D	P523	1.1	0.6	0.5	0	0	0
Total S&T		**2.1**	**1.1**	**0.5**	**0**	**0**	**0**
Non-S&T Funding							
0604384BP	BJ5	1.0	0.5	0	0	0	0
Total Non-S&T		**1.0**	**0.5**	**0**	**0**	**0**	**0**

J.03 Counterproliferation I ACTD

Objectives. Develop and demonstrate technologies in conjunction with operational concepts to target and defeat cut-and-cover, shallow-buried, or above-ground-bermed chemical and biological weapon storage and production facilities while minimizing collateral hazards. This technology development is for demonstration in Phase I and II of the Counterproliferation ACTD. Technologies being developed fall into three categories: weapons, sensors, and planning/targeting tools.

Payoffs. Phase I (12/95–2/97) of this ACTD demonstrated the application of current warhead technology augmented with a programmable, void-sensing/depth-of-burst-sensing, hard-target smart fuse (HTSF). Planning tools for targeting (integrated munitions effects assessment (IMEA)) and collateral effects prediction (hazard prediction assessment capability (HPAC)) were also demonstrated. In Phase II, to be completed in FY98, Phase I technologies will be supplemented by the following technologies. The advanced unitary penetrator (AUP) will improve the penetration capability of the BLU-109 by a factor of two. The Inertial Terrain-Aided Guidance (ITAG) system will provide adverse-weather capability while maintaining precision-guided, munitions-level CEPs. The weapon-borne sensor will provide the acceleration history of the penetrator to provide target characterization and combat assessment (CA). Tactical unattended ground sensors (TUGSs) will provide characterization and location of critical equipment for targeting and CA. A modified tactical forward-looking infrared (FLIR) pod modification (TFPM) will provide plume signatures for CA. The MEA and HPAC planning tools will be integrated to provide increased utility for targeting and collateral effects prediction in Phase II and will be upgraded to provide more accurate predictions for hardened, buried structures.

Challenges. Primary challenges involve integration of existing technologies and systems into an effective capability.

Milestones/Metrics.

FY1998: Phase II technology demonstrations of AUP, ITAG, weapon-borne sensor, and TFPM; further integration of HTSF and IMEA. Leave-behinds/residual capabilities for demonstrated technologies delivered to EUCOM (including HTSF, AUP, and targeting tools).

FY2000: Complete follow-on support for residuals.

Customer POC	Service/Agency POC	USD(A&T) POC
Col Fred Koch, USAF EUCOM J5-N/CP	Mr. Vayl Oxford DSWA/PMC	Dr. Judith Daly ADUSD(AD)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0603160BR	P539	7.4	2.2	1.5	0	0	0
0603750D	P523	1.2	5.2	0	0	0	0
	Total	**8.6**	**7.4**	**1.5**	**0**	**0**	**0**

J.04 Counterproliferation II ACTD

Objectives. (1) Employ current technology products in weapons and improved target planning tools, using new weapon delivery tactics, and operationally demonstrate their enhanced penetration capabilities against a simulated chemical/biological (CB) facility considerably harder than the structure used during the CP I ACTD. (2) Exploit near-term technology by demonstrating the baseline capabilities of the Joint Air-to-Surface Standoff Missile (JASSM) to conduct CB counterforce missions through operationally realistic attacks against a simulated CB weapons production facility. (3) Demonstrate use of a conventional air-launched cruise missile (CALCM)-based penetrator and use UAV-based chemical sensors for collateral effects assessment. (4) Evaluate the end-to-end set of products of the CP II ACTD, including the target planning tool in its final operational context, a TLAM standoff penetrating weapon capability, and a remote combat assessment using a mini-UAV with a point chemical sensor on board. This will also involve demonstration of a weaponized enhanced payload to minimize collateral effects associated with dispersal of NBC materials.

Payoffs. The CP II ACTD will improve existing standoff weapon platforms to provide enhanced penetration, advanced fuzing, and enhanced payloads. Sensors and data fusion will address confirming the presence of chemical agents post-attack and assist in predicting transport patterns by updating prestrike predictions of the potentially hazardous plume with real-time data. An Integrated Target Planning Tool Set (ITPTS) will be delivered to the warfighter to predict weapon performance against complex NBC structures and associated collateral effects, and to develop targeting solutions to minimize collateral effects with advanced weather and wind prediction models.

Challenges. Primary challenges involve integration of existing technologies and systems into an effective capability. Specific challenges are identified in the milestones and metrics below.

Milestones/Metrics.

FY1998: Develop weapon and sensor technologies to more accurately characterize the weapons of mass destruction (WMD) target to allow more precise selection of a three-dimensional aimpoint, precision delivery of the weapon from standoff locations, and more accurate and timely BDA data.

FY1999: Demonstrate a consecutive weapon delivery tactic to achieve enhanced penetration and base JASSM capability to perform CP counterforce mission.

FY2001: Demonstrate a CALCM-based standoff penetrator and UAV remote collateral effects assessment.

FY2002: DIVINE CANBERRA will demonstrate a penetrating capability in the Tactical Land Attack Missile (TLAM) chemical agent point detection from an expendable sensor platform and advanced CP target planning systems. It will also include a demonstration of a weaponized enhanced payload to mitigate collateral effects.

Customer POC	Service/Agency POC	USD(A&T) POC
Col Fred Koch, USAF EUCOM J5-N/CP	Mr. Vayl Oxford DSWA/PMC	Dr. Judith Daly ADUSD(AD)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0603160BR	P539	33.5	54.9	49.9	47.5	48.3	49.3
0603750D	P523	0	6.0	0	0	0	0
	Total	**33.5**	**60.9**	**49.9**	**47.5**	**48.3**	**49.3**

COMBATING TERRORISM

Defense Technology Objectives
for the Joint Warfighting Science and Technology Plan

Combating Terrorism

L.01 Entry Point Screening I-156
L.02 Surveillance and Tracking I-157
L.03 Infrastructure Protection I-159
L.04 Standoff Detection of Explosives I-161
L.05 Improvised Explosive Device Countermeasures I-163
L.06 Structural Blast Mitigation I-165
L.07 Terrorist Chemical/Biological Countermeasures I-167
L.08 Tactical Operations Support I-169
L.10 Automated Terrorist Incident Indications and Warning I-170

L.01 Entry Point Screening

Objectives. Develop improved capabilities for screening personnel, automobiles, and cargo vehicles for the presence of dangerous materials, particularly commercial, military, and improvised explosives and chemical, biological, and nuclear threat agents/materials. Detection methods not dependent on a nuclear source will be emphasized. Systems able to detect humans hidden in vehicles will also be developed. Candidate technologies of interest include combined transmission/backscatter x-ray imaging, gamma imaging, vehicle weigh-in-motion analysis, trace explosive detectors based on ion and ion-trap mobility spectroscopy, chemiluminescence, and gas-chromatography mass spectrometry.

Payoffs. The systems being developed will augment existing means for providing perimeter security for a wide variety of military installations and enhance current entry point screening capabilities. Improved capabilities for detecting terrorists and a wide range of threat agents at entry points will provide significant terrorist deterrence and denial benefits to threatened personnel. Warning times will also be increased, allowing additional time for the evacuation of personnel or the implementation of other protective measures.

Challenges. Detecting threat agents and devices in vehicles is a difficult task currently accomplished through time-intensive searches by security guards who may be at great risk. Current developmental contraband detection systems, developed for narcotics detection at border crossings, are generally very large and require a nuclear source to image vehicle interiors. Key challenges to developing more effective threat agent detection capabilities include achieving low false alarm rates, high sensitivity, and high throughput in systems that are nonintrusive and portable. This effort leverages developments by the DoD Counter Drug Technology Development Office and the Department of Energy.

Milestones/Metrics.

FY1998: Demonstrate a combined transmission/backscatter x-ray vehicle inspection system able to detect 100 lb or more of explosives with a throughput rate of 20 vehicles per hour and a false alarm rate of <5%; demonstrate the ability to rapidly detect explosive devices concealed on people; demonstrate the ability to accurately detect humans hidden in a vehicle.

FY2001: Demonstrate the capability (using gamma imaging) to detect 50 lb or more of explosives in a vehicle with a throughput rate of 30 vehicles per hour and a false alarm rate of <3%; demonstrate an effective imaging system for vehicle and container inspection systems not dependent on a nuclear source.

FY2002: Demonstrate a false alarm rate of <1% for a vehicle explosive detection system; demonstrate the capability to detect >1 gal of chemical agent concealed in a vehicle with a false alarm rate of <5% using a fast-neutron interrogation system.

Customer POC	Service/AgencyPOC	USD(A&T) POC
Mr. Leo Targoscz NCIS	Mr. Jeffrey David OST	Mr. Jeffrey Paul DDR&E(SEBE)
LTC Vincent Kam, USA JCS/J34		Mr. John Reingruber ASD(SO/LIC)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0603122D	P484	0.7	0.7	0.7	0.7	0.7	0
	Total	**0.7**	**0.7**	**0.7**	**0.7**	**0.7**	**0**

L.02 Surveillance and Tracking

Objectives. Develop advanced standoff audio and visual surveillance systems that will enable identification, monitoring, and tracking of individual terrorists in the field. New through-wall surveillance capabilities will also be developed to enable discrimination between hostiles and friendlies in a hostage barricade situation.

Payoffs. Improved capabilities for identifying, monitoring, and tracking terrorists will help to reduce the terrorist threat to U.S. military and other government personnel, facilities, and infrastructure by facilitating timely interdiction of terrorists, threat agents, and devices and the implementation of protective countermeasures. Improved capabilities for through-wall surveillance will provide commanders in the field with information critical to planning assault operations with minimum casualities.

Challenges. Optimal surveillance and tracking techniques are generally situation specific. Tasking often occurs on very short notice, and available means for identifying, monitoring, and tracking potential terrorists may not be sufficient to achieve desired objectives. Existing techniques must be modified—and new techniques developed—to enable critical surveillance and tracking functions to be accomplished in varied environments. These techniques must operate without being detected by terrorists and must function under a wide range of environmental conditions (low light, large thermal distortions, high noise levels, etc.). For through-wall surveillance, critical issues include achieving real-time or near-real-time imaging capabilities with sufficient resolution to distinguish hostiles from friendlies for a variety of structural materials and designs.

Milestones/Metrics.

FY1999: Demonstrate a video surveillance system able to identify individuals at ranges of up to 1 mile under adverse environmental conditions; demonstrate a lightweight, through-wall surveillance system capable of resolving people from background in near real-time through standard interior wall construction.

FY2000: Demonstrate a clandestine audio surveillance system able to isolate and monitor individual conversation within a background of other conversations at a range of up to 100 yd.

FY2001: Demonstrate improved audio surveillance capabilities for identifying individuals at ranges of 2 miles or more under adverse-weather conditions; demonstrate a clandestine audio surveillance system able to resolve individual conversations at ranges of 100 yd or more in an all-noise background that includes vehicle and industrial audio disturbances.

FY2002: Demonstrate a lightweight, through-wall surveillance system capable of resolving people from background in real-time through standard masonry exterior wall construction.

FY2003: Demonstrate improved audio surveillance capabilities at a range of 1 mile or more; demonstrate through-wall surveillance capabilities for distinguishing hostiles from friendlies for both interior and exterior construction in real time.

Customer POC	Service/Agency POC	USD(A&T) POC	
LTC Vincent Kam, USA	Mr. James Lawrence	Mr. Jeffrey Paul	Mr. John Reingruber
JCS/J34	OST	DDR&E(SEBE)	ASD(SO/LIC)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
S&T Funding							
0603122D	P484	0.5	1.0	1.0	1.0	1.0	1.0
Total S&T		**0.5**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**
Non-S&T Funding							
Foreign S&T		0.2	0.2	0.1	0	0	0
Total Non-S&T		**0.2**	**0.2**	**0.1**	**0**	**0**	**0**

L.03 Infrastructure Protection

Objectives. Develop and demonstrate advanced capabilities for defining and mapping critical elements of our national infrastructure, identifying and characterizing potential vulnerabilities and threats to those elements, determining associated risks and potential consequences, and defending against attacks involving either physical or electronic means. Infrastructure elements to be considered include electric power grids, natural gas and petroleum distribution systems, water supply systems, transportation systems (encompassing all ground and air components such as railways, waterways, roadways, bridges, tunnels, and air traffic control systems), and communications networks.

Payoffs. The development of new capabilities pertinent to infrastructure analysis and protection will enable more reliable impact assessments, improved risk analyses, flexible infrastructure/mission process analyses, timely threat support, implementation of robust protective measures, and improved contingency planning operations. The potential vulnerability of critical elements of the national infrastructure to terrorist attack will be reduced, and the consequences of such attacks will also be made less severe. Some elements of our national infrastructure (e.g., communications networks, surveillance satellites) provide global capabilities that are critical to the execution of a wide range of military missions. Maintaining the continued availability of these and other infrastructure capabilities is of paramount importance to U.S. military forces.

Challenges. The development and validation of analytical tools for evaluating many critical issues pertinent to the vulnerability and protection of various elements of our national infrastructure presents many technical challenges. Such tools do not currently exist. New data fusion engines must be developed to assimilate and link disparate databases and data from a wide variety of sources to support the definition, identification, and mapping of infrastructure systems and subsystems, including the location of critical nodes and components. An analysis methodology for identifying critical dependencies and interdependencies across infrastructure elements must be devised. Credible analytical means for characterizing potential threats to infrastructure systems must be identified. Complex new tools are also needed for automatically detecting, reporting, characterizing, and responding to attacks on information systems and networks via electronic means; defending against such assaults requires advances in survivability, reliability, assurance enhancement, and "fire-wall" technologies. Advanced diagnostic tools must be devised to identify and quantify the net consequences of attacks on individual elements of the infrastructure to aggregated users. Finally, gaming and simulation tools for collaborative contingency and emergency planning must be developed.

Milestones/Metrics.

FY1999: Demonstrate improved capabilities for identifying and mapping critical infrastructure nodes, components, and interdependencies, concentrating first on the electric power grid; demonstrate a database of open-source threat information relevant to infrastructure systems with the potential for damaging or disabling critical infrastructure components and subsystems.

FY2000: Demonstrate improved systematic analysis tools and methodologies for examining and assessing the interrelationship between primary infrastructure systems, and for evaluating the potential for cascading failures resulting from a terrorist attack against critical nodes or links.

FY2001: Demonstrate improved capabilities for identifying specific weaknesses of various infrastructure elements and networks using automated, platform-independent, vulnerability analysis and risk assessment tools; demonstrate a 50% improvement in the number of variables in the characterization of RF-based and other directed-energy threat weapons designed for disruption, destruction, or intrusion of infrastructure-specific computer systems.

FY2002: Demonstrate a 40% improvement in the performance of automated intrusion-detection systems designed to detect electronic attacks and protect information networks.

FY2003: Demonstrate improved measures for protecting critical infrastructure computer networks and supervisory control and data acquisition systems against failure induced by electronic intrusion; demonstrate a 50% improvement in the utility of collaborative gaming and simulation tools designed to assist government users in contingency and emergency planning.

Customer POC	**Service/Agency POC**	**USD(A&T) POC**	
LTC Vincent Kam, USA	Mr. Todd Anderson	Mr. Jeffrey Paul	Mr. John Reingruber
JCS/J34	OST	DDR&E(SEBE)	ASD(SO/LIC)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0603122D	P484	1.0	1.5	1.5	1.5	1.5	1.5
	Total	**1.0**	**1.5**	**1.5**	**1.5**	**1.5**	**1.5**

L.04 Standoff Detection of Explosives

Objectives. Develop advanced techniques and specialized equipment for use by U.S. and Allied forces enabling the detection and characterization of a variety of explosive compositions at standoff distances ranging from very short distances (<1 meter) to as much as 100 meters or more. Approaches for detecting both solid and vapor phases of explosives that are independent of concealment and access geometries will be explored. Technologies of interest for explosive detection include those also providing the capability to detect explosive device components, including detonators, switches, power supplies, and wires (e.g., neutron and laser technologies). Systems designed for portable operation will be emphasized.

Payoffs. Improved detection capabilities will enable less obtrusive or clandestine examination of individuals, automobiles, and trucks that might be involved in the transport of explosives. Such capabilities will also facilitate the more rapid inspection of cargo at various transport nodes and at storage locations. Standoff threat detection will contribute to improved capabilities for perimeter security and enhance protection of critical military and civilian facilities and personnel against terrorist attack. This effort will contribute to and leverage related developments supported under DTO L.01.

Challenges. There are currently no reliable methods for standoff detection of explosives and explosive devices. Several methods that have shown promise for standoff detection of explosives offer capabilities limited to a few meters. Robust and reliable approaches that also minimize false alarm rates are required for any practical standoff threat detection system.

Milestones/Metrics.

FY1999: Demonstrate the detection of concealed explosive materials in excess of 100 lb at standoff distances greater than 10 ft.

FY2000: Demonstrate the detection of 100 lb of concealed explosives at standoff distances of at least 10 ft in less than 2 minutes with a false alarm rate of <10%.

FY2001: Demonstrate the detection of concealed explosive materials in excess of 100 lb at standoff distances greater than 100 ft.

FY2002: Demonstrate the detection of 100 lb of explosive materials at a standoff distance greater than 100 ft in 2 minutes or less with a false alarm rate of <5%.

FY2003: Demonstrate the detection of concealed explosives in excess of 100 lb at standoff distances greater than 300 ft in less than 1 minute with a false alarm rate of <1%.

Customer POC	**Service/Agency POC**	**USD(A&T) POC**	
LTC Vincent Kam, USA	Mr. James Lawrence	Mr. Jeffrey Paul	Mr. John Reingruber
JCS/J34	OST	DDR&E(SEBE)	ASD(SO/LIC)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
S&T Funding							
0603122D	P484	1.8	1.8	1.8	1.8	1.8	1.5
Total S&T		**1.8**	**1.8**	**1.8**	**1.8**	**1.8**	**1.5**
Non-S&T Funding							
Foreign S&T		1.1	0.8	0.5	0.5	0	0
Total Non-S&T		**1.1**	**0.8**	**0.5**	**0.5**	**0**	**0**

L.05 Improvised Explosive Device Countermeasures

Objectives. Develop new equipment and systems that will enable explosive ordnance disposal (EOD) teams to safely access large vehicle bombs and other improvised explosive devices (IEDs), conduct diagnostic procedures, and render such bombs and IEDs safe for subsequent handling and disposal. Both precision and general explosive device disruption tools will be developed, tested, and delivered to EOD personnel for field use. Precision disruption techniques, which are used when the internal configuration of an IED is known, enable disablement of timing circuits, power supplies, or the device firing train to prevent detonation. General disruption techniques are applied to devices when the internal configuration is not known or when there is insufficient time for diagnosis/determination; they enable destruction of the device without detonation. Improved IED access and diagnostic methods will also be developed, and new render-safe procedures will be established.

Payoffs. New general IED disruption systems will provide EOD teams with enhanced capabilities for neutralizing large vehicle bombs. Improved diagnostic capabilities will enable more effective use of emerging precision disruption techniques for a wide range of IEDs. Overall capabilities for protecting personnel, facilities, and elements of the national infrastructure that might be subject to terrorist attack will be enhanced. This DTO leverages efforts by the Naval Explosive Ordnance Disposal Technology Division and the Counterproliferation Support Program.

Challenges. IEDs, including large vehicle bombs, present significant life-threatening challenges to EOD teams responsible for their diagnosis and disablement. Currently available diagnostics tools (e.g., the Advanced Radiographic System) provide useful threat assessment capabilities, but device disablement capabilities are limited. Satisfactory procedures for disabling most conventional military ordnance and various IEDs have been established, but there are no proven methods for analyzing and disabling large vehicle bombs. The problems presented by most IED threats are time urgent, and both new and improved diagnostic and disablement techniques that can be executed rapidly must be developed.

Milestones/Metrics.

FY1998: Demonstrate the capability to disrupt car bombs (<100 lb) with a 90-mm water cannon when the locations of critical components are known; demonstrate general disruption capabilities using a linear water charge approach for IEDs contained in the trunks of automobiles.

FY2000: Demonstrate general disruption techniques against large vehicle bombs (>5,000 lb) concealed in cargo vans and trailers; demonstrate the ability to precisely locate and resolve individual components in IEDs concealed in passenger vehicles.

FY2002: Demonstrate a general disruption technique effective against large vehicle bombs contained in heavy-walled vehicles; demonstrate new access and diagnostic capabilities for precise location and identification of components in large vehicle bombs.

Customer POC	Service/Agency POC	USD(A&T) POC	
LTC Vincent Kam, USA	Mr. Ronald Cochran	Mr. Jeffrey Paul	Mr. John Reingruber
JCS/J34	OST	DDR&E(SEBE)	ASD(SO/LIC)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602315N		0.6	0.6	0.1	1.0	1.0	0
0603122D	P484	2.0	2.1	2.1	2.1	2.1	0
0603160BR	P539	0.8	0.5	0.8	0.8	0.8	0
	Total	**3.4**	**3.2**	**3.0**	**3.9**	**3.9**	**0**

L.06 Structural Blast Mitigation

Objectives. Develop new techniques for shock and damage mitigation in structures subjected to blast loading, advanced building design and refortification methods, and vulnerability assessment tools pertinent to evaluating and reducing the effects of explosive blasts on structures. The program will focus on reducing debris hazards (e.g., glass, wall fragments, internal building components), which represent the major cause of injury to personnel in terrorist bomb events, and on preventing structural collapse, which is the major cause of fatalities. Design methods for both new facilities and retrofits to existing structures will be developed. This effort supports DTOs in the Military Operations in Urban Terrain and the Joint Readiness and Logistics and Sustainment of Strategic Systems JWCOs.

Payoffs. New capabilities for mitigating blast effects will help to reduce injuries and fatalities in facilities subjected to terrorist attack and facilitate the more rapid execution of rescue and recovery operations. Keep-out distances required for maintaining safe building environments will be reduced, contributing to improved perimeter security. Validated structural protection and response models will be provided for incorporation into new analytical force protection tools to be used by field commanders.

Challenges. The development of accurate, practical models for predicting blast effects associated with detonation of explosive devices, structural response for a wide range of structure types and designs, and injuries to personnel based on combined blast and structural response considerations is a difficult and multifaceted task. Required models will be created as modules for incorporation into even more complex computational vulnerability assessment and building design tools. Other challenges include the development of architecturally acceptable blast mitigation building design and refortification features that are affordable, easy to install, and rely on readily available materials.

Milestones/Metrics.

FY1999: Demonstrate automated methods and criteria for reducing personnel injuries due to glass and wall debris hazards by decreasing required blast standoff distance for hazard generation by 40%; evaluate new and existing (seismic) techniques for improving the resistance of columns subjected to blast loads from vehicle bombs.

FY2000: Evaluate and demonstrate the effectiveness of new blast wall designs for reducing pressure and debris impacts on personnel and structures.

FY2001: Demonstrate new methods and establish criteria for reducing fatalities due to progressive structural collapse in flat slab structures.

FY2003: Demonstrate improved procedures and automated tools for assessing the vulnerability of existing structures to blast effects; develop methods for designing new buildings and retrofitting existing buildings that are able to reduce required blast standoff distances for significant damage by 40%.

Customer POC	**Service/Agency POC**		**USD(A&T) POC**
LTC Vincent Kam, USA JCS/J34	Mr. Gil Buhrmann OST	Mr. Douglas Sunshine DSWA/PMT	Mr. Jeffrey Paul DDR&E(SEBE)
	Mr. Douglas Wehring CEMRO-ED-ST	Dr. Richard Jones NFESC	Mr. John Reingruber ASD(SO/LIC)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602784A	T40	0.9	1.0	1.0	1.0	0	0
0603122D	P484	8.0	10.0	12.0	12.0	12.0	10.0
	Total	**8.9**	**11.0**	**13.0**	**13.0**	**12.0**	**10.0**

L.07 Terrorist Chemical/Biological Countermeasures

Objectives. Develop effective countermeasures to the transport and use of chemical/biological (CB) agents by terrorists. Improved capabilities for detecting and identifying such agents prior to or after their deployment will be developed. The effort will focus on developing and fielding effective means for detecting and identifying CB agents, including a time-amount profile dosimeter for measuring individual exposures; developing suitable methods and materials for mitigating their adverse effects, including agent dissemination devices and high-intensity, wide-spectrum, pulsed UV light neutralization techniques; establishing appropriate cleanup procedures; and developing protective measures that ensure personnel safety without compromising the ability to achieve mission objectives.

Payoffs. The development of more effective countermeasures to potential terrorist use of CB agents will greatly enhance the safety of military and civilian personnel by facilitating timely interdiction of terrorists and agent materials, providing protective measures able to limit the effectiveness of dispersed agents, providing rapid-acting and nonhazardous cleanup materials and procedures, and facilitating more rapid responsive actions by military and law enforcement personnel. The availability of effective countermeasures could also help to deter the use of CB agents by terrorists.

Challenges. Key challenges include achieving effective countermeasure capabilities in lightweight, compact systems that are portable and readily available to first responders to terrorist incidents; developing reliable systems able to detect and identify a wide range of CB threat agents; identifying reliable means for adapting enzyme decontamination systems to the destruction of other threat agents; and overcoming anticipated system complexity, operability, and affordability issues. Another key challenge involves conditioning and training canines to detect low levels of chemical agents.

Milestones/Metrics.

FY1999: Demonstrate and field a first-generation CB dosimeter that relies on passive sampling; demonstrate nonintrusive, low-level detection of chemical agents by canines; demonstrate high-intensity, wide-spectrum, pulsed UV light for neutralizing surface biological warfare contaminants; produce large quantities of proven, nonhazardous, enzyme decontamination materials for neutralizing G-type nerve agents.

FY2000: Produce large quantities of proven nonhazardous enzyme decontamination materials for neutralizing G-type nerve agents; demonstrate a first-generation biological dosimeter.

FY2001: Demonstrate a second-generation CB dosimeter based on active sampling techniques that provides greater detection sensitivity; demonstrate high-intensity, wide-spectrum, pulsed UV light techniques for neutralizing CB agents in air-handling and water-purification systems.

FY2003: Demonstrate detection systems having greater sensitivity, reduced false alarm rates, and capabilities for detecting all priority CB agents; demonstrate waterless removal of surface CB warfare contaminants using high-intensity, pulsed UV light.

Customer POC	**Service/Agency POC**	**USD(A&T) POC**	
LTC Vincent Kam, USA	Ms. Tracy Cronin	Mr. Jeffrey Paul	Mr. John Reingruber
JCS/J34	OST	DDR&E(SEBE)	ASD(SO/LIC)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0603122D	P484	3.0	3.0	3.0	3.0	2.5	2.5
0603160D	P539	0.8	0	0	0	0	0
0603160BR	P539	0	0.8	0.8	0.9	1.0	2.0
	Total	**3.8**	**3.8**	**3.8**	**3.9**	**3.5**	**4.5**

L.08 Tactical Operations Support

Objectives. Develop advanced technological capabilities and equipment to support the activities of military forces responsible for the planning and execution of antiterrorist and counterterrorist operations. Specific efforts will include developments involving advanced sensors, weapons, information and communications systems, targeting systems, and improved protective measures for tactical forces. Representative products will include advanced night vision goggles, a miniature laser rangefinder, and designs supporting the development of a high-speed assault boat.

Payoffs. Improved capabilities for supporting antiterrorist and counterterrorist operations by tactical forces will increase the probability of achieving mission objectives for a variety of such operations, including both preemptive strike and retaliatory actions. Operations will be executed with greater speed and precision. Casualties suffered by U.S. forces will be reduced; fratricide problems will be minimized. Demonstrated capabilities for conducting effective tactical operations against terrorists should help to deter future terrorist incidents.

Challenges. Specific technical challenges to achieving improved capabilities for tactical support operations include (1) extending technology advances emerging from Army Night Vision and Electronic Sensors Directorate (NVESD) programs to the development of improved night vision goggles with significantly reduced blooming and halo effects; (2) developing improved, miniature laser rangefinders to provide snipers with more reliable first-shot accuracy; and (3) leveraging DARPA and USSOCOM efforts and achieving innovative advanced hull designs for high-speed boats to be used by special forces that can operate effectively in high sea states.

Milestones/Metrics.

FY1998: Demonstrate improved night vision goggles providing a reduction in blooming of at least 30% compared to current systems; demonstrate a practical and accurate miniature laser rangefinder for use with tactical weapons over ranges of up to 2 km; develop advanced hull designs for a high-speed, low-profile assault boat.

FY2000: Demonstrate reductions in blooming and halo effects in night vision goggles by at least 60% compared to current systems; demonstrate the sea-keeping performance capabilities of an advanced high-speed, low-profile assault boat with typically equipped assault teams in sea states up to 4; demonstrate new communications capabilities for improving the flow of tactical information between forces involved in antiterrorist operations and command centers.

FY2001: Complete design modifications to a high-speed, over-water assault boat that will enable delivery or deployment from C–141 aircraft.

Customer POC	Service/Agency POC	USD(A&T) POC	
LTC Vincent Kam, USA	Mr. Jeffrey David	Mr. Jeffrey Paul	Mr. John Reingruber
JCS/J34	OST	DDR&E(SEBE)	ASD(SO/LIC)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0603122D	P484	1.3	1.3	1.0	1.0	0	0
	Total	**1.3**	**1.3**	**1.0**	**1.0**	**0**	**0**

L.10 Automated Terrorist Incident Indications and Warning

Objectives. Develop and demonstrate an automated profiling system and an associated architecture that will enable new capabilities for scanning large databases and provide cues and information linkages pertinent to terrorist activities prior to actual incidents. The work will involve the collection, indexing, and interpretation of extensive information and data on terrorist organizations, individual terrorists, and potential terrorist activities and plans. The DTO has three main areas of focus: (1) defining the types and sources of information that would be indicative of possible terrorist activities (e.g., electronic phone/address books, credit card transactions, airline itineraries, and systematic or large purchases of biological or chemical materials); (2) exploiting critical artificial intelligence (AI) technologies that will sift and analyze the databases, including genetic algorithms, expert systems, fuzzy logic systems, and neural networks; and (3) exploiting alarm and other warning technologies that can reach all personnel and direct specific actions based on the identified threat. Critical infrastructure nodes and interdependencies derived from DTO L.03 will be factored into the information database being developed under this DTO. A hybrid architecture will be developed that combines the strengths of each AI technology and applies it to the specific problem of terrorist indications and warning.

Payoffs. The development of an automated system that can identify and correlate information about potential terrorist activities and plans will enable more time for our forces to develop protective measures or to counter terrorist activities. This automated capability will also provide a complement to the use of human information sources and enable a degree of fact-checking and cross-referencing. Force vulnerability will be reduced as possible terrorist targets are identified prior to the occurrence of an incident and personnel in the targeted area are placed on a higher state of alert.

Challenges. A major challenge will be to identify and hypothesize useful connections between various kinds of information that can lead to the uncovering of terrorist activities. Information availability, multiple data formats, and inherent database errors—including missing or incomplete data and a user-friendly presentation format—are all difficult technical challenges. Another significant challenge is the fact that terrorist incidents are relatively rare; consequently, little lessons-learned information is available. Measures of system effectiveness need to be developed to determine whether the rules and algorithms of the automated system are accurate. This is necessary to eliminate high levels of false alarms while still maintaining a high level of incident detection capability. Simulated incident scenarios may need to be developed to test the robustness of the system.

Milestones/Metrics.

FY1999: Develop measures of system effectiveness for technical performance (response time, flexibility, adaptability, etc.) and functional capability (false alarm rate, predictive performance); define input data requirements, format, source, and interrelationships; develop system architecture requirements and system design.

FY2001: Demonstrate and test prototype system using simulated incident scenarios and data sources; determine system performance effectiveness and sensitivity to data errors or incomplete information.

FY2003: Demonstrate and test prototype system using real data source inputs; demonstrate system effectiveness against a terrorist incident directed toward an electric power grid.

Customer POC	**Service/Agency POC**	**USD(A&T) POC**	
LTC Vincent Kam, USA	Mr. James Lawrence	Mr. Jeffrey Paul	Mr. John Reingruber
JCS/J34	OST	DDR&E(SEBE)	ASD(SO/LIC)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0603122D	P484	0.1	0.3	0.3	0.3	0.3	0.3
	Total	**0.1**	**0.3**	**0.3**	**0.3**	**0.3**	**0.3**

SECTION II

Defense Technology Objectives for the Defense Technology Area Plan

AIR PLATFORMS

Defense Technology Objectives
for the Defense Technology Area Plan

Air Platforms

AP.01.00 Advanced Aerodynamic Concepts for Increased Flight Efficiency II-2
AP.02.00 Fixed-Wing Vehicle Structures Technology II-4
AP.03.00 Aircraft Support/Sustainment Reduction II-5
AP.04.00 Flight Control Technology for Affordable Global Reach/Power II-6
AP.05.00 Maturity Demonstration of Advanced Fixed-Wing Vehicle Technologies II-8
AP.06.00 Helicopter Active Control Technology II-10
AP.07.00 Demonstration of Advanced Rotor Concepts II-11
AP.08.00 Fighter/Attack/Strike Propulsion II-12
AP.09.00 Transport/Patrol/Helicopter Propulsion II-14
AP.10.00 Cruise Missile/Expendable Propulsion II-16
AP.11.00 Aircraft Power (MEA) II-18
AP.12.00 Rotorcraft Drive II-20
AP.13.00 Affordable/Supportable Fixed-Wing Vehicle Subsystems Technology II-21
AP.14.00 Rotary-Wing Vehicle Structures Technology II-22
AP.15.00 Affordable/Supportable Rotary-Wing Vehicle Subsystems Technologies II-23
AP.16.00 Rotary-Wing Vehicle Signature Reduction Technologies II-25
AP.17.00 Hydrocarbon Scramjet Missile Propulsion II-26
AP.18.00 Improved JP–8 Fuel II-28
AP.19.00 High-Heat-Sink Fuels (JP–900/Endothermic) II-30
AP.20.00 DARPA Micro Air Vehicles Program II-32

AP.01.00 Advanced Aerodynamic Concepts for Increased Flight Efficiency

Objectives. Demonstrate affordable aerodynamic technologies that provide increased cruise efficiency, increased maneuver capability, safer carrier operability, and reduced weight over current fixed-wing aircraft technology, yielding increased payload/range, lower costs, and lower weights both with and without external stores. The overall objectives are to demonstrate, by FY03, a 10% increase in cruise and maneuver lift/drag (L/D), a 20% increase in landing approach lift coefficient, a 25% reduction in nozzle weight, a 50% reduction in air induction system weight, and a 30% reduction in aerodynamic design cycle time, contributing to goals of a 20% reduction in production cost, a 20% reduction in O&S cost, a 20% reduction in EMD cost, a 20% reduction in airframe weight, a 10% increase in cruise L/D, and a 20% increase in maneuverability. This DTO leverages considerable resources from the 6.2 program element to develop aerodynamics-enabling technologies vital to the accomplishment of DTO objectives

Payoffs. This DTO and its preceding technology thrust have a proven record of transitioning technology to new and modified air platforms. Included in this history are air-induction systems for the F–16, F–22, and both Joint Strike Fighter configurations as well as exhaust nozzles on the F–18 and F–22, powered lift on the C–17, and weapons bay improvements on the F–117. Typical payoffs include a 35% increase in aircraft range or payload, a 30% reduction in both acquisition and O&S costs, a 20% reduction in vulnerability, and a 20% reduction in aircraft takeoff gross weight.

Challenges. Technology barriers to overcome for increased cruise and maneuver efficiency are the weight of the higher aspect ratio wings, controlling and minimizing localized separated flow, and integrating a high-lift system into a thin wing. Barriers to achieving increased cruise efficiency while carrying external stores in a low-drag weapons pod are weight, acoustic, and store separation environments. Barriers to achieving a reduced weight thrust vectoring nozzle with full area control include response rates, controllability, airflow requirements, and load sharing with a cold airframe structure. Barriers to achieving lightweight, compact inlets include reducing duct length with minimal total pressure loss and suitable flow quality, acceptable boundary layer control while maintaining stability, total pressure recovery and flow quality, and maintaining high performance above Mach 1.5.

Milestones/Metrics.

FY1998: Experimentally validate cruise L/D; demonstrate, at technology readiness level (TRL) 3, half of the required 10% increase in cruise L/D.

FY1999: Demonstrate, at TRL 3, accurate aerostructural solutions with arbitrary CFD/CSD codes for a significant portion of the required 30% reduction in aerodynamic design cycle time.

FY2000: Validate, at TRL 4, inlet hammershock load prediction capability necessary to realize a significant portion of the required 50% reduction in air-induction system weight.

FY2001: In transonic wind tunnel, validate, at TRL 5, high-L/D, cruise-efficient fighter configuration to demonstrate half of the required 10% increase in cruise and maneuver L/D.

FY2002: Ground demonstrate reduced weight and volume, high-performance, full-scale-compact, fixed-geometry inlet for cruise-efficient fighter aircraft resulting in significant progress toward the objective of 50% reduction in air-induction system weight.

FY2003: Flight demonstrate appropriate DTO technologies at TRL 6 on the FATE–1/UCAV flight test platform to validate a 10% increase in cruise and maneuver L/D with and without stores.

Customer POC	Service/Agency POC		USD(A&T) POC
Col George Monroe, USAF	Mr. William King	Mr. Terry Neighbor	Dr. Donald Dix
HQ ACC/DRM	ONR 351	AFRL-VA	DDR&E(AT)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602122N		1.1	0.8	0.8	0.8	1.1	1.1
0602201F	2404	8.8	9.2	9.8	9.5	9.8	10.2
0603245F	2568	1.7	2.6	1.1	1.1	1.4	3.3
	Total	**11.6**	**12.6**	**11.7**	**11.4**	**12.3**	**14.6**

AP.02.00 Fixed-Wing Vehicle Structures Technology

Objectives. Address four of the fixed-wing vehicle subarea goals: 20% reduction in production cost, 20% reduction in development cost, 20% reduction in operations and support cost, and 20% reduction in air vehicle weight fraction. This DTO demonstrates structural performance improvements resulting from reduced weight and cost, leading to the following structures technology objectives: in FY00, a 30% reduction in structural manufacturing cost for fighter/attack airframe; and by FY03, a 25% reduction in design cycle cost and a 20% fighter weight reduction. Specific technology objectives include a composite primary structural demonstration for a 30% structural weight reduction and 20% reduced fabrication costs, and a manned flight demonstration of active aeroelastic wing for a 10% structural weight reduction.

Payoffs. These technologies will directly contribute to the attainment of aircraft system payoffs of a 10% reduction in acquisition costs, a 10% reduction in O&S cost, a 25% increase in mission range or payload, a 15% reduction in susceptibility, and a 10% reduction in takeoff gross weight.

Challenges. Existing development times and costs are too high because of the nonassociative design environments and the need for extensive subelement design and hardware testing. Current aircraft structures are highly complex, with too many parts and too many fasteners. The cost of design, lay-up, manufacturing, and assembly of advanced composites is too high, which prevents their wider application. Current analytical codes are unable to predict structural responses to twin-tail buffet and weapon bay acoustic excitation. Conformal antennas to reduce drag and improve radar and communication performance require the combination of load-bearing structures with the antenna EM characteristics.

Milestones/Metrics.

FY2000: Composite primary structural ground test demonstration for 30% structural weight reduction and 20% reduced fabrication costs.

FY2002: Flight demonstration of active aeroelastic wing on a joint AF/NASA fighter aircraft for 10% structural weight reduction.

FY2003: Ground and flight demonstration of fighter/attack airframe composite structures for 30% reduced manufacturing cost, 25% reduced design cycle cost, and 20% reduced weight.

Customer POC	Service/Agency POC		USD(A&T) POC
Col George Monroe, USAF	Mr. William King	Mr. Terry Neighbor	Dr. Donald Dix
HQ ACC/DRM	ONR 351	AFRL-VA	DDR&E(AT)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602201F	2401	7.7	8.3	8.5	8.7	8.7	9.0
0602122N		0.4	0.5	0.8	0.8	0.7	0.8
0603211F	486U	4.4	5.3	2.6	3.1	5.7	2.2
	Total	**12.5**	**14.1**	**11.9**	**12.6**	**15.1**	**12.0**

AP.03.00 Aircraft Support/Sustainment Reduction

Objectives. Develop, demonstrate, and transition technologies to extend the lives and reduce the costs of aging aircraft. This DTO addresses the fixed-wing vehicle subarea goal of 20% reduction in O&S costs by FY03 by reducing structural O&S costs by 25%. Corrosion/fatigue and widespread fatigue damage (WFD) advances will improve the life assessment of aircraft structures having multisite damage (MSD) and corrosion. Focusing on probabilistic analysis, metrics and transformations accounting for corrosion and MSD will be developed, demonstrated, and transitioned to the air logistics centers (ALCs). Damage-tolerant bonded repairs will be developed and demonstrated. A design tool for use by ALC engineers to quickly and confidently design patch repairs will be transitioned to operational use. Improved prediction and control of damaging dynamic loads will increase fatigue life and reduce support costs. The ability to predict the effects of unsteady aerodynamic loads will be developed and used with advanced structural concepts to increase fatigue life and reduce the support cost of aircraft.

Payoffs. These technologies will directly support the aircraft payoffs of 10% reduction in O&S costs and 10% increase in operational readiness. The dual-use nature of the technology means that it will also be applied to make the U.S. commercial fleet last longer and have lower maintenance costs, which is vital to maintaining low costs for business travel, shipping, and mail.

Challenges. Current aircraft experience high-limit cycle loads and excess tail buffet and fatigue. There is currently no means for predicting the response of aircraft structures to degradation due to unsteady aerodynamics. The current aging fleet experiences excessive maintenance costs due to corrosion and MSD. Corrosion chemistry and random fatigue cracking are not fully understood, and residual strength analysis tools and nondestructive inspection techniques for detecting these forms of damage are lacking. Buried engine structural stresses are too high, resulting in excess fatigue. Aft structures are too hot, resulting in excessive fatigue and high maintenance costs per flight hour.

Milestones/Metrics.

FY1998: Preferred spare for the 66% wing spar of the T–38.

FY2000: Validate model for the effects of corrosion on structural integrity contributing to the 10% increase in operational readiness and reducing O&S costs.

FY2001: Validate design tool for bonded composite repair of metallic structures for reduced O&S costs.

FY2003: Flight demonstrate active suppression system for weapons bay acoustics noise; demonstrate appropriate DTO technologies to validate a 20% reduction in structural O&S costs.

Customer POC	**Service/Agency POC**		**USD(A&T) POC**
Col George Monroe, USAF	Mr. William King	Mr. Terry Neighbor	Dr. Donald Dix
HQ ACC/DRM	ONR 351	AFRL-VA	DDR&E(AT)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602201F	2401	4.8	5.3	5.2	5.5	5.5	5.7
0602201F	2402	0	3.0	0.7	0	0	0
0602122N		0.4	0.5	0.7	0.7	0.7	0.7
0603211F	486U	0.3	1.1	7.1	8.6	7.1	11.0
0603245F	2568	0	0	0	0	0	1.1
	Total	**5.5**	**9.9**	**13.7**	**14.8**	**13.3**	**18.5**

AP.04.00 Flight Control Technology for Affordable Global Reach/Power

Objectives. Develop flight control technologies leading to affordable aircraft control systems that (1) automatically adjust to and survive combat damage, (2) have on-board systems to identify flight control component failures to reduce repair time, (3) provide supersonic tailless fighter control to improve range and payload, (4) have power-by-wire/fly-by-light control technology to improve reliability, (5) have low observable (LO) air data systems to improve survivability, and (6) operate in poor visibility with an autonomous landing system to increase operational readiness. By FY03, the program will achieve the following phase one objectives: 15% reduction of the weight/drag of aircraft tails and flight control system, 25% reduction in flight control system development costs, 20% increased aircraft agility, 70% reduction in control related accidents, and 20% reduction in flight control system operation and support costs.

Payoffs. Development of this technology will, by FY02, contribute to the reduction of fighter/attack aircraft O&S costs by 20%, reduction of aircraft gross weight by 10%, reduction of vulnerability by 15%, and improvement of lethality by 5%. For large aircraft, the program will, by FY02, contribute to the reduction of O&S costs by 10%, increase in operational readiness by 10%, and increase of range or payload by 20%.

Challenges. Technology barriers include the inability to generate directional aerodynamic control power for tailless aircraft; identify on-line aerodynamic model and control law changes needed to compensate for battle-damaged or failed control surfaces; package high-horsepower electric actuation within aircraft mold lines; nonintrusively measure air data for highly dynamic flight vehicles in all weather conditions; and develop high g tolerant photonic connectors, backplane, and electro-optic conversion components for fly-by-light.

Milestones/Metrics.

FY1998: Flight test fly-by-light component contributing to 15% reduced weight of the flight control system. From planned flight simulation, demonstrate increased shipboard launch-and-recovery envelope control laws modifications contributing to 10% increased operational awareness.

FY1999: Complete laboratory demonstration of optical air data components contributing to 20% reduced flight control system O&S costs.

FY2000: Demonstrate reconfigurable control tailless aircraft simulation contributing to 70% reduced control-related accidents and 20% increase in fighter agility.

FY2001: Flight demonstrate high-horsepower stabilator electric actuator on a fighter contributing to 20% reduced flight control system O&S costs.

FY2002: Flight demonstrate onboard, pilot-induced oscillation detection/prevention algorithm contributing to 70% reduced control-related accidents.

FY2003: Complete laboratory validation of new photonic vehicle management system contributing to 25% reduced flight control system development cost and 15% reduced flight control system weight. From planned flight demonstration, demonstrate ship airwake and air vehicle interaction for launch and recovery contributing to 25% reduced flight control system development cost.

Customer POC	**Service/Agency POC**		**USD(A&T) POC**
Col George Monroe, USAF	Mr. William King	Mr. Terry Neighbor	Dr. Donald Dix
HQ ACC/DRM	ONR 351	AFRL-VA	DDR&E(AT)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602122N		0.9	1.0	1.1	1.1	1.2	1.3
0602201F	2403	11.2	11.7	12.3	12.5	12.9	13.4
0603205F	2978	1.8	2.6	2.6	2.0	1.2	0.4
0603245F	2568	0	0.8	1.9	2.3	1.5	2.9
	Total	**13.9**	**16.1**	**17.9**	**17.9**	**16.8**	**18.0**

AP.05.00 Maturity Demonstration of Advanced Fixed-Wing Vehicle Technologies

Objectives. Demonstrate advanced fixed-wing vehicle technologies in a relevant environment, and validate that these technologies achieve the Fixed-Wing Vehicle (FWV) program subarea goals by 2003. There are three affordability goals (reductions in production, O&S, and EMD costs for an unresized vehicle—equivalent to no increase in costs per pound for a resized vehicle) and three performance goals (reduced air vehicle weight fraction, increased lift/drag, and increased usable flight envelope). Upon completion of these demonstrations, the technologies will be sufficiently mature for incorporation into new and existing weapon systems. This DTO includes major efforts to show achievement of the goals: the Future Aircraft Technology Enhancement (FATE), Virtual Future Aircraft Technology Enhancement (VFATE), and supporting programs. FATE is flight test program using an unmanned S&T research vehicle to demonstrate FWV technologies requiring in-flight verification. The program has been expanded to include the enabling technology set for an unmanned combat air vehicle (UCAV) and is referred to as FATE/UCAV. The test vehicle will be sized for an appropriate mission. VFATE will define a modeling, simulation, and analysis (MS&A) program to represent matured FWV technologies accurately and sufficiently to show achievement of the subarea goals and interface with the Conceptual Aircraft System Design and Analysis Toolkit (CASDAT) and cost modeling efforts already underway. The supporting programs are Active Aeroelastic Wing (AAW) Program, Auto Ground Collision Avoidance (Auto GCAS) Program, and Extended-Range Demonstration (ERD) Program.

Payoffs. All payoffs in this DTO are relative to the overall FWV program subarea payoffs, which include a 25% increase in range or payload and a 10% reduction in takeoff gross weight (TOGW). Individually, AAW technology will provide a 7%–10% reduction in aircraft TOGW for subsonic cruise configuration and a 20% reduction in TOGW for a supersonic cruise configuration. The Auto GCAS was evaluated by Air Force Safety and determined capable of preventing over 95% of all fighter controlled-flight-into-terrain (CFIT) accidents. CFIT is the leading cause of all Air Force losses in peacetime, and prevention would result in a substantial saving of both aircraft and aircraft occupants while expanding the safely usable flight envelope. The ERD program will demonstrate that thrust vectoring enables an estimated 3%–7% increase in range through offloading aerodynamic control surfaces during certain phases of flight. The additional control power provided by vectoring nozzles is projected to reduce the peacetime aircraft loss rate by 15%–20% through a reduction in the number of loss-of-control accidents. The FATE/UCAV program will demonstrate technologies as required in flight tests that are key to achieving the payoffs. The VFATE program will be scoped to allow a substantial decrease in the physical testing required, both ground test and inflight test, and thus production and O&S costs.

Challenges. Technologies must be validated to sufficient levels of maturity (ready for technology transition) to be used to meet the goals and payoffs. As an example, the AAW has been thoroughly tested in the wind tunnel, now it must be tested in full scale on a fighter aircraft. The aircraft must be capable of supersonic speeds in order to assess the effects of aeroelasticity at full-scale Reynolds numbers and to assess the effects of nonlinear structural, actuation, and electro-hydraulic hysteresis with respect to the AAW technology. Particular challenges include the implementation of an actuation system to use the leading-edge outboard control surface as a maneuvering control and the use of ailerons both pre- and post-aeroelastic aileron reversal. Auto GCAS's major challenge is ensuring the system performs with no nuisance warnings throughout the complete flight envelope. ERD's technical challenges include the successful integration of the nozzle and aircraft control laws, control power development at supersonic speeds, and reliability with failure mode accommodation. FATE/UCAV will flight demonstrate individual and combinations of technologies for which a full-scale representation on a manned vehicle would be too expensive. For the VFATE program, applied technologies must be represented in a realistic manner and done to sufficient fidelity to provide the confidence that the FWVP subarea goals are achieved—and do it within resource limits.

Milestones/Metrics.

FY1998: Complete AAW preliminary design for the F/A–18 testbed. Integrate and flight demonstrate Auto GCAS in F–16 platform to validate capability of preventing CFIT. Conduct ERD flight test of inner-loop control laws. Complete VFATE program definition; demonstrate analysis of concept feasibility, resulting in rough sizing of vehicles with baseline technologies. Section 845 Agreement (Phase 1) issued to begin the FATE/UCAV program.

FY1999: Complete AAW critical design, followed by detailed design/modification, ground, and flight testing. Integrate and flight demonstrate Auto GCAS in Swedish aircraft. Demonstrate incorporation of advanced technologies of interest in vehicle concept based on gross and estimated parameters, resulting in three-view drawings, size, and performance of vehicle. FATE/UCAV program downselection for detailed design and manufacturing.

FY2001: Validate AAW technology through full-scale flight demonstration of active aeroelastic wing structures at technology readiness level 6; contributes to 20% reduction in structural weight. FATE/UCAV vehicle accomplishes first flight.

FY2003: FATE/UCAV program demonstrates weapon system utility.

Customer POC	**Service/Agency POC**	**USD(A&T) POC**
Col George Monroe, USAF HQ ACC/DRM	Mr. William King ONR 351	Dr. Donald Dix DDR&E(AT)
Mr. Rich Trenck APEO (A)	Mr. Terry Neighbor AFRL-VA	

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602122N		0.3	0.3	0.3	0.3	0.3	0.3
0602201F	2404	3.2	3.4	3.2	3.5	3.5	3.6
0603205F	2978	0.6	0.9	2.0	2.3	2.9	4.4
0603211F	486U	1.7	2.5	0	0	0	0
0603245F	2568	1.4	2.0	4.5	4.9	4.8	0.6
	Total	**7.2**	**9.1**	**10.0**	**11.0**	**11.5**	**8.9**

AP.06.00 Helicopter Active Control Technology

Objectives. Demonstrate integrated, state-of-the-art rotorcraft flight control technologies with exploitation of advanced fixed-wing hardware components and architectures. The objective is to demonstrate, through simulation and flight test, second-generation rotorcraft digital fly-by-wire/-light control systems with fault-tolerant architectures including carefree maneuvering, task-compliant control law, and integrated fire, fuel, and flight control capabilities, designed with robust control law design methods. The goals are to demonstrate, by FY02, a 50% reduction in the probability of degraded handling qualities due to flight control system failures, a 60% improvement in weapons pointing accuracy, a 50% increase in agility and maneuverability, and a 30% reduction in flight control system flight test development time (compared to FY94 technology).

Payoffs. The Helicopter Active Control Technology (HACT) DTO will demonstrate capability improvements to all-weather/night mission performance, flight safety, and development time and cost that contribute to a 4% reduction in RDT&E costs, a 65% increase in maneuverability/agility, and a 20% reduction in major accident rate. These improvements will contribute to system-level payoffs in reducing development and O&S costs.

Challenges. The program will overcome technical barriers such as the lack of knowledge of optimal rotorcraft response types; inadequate techniques for sensing the onset of envelope limits, cueing the pilot, or limiting pilot inputs; inadequate air vehicle math modeling for high-bandwidth flight control; inadequate flight control system design, optimization, and validation techniques; and lack of knowledge in the optimum functional integration of flight control, weapon systems, and pilot interface.

Milestones/Metrics.

FY1999: Complete hardware and software preliminary design.

FY2000: Fabricate hardware and perform software V&V and HWIL simulation.

FY2002: Integrate flight control system with flight test vehicle; demonstrate via piloted simulation and flight test 50% reduction in the probability of degraded handling qualities due to flight control system failures, 60% improvement in weapons pointing accuracy, 50% increase in agility and maneuverability, and 30% reduction in flight control system flight test time.

Customer POC
Mr. Ted Hundley
USA Aviation Center

Service/Agency POC
Mr. Robert Kennedy
HQ USA AMCOM

Mr. Jeffrey Smith
DARPA/TTO

Mr. William King
ONR 351

USD(A&T) POC
Dr. Donald Dix
DDR&E(AT)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0603003A	313	0.5	3.3	10.0	9.0	6.3	0
	Total	**0.5**	**3.3**	**10.0**	**9.0**	**6.3**	**0**

AP.07.00 Demonstration of Advanced Rotor Concepts

Objectives. Demonstrate aeromechanics technologies leading to an increase in maximum blade loading of 8% by 2000, an increase in rotor aerodynamic efficiency of 6% by 2004, a reduction in aircraft loads and vibration loads of 20% by 2000, and a reduction in vehicle adverse forces of 12% by 2004 via advanced concept evaluation and application in enabling technology and applied technology efforts.

Payoffs. These demonstrations contribute to rotary-wing vehicle system level payoffs for FY05 of a 91% increase in range or 66% increase in payload, a 6% increase in cruise speed, a 65% increase in maneuverability/agility, a 20% increase in reliability, and a 21% reduction in O&S costs for fielded and new systems.

Challenges. Achieving these objectives will be accomplished by executing a set of programs and demonstrations to substantially increase the prediction effectiveness of rotorcraft analysis methodology and to overcome barriers such as the accurate prediction and control of stall, drag, and compressibility characteristics; actuators constructed using smart materials for primary control and vibration control; and understanding and modeling the effects of critical rotorwakes on the dynamics of rotorcraft.

Milestones/Metrics.

FY1998: Demonstrate model scale, active on blade, active control rotor concepts for reducing vibration and noise.

FY2000: Demonstrate concepts toward eliminating conventional rotor lag dampers through the application of smart structures and rotorcraft analysis methodology improvements.

FY2002: Fabricate advanced active control rotor for wind tunnel testing.

FY2004: Demonstrate 16% increase in maximum blade loading, 6% increase in rotor aero-dynamic efficiency, 40% reduction in aircraft loads and vibration loads, and 12% reduction in vehicle adverse forces via model and full-scale whirl and flight tests.

Customer POC	**Service/Agency POC**		**USD(A&T) POC**
Mr. Ted Hundley	Mr. Robert Kennedy	Mr. William King	Dr. Donald Dix
USA Aviation Center	HQ USA AMCOM	ONR 351	DDR&E(AT)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602211A	47A	3.4	3.5	3.4	0	0	0
0602211A	47B	0.6	0.6	0.6	0	0	0
0603003A	313	0	0	0	3.0	9.5	22.9
	Total	**4.0**	**4.1**	**4.0**	**3.0**	**9.5**	**22.9**

AP.08.00 Fighter/Attack/Strike Propulsion

Objectives. Develop and demonstrate turbofan/turbojet engine technologies for fighter/attack, bomber, and military transport aircraft and provide improved design tools and practices not only to this DTO but to the other two DTOs that are supported by the Integrated High-Performance Turbine Engine Technology (IHPTET) program (AP.09.00 and AP.10.00). The goals this DTO are to demonstrate, by 1999, a 60% increase in thrust/weight ratio, a 200°F increase in combustor inlet temperature, and a 20% decrease in production and maintenance costs relative to the 1987 state-of-the-art baseline; and, by 2003, to demonstrate a 100% increase in thrust/weight ratio, a 400°F increase in combustor inlet temperature, and a 35% reduction in production and maintenance costs.

Payoffs. IHPTET has a proven record of transitioning technology for new and upgraded engines—including engines for the F–15, F–16, F/A–18E/F, C–17, and C–130J—and is the source of engine technology for the Joint Strike Fighter (JSF) and F–22 (F119 engine) programs. Typical payoffs include a 40% reduction in fuel burned, a 35% reduction in takeoff gross weight, a 50% increase in aircraft payload, and a 115% increase in mission radius, all of which lead to improved affordability (system capability/system cost). In addition, the dual-use nature of the technology makes IHPTET a key determinant in the overall quality of U.S. commercial aircraft, which is vital to maintaining the U.S. position in the $100 billion per year civil market.

Challenges. Higher temperatures at combustion initiation are required to decrease fuel consumption and expand the flight envelope; higher maximum temperatures are required to increase the output-per-unit-airflow (specific thrust); less weight-per-unit-airflow is required to increase the output-per-unit-weight (thrust/weight or power/weight ratio); and all of the preceding advances must be accomplished while maintaining or increasing component efficiencies, durability, and life and by reducing cost. Specific technology development areas include application of higher temperature capability, lower density materials; aerothermodynamic design capability for improved component efficiencies and control of heat transfer; innovative structural concepts; and compatibility of these developments with lower cost manufacturing processes.

Milestones/Metrics.

FY1998: Demonstrate, through core/engine durability tests, gamma-TiAl compressor blades and supercooled/transpiration-cooled turbine blades and vanes. Achieves +50°F combustor inlet temperature.

FY1999: Demonstrator core/engine tests of an organic-matrix composite (OMC) static structure, forward swept fan, active stability control, metal-matrix composite (MMC) compressor and shaft, cast-cool/supercooled turbine components, swirl augmentor, and fluidic nozzle area control. Achieves 54% improvement in engine thrust/weight and 32% decrease in fuel burned.

FY2001: Demonstrator core/engine tests of a high-stage loading compressor, dual-web turbine disk, ceramic bearings, high-work vaneless low turbine, and distributed controls. Achieves +200°F improvement in combustor inlet temperature, 65% improvement in engine thrust/weight, and 34% decrease in fuel burned.

FY2004: Demonstrator core/engine tests of a gamma-TiAl/MMC compressor rotor, OMC/hybrid swept fan, magnetic bearings, advanced ceramic matrix composite/refractory turbine blades and vanes, trapped vortex combustor with radiative ignition, and active structural control. Achieves +400°F improvement in combustor inlet temperature, 100% improvement in engine thrust/weight, and 40% decrease in fuel burned.

Customer POC		Service/Agency POC	USD(A&T) POC
Mr. David Edmunds F119 Program Office	Col George Monroe, USAF HQ ACC/DRM	Mr. Richard Quigley AFRL-PR	Dr. Donald Dix DDR&E(AT)
Mr. Daniel Kunec JSF Program Office	Mr. Olen Sisson APEO (T)	Mr. Charles Gorton NAVAIR-4.4T	

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602122N		4.3	5.1	5.1	5.5	5.9	5.9
0602203F	3048	3.0	1.6	1.2	1.2	5.4	3.2
0602203F	3066	27.7	35.2	36.5	37.1	37.3	39.3
0603202F	668A	20.6	25.8	26.7	27.7	26.5	28.2
0603216F	681B	25.8	30.2	31.2	32.9	32.0	33.6
0603217N	W2014	3.9	4.8	4.4	4.5	4.5	4.5
	Total	**85.3**	**102.7**	**105.1**	**108.9**	**111.6**	**114.7**

AP.09.00 Transport/Patrol/Helicopter Propulsion

Objectives. Develop and demonstrate core engine technologies for turboprop/turboshaft applications such as rotary-wing, special operations, transport, and patrol/EW aircraft, as well as derivative turbofan/turbojet configurations for trainer and uninhabited aerial vehicle aircraft; and provide multiuse improved design tools and practices not only to this DTO but to the other two DTOs that are supported by the Integrated High-Performance Turbine Engine Technology (IHPTET) program (AP.08.00 and AP.10.00). Phase I of the IHPTET program has been completed. The achievement of Phase II goals is well underway: a 30% reduction in specific fuel consumption (SFC), an 80% increase in power/weight ratio, a 600°F increase in turbine rotor inlet temperature (TRIT), and a 20% reduction in production and maintenance costs. The Phase III goals include a 40% reduction in SFC, a 120% increase in power/weight ratio, a 1,000°F increase in TRIT, and a 35% reduction in production and maintenance costs relative to the 1987 state-of-the-art baseline.

Payoffs. IHPTET has a proven record of transitioning technology for new and upgraded engines—including engines for the RAH–66 Commanche and Growth UH–1—and is the source of engine technology for the next-generation rotorcraft and unmanned combat air vehicle (UCAV) programs. Typical payoffs include a 200% increase in time on station for patrol/surveillance aircraft; a 33% increase in payload with a 50% reduction in fuel consumption for an equivalent CH–47D mission; or a 40% increase in mission radius with double the personnel payload for a UH–60L helicopter. All of these payoffs lead to improved aircraft affordability (system capability/system cost). In addition, the dual-use nature of turbine engine technology makes IHPTET a key determinant in the overall competitiveness of U.S. commercial aircraft, which is vital to maintaining the U.S. leadership in the expanding civil market.

Challenges. Higher pressure ratios and temperatures at combustion initiation are required to decrease fuel consumption; higher maximum turbine temperatures are required to increase the output-per-unit-airflow (specific power or specific thrust); less weight-per-unit-airflow is required to increase the output-per-unit-weight (power/weight); and all of the preceding advances must be accomplished while maintaining or increasing component efficiencies, durability, and life while reducing cost. Specific technology development areas include application of higher temperature capability, lower density materials; improved aerothermodynamic design capability to increase component efficiencies and control heat transfer; innovative structural concepts for parts count reduction and improved durability; and compatibility of these developments with lower cost manufacturing processes. Other technology barriers include effective control of cooling air in small blades and vanes, centrifugal impeller aerodynamics, and operation at higher rotor speeds.

Milestones/Metrics.

FY1998: Demonstrator core test including a splittered axial rotor and rich-quench-lean combustor. Achieves 28% reduction in SFC, 102% increase in power/weight, and 400°F increase in TRIT.

FY1999: Demonstrator core test including high-effectiveness cooling turbine blades, 360°F ceramic LPT shroud, and monolithic ceramic low-pressure turbine (LPT) vanes. Achieves 30% reduction in SFC, 112% increase in power/weight, and 600°F increase in TRIT.

FY2001: Demonstrator core test including forward-swept aero and nonmetallic combustor and LPT blades. Achieves 34% reduction in SFC, 130% increase in power/weight, and 800°F increase in TRIT.

FY2002: Demonstrator core test of HP vanes and blades that achieves 36% reduction in SFC, 140% increase in power/weight, and 900°F increase in TRIT.

FY2003: Demonstrator core test that achieves full speed and temperature with forward swept aerodynamics, full nonmetallic hot section components, and magnetic bearings. Achieves 40% reduction in SFC, 148% increase in power/weight, and 1,000°F increase in TRIT.

Customer POC	Service/Agency POC	USD(A&T) POC
Col Ryan Dow, USAF HQ AMC/XPR	Mr. Richard Quigley AFRL-PR	Dr. Donald Dix DDR&E(AT)
MG James Snider, USA SFAE-AV	Mr. Charles Gorton NAVAIR-4.4T	
Mr. Rich Trenck APEO (A)	Ms. Sandra Hoff AATD AMSAM-AR-T-P	

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602122N		0.7	0.6	0.7	0.6	0.6	0.5
0602203F	3048	0.1	0	0	0	0	0
0602203F	3066	1.1	2.2	2.3	2.4	2.4	2.5
0602211A	47A	1.3	1.4	1.3	1.5	1.5	1.6
0602211A	47B	1.2	1.3	1.3	1.4	1.4	1.5
0603003A	447	6.2	6.6	7.2	7.2	7.1	7.2
0603216F	681B	2.3	2.0	2.0	2.0	2.0	2.0
0603217N	W2014	0	1.0	0.7	1.1	1.7	1.0
	Total	**12.9**	**15.1**	**15.5**	**16.2**	**16.7**	**16.3**

AP.10.00 Cruise Missile/Expendable Propulsion

Objectives. Develop and demonstrate core engine technologies for cruise missile/UAV applications and provide multiuse design tools and practices not only to this DTO but to the other two DTOs (AP.08.00 and AP.09.00) that are supported by the Integrated High-Performance Turbine Engine Technology (IHPTET) program. The goals are to demonstrate, by 1998, a 70% increase in thrust/airflow and a 45% reduction in cost. By 2003, the goal is to demonstrate a 100% increase in thrust/airflow, a 40% reduction in specific fuel consumption, and a 60% reduction in cost.

Payoffs. IHPTET has a proven record of transitioning technology for new and upgraded engines—including engines for the Joint Air-to-Surface Standoff Missile and the DarkStar uninhabited aerial vehicle. Payoffs for achieving the limited-life/expendable propulsion goals include supersonic cruise missiles with a 200% range increase over a rocket, a 30% payload increase enabling an intercontinental range ALCM-sized missile, and over 100% increase in loiter time for URAVs and UCAVs. Another payoff is the early and affordable demonstration of high-risk technologies for potential transition to fighter/attack/strike and transport/patrol/helicopter propulsion. All of these payoffs lead to improved aircraft affordability (system capability/system cost).

Challenges. Higher temperatures at combustion initiation are required to decrease fuel consumption (via increased compression system pressure ratio) or increase maximum flight speed thereby expanding the flight envelope; higher maximum temperatures are required to increase the output-per-unit-airflow (specific thrust); less weight-per-unit-airflow is required to increase the output-per-unit-weight (thrust/weight or power/weight ratio); and all of the preceding advances must be accomplished while maintaining or increasing component efficiencies, durability, and life while reducing cost. Specific technology development areas include application of advanced materials that exhibit higher temperature capability and lower density; improved aerothermodynamic design capability for improved component efficiencies and control of heat transfer; innovative structural concepts for part-count reduction and improved durability; and compatibility of these developments with lower cost manufacturing processes. Technologies unique to expendable/limited-life propulsion include limited-life design criteria, long shelf-life requirements without maintenance, and instrumentation of extremely small components.

Milestones/Metrics.

FY1998: Demonstrator engine test including a forward-swept compressor, hybrid ceramic bearings, uncooled ceramic matrix composite (CMC) hot section, high-heat-release combustor, and carbon/carbon exhaust nozzle. Achieves a 70% increase in thrust/airflow with a 45% cost reduction.

FY2000: Demonstrator engine test including high-temperature advanced metallic combustor and all ceramic bearings. Achieves an 80% increase in thrust-per-unit-airflow with a 55% cost reduction.

FY2001: Demonstrator engine test including a shrouded organic matrix composite (OMC) fan, high-stage loading compressor, and uncooled monolithic ceramic turbine. Achieves a 40% reduction in specific fuel consumption with a 60% reduction in cost.

FY2003: Demonstrator engine test including a splittered fan/compressor and a low-cost, low-solidity turbine. Achieves a 100% increase in thrust-per-unit-airflow with a 60% reduction in production cost.

Customer POC	Service/Agency POC	USD(A&T) POC
Mr. Joseph Bonaiuto APEO (CU)	Mr. Richard Quigley AFRL-PR	Dr. Donald Dix DDR&E(AT)
Col George Monroe, USAF HQ ACC/DRM	Mr. Charles Gorton NAVAIR-4.4T	

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602122N		0	0	0.3	0.3	0.4	0.6
0602203F	3048	0.3	0	0	0	0	0
0602203F	3066	2.5	3.3	3.4	3.4	3.6	3.6
0603202F	668A	2.7	5.0	4.9	4.9	5.0	5.0
0603217N	W2014	0	1.8	2.2	1.7	1.8	2.0
	Total	**5.5**	**10.1**	**10.8**	**10.3**	**10.8**	**11.2**

AP.11.00 Aircraft Power (MEA)

Objectives. By FY98 under the More Electric Aircraft (MEA) initiative, demonstrate the ability to eliminate the need for a central hydraulic system through electric power, demonstrating a 10X increase in aircraft electrical system reliability and a 100% increase in power system fault tolerance. By FY05, the program will demonstrate a 2X increase in integrated power unit (IPU) densities, environmentally safe 28-Vdc batteries, high-power density 270-Vdc batteries (less than 1 kW/kg), no airframe-mounted gearbox, a 20X increase in power system reliability, and a 200% increase in power system fault tolerance for electric flight control and brake actuation systems.

Payoffs. Aircraft and system-level payoffs for the power technology improvements demonstrated in this DTO include a 20% reduction in deployment requirements for combat aircraft due to reduced ground support equipment; a 15% reduction in maintenance manpower; two-level maintenance instead of three-level; a 15% increase in sortie generation rate; an 8%–9% reduction in combat aircraft life-cycle cost; an 8% reduction in takeoff ground weight for a Joint Strike Fighter-type platform; a 4X increase in power system reliability for an F–16 platform; and a 15% reduction in vulnerability for combat aircraft.

Challenges. Major MEA challenges exist in each of the four technical efforts. In power generation, high-temperature operation is a challenge where the electrical generator must operate in the environment internal to the turbine engine that can reach 300°C. High-strength magnetic materials are required for the ruggedness necessary to operate large diameter electrical machinery equivalent in diameter to the engine rotor at speeds up to 18,500 rpm. For power distribution, challenges in lightweight, low-volume advanced thermal management techniques exist to deal with the issue of higher power density and the desire to eliminate liquid-based cooling. Development of high-quality silicon and possibly silicon carbide switch devices with the capability to operate at higher temperatures (due to higher electrical efficiency) may help reduce the thermal issue. In energy storage, the challenge is to provide uninterruptable power for an MEA configuration aircraft. Lightweight, rechargeable high-voltage batteries are required that can operate over the militarily demanded –40° to +165°F range. In the subsystems interactions technical effort, the challenge is to meet current and voltage variation tolerance levels as required by MIL-STD-704 as well as to meet requirements for electromagnetic compatibility.

Milestones/Metrics.

FY1998: Complete testing of the Power Management and Distribution System for an MEA (MADMEL) ground demonstrator eliminating the central hydraulic system through electrical power generation, distribution, and actuation; 10X increase in electrical system reliability; 100% increase in power system fault tolerance.

FY1999: Complete advance motor drive testing leading to 100% increase in power density and 93%–95% efficiency for power electronics.

FY2000: Complete IPU motor and bearing integration and testing that allows achievement of a 300% increase in reliability and 150% increase in power density.

FY2002: Demonstrate environmentally safe nickel-metal hydride aircraft battery.

FY2003: Complete development of high-temperature (200°C) inverter/converter technology that will allow use of air cooling.

FY2005: Engine internal (integrated starter/generator) demonstration.

Customer POC	Service/Agency POC	USD(A&T) POC
Col Ryan Dow, USAF HQ AMC/XPR	Mr. Richard Quigley AFRL-PR	Dr. Donald Dix DDR&E(AT)
Mr. Fred Schwartz SSF	Mr. Charles Gorton NAVAIR-4.4T	

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602122N		0.3	0.9	1.2	1.3	1.2	1.2
0602203F	3145	13.9	12.8	13.0	14.2	14.6	15.1
0603216F	3035	3.5	3.4	3.8	4.0	4.2	4.4
	Total	**17.7**	**17.1**	**18.0**	**19.5**	**20.0**	**20.7**

AP.12.00 Rotorcraft Drive

Objectives. By 2000, demonstrate a 25% increase in power-to-weight ratio, a 10-dB reduction in drive-system-generated noise, and a 10% reduction in both production and O&S costs. Along with these goals, the demonstration will validate the application of advanced materials and a design methodology that will result in a doubling of the mean time between replacement (MTBR) of the drive system.

Payoffs. Rotorcraft drive systems payoffs include, for example, a 15% increase in range or a 25% payload increase for an AH–64 antiarmor mission, as well as a 50% reduction in drive system maintenance labor-hour per flight hour and an 8%–10% reduction in total aircraft operating cost per flight hour. The drive system source noise reduction translates directly into increased crew/pilot endurance and efficiency in the short term and reduced hearing loss in the long term.

Challenges. Technical barriers associated with achievement of the weight and noise goals and the doubling of MTBR involve (1) development of very compact/durable, high-reduction ratio gear configurations with a +99.5% efficiency and extremely low vibration and noise characteristics; (2) maintaining drive system component durability while utilizing a reduced weight/volume, high-temperature lubrication system; (3) application of advanced steel alloys, coatings, and processing methods with increased high-temperature fracture toughness, bending fatigue strength, and surface durability to gears and bearings; (4) application of lightweight, affordable, corrosion-resistant housing materials that maintain strength at elevated temperatures; (5) development of lightweight, low-speed/high-load capacity bearings that possess extreme durability while operating in a poor lubrication environment; and (6) the development of manufacturing processes and capabilities for producing resultant drive train components (e.g., gears and bearings).

Milestones/Metrics.

FY1998: Complete detailed design and analysis of the Advanced Rotocraft Transmission (ART) II demonstrator and initiate fabrication of test hardware.

FY1999: Complete ART II demonstrator static load and initial development testing.

FY2000: Demonstrate 25% increased power-to-weight ratio and 10-dB reduction in drive-system-generated noise through final testing of ART II demonstrator.

Customer POC	Service/Agency POC		USD(A&T) POC
MG James Snider, USA	Mr. Thomas House	Mr. David Cale	Dr. Donald Dix
SFAE-AV	AMCOM/AMSAM-AR-Z	AMCOM/AMSAT-R-TP	DDR&E(AT)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602211A	47A	0.1	0	0	0	0	0
0602211A	47B	0.4	0	0	0	0	0
0603003A	313	3.8	9.0	7.0	0	0	0
	Total	**4.3**	**9.0**	**7.0**	**0**	**0**	**0**

AP.13.00 Affordable/Supportable Fixed-Wing Vehicle Subsystems Technology

Objectives. Develop and demonstrate fixed-wing vehicle subsystem technologies for fighter/attack, airlift/bomber/patrol aircraft. This DTO is one of six for the Fixed-Wing Vehicle (FWV) program. The goals are to demonstrate, by 2003, an 7% reduction in air vehicle weight fraction, a 20% reduction in unit production costs at T–1, a 19% reduction in O&S cost per flight-hour, and a 20% reduction in development cost relative to the 1995 state of the art; and by 2008, a 10% reduction in air vehicle weight fraction, a 30% reduction in unit production costs at T–1, a 28% reduction in O&S cost per flight hour, and a 30% reduction in development cost.

Payoffs. The FWV program will develop the technologies necessary to field affordable, technologically superior fixed-wing vehicles in the 21st century. Typical payoffs include a 15% reduction in takeoff gross weight, a 30% increase in payload, a 15% increase in operational readiness, and a 20% reduction in vulnerability. These payoffs lead to reduced acquisition and O&S costs.

Challenges. Technology barriers include management of a growing aircraft heat load with a shrinking aircraft heat sink; application of electric actuation to utility subsystems that require more power and higher actuation rates than are currently available, and development of mathematical models of complex physical processes for realistic modeling and simulation.

Milestones/Metrics.

FY1998: Flight demonstrate advanced computed-air-release-point algorithm to increase payload delivery accuracy. Laboratory demonstrate extended-life aircraft tire. Contributes to a 40% reduction in subsystems O&S cost.

FY2000: Laboratory demonstrate an exhaust washed structure. Contributes to a 20% reduction subsystems production costs, 20% reduction in subsystems weight, and 40% reduction in subsystems O&S cost.

FY2001: Demonstrate cargo trajectory simulation model to increase payload delivery accuracy contributing to a 10% increase in operational readiness. Validate subsystems total energy model contributing to a 20% reduction in subsystems engineering manufacturing and design cost.

FY2003: Laboratory demonstrate aircraft integrated subsystems and distributed cooling systems. Flight certify electric utility subsystems. Validate hydrodynamic ram attenuation model methodology for composite materials. Contributes to a 20% reduction in subsystems weight, 20% reduction in subsystems production cost, and 20% reduction in subsystems O&S cost.

Customer POC	Service/Agency POC		USD(A&T) POC
Col George Monroe, USAF	Mr. William King	Mr. Terry Neighbor	Dr. Donald Dix
HQ ACC/DRM	ONR 351	AFRL-VA	DDR&E(AT)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602201F	2402	7.8	5.4	5.0	5.7	5.7	6.1
0603205F	2978	1.7	0.5	0	0.2	0.5	0.2
0603211F	486U	0.2	0	0	0	0	0
0603245F	2568	0	0	0	0	0	0.5
	Total	**9.7**	**5.9**	**5.0**	**5.9**	**6.2**	**6.8**

AP.14.00 Rotary-Wing Vehicle Structures Technology

Objectives. Demonstrate structures technologies leading to a reduction in structural weight and a reduction in manufacturing labor-hours per pound of structure without adversely impacting airframe signature. This will be accomplished through both enabling technology and applied technology efforts. The program will develop and demonstrate manufacturing process feedback algorithms to actively control the cure state of composite resins and all-composite joints for three types of rotary-wing-vehicle primary structure interfaces. It will validate bond strength by nondestructive evaluation (NDE) of selected composite structures and demonstrate airframe sections tailored for structural efficiency, producibility, and field supportability.

Payoffs. These demonstrations contribute to rotary-wing vehicle, system-level payoffs of a 55% increase in range or a 36% increase in payload, a 20% increase in reliability, and a 5% reduction in O&S costs over current technology for utility vehicles.

Challenges. The objectives will be achieved by executing programs to improve defect characterization in composite structure, measure rheology of resins during cure cycles, maintain uniform pressure along bondlines during co-cure of large assemblies, analyze redundant load paths with impulse loading conditions, nondestructively evaluate bonded structures, and predict and validate strength and stiffness of tailored structures.

Milestones/Metrics.

FY1998: Develop and demonstrate manufacturing process feedback algorithms to actively control the cure state of composite resins to reduce manufacturing labor.

FY1999: Demonstrate laminate-laminate, laminate-honeycomb, and honeycomb-honeycomb primary structure joints for weight reduction at equivalent strength.

FY2000: Demonstrate adaptive out-of-autoclave tooling for optimized co-cure of composite structural elements with highly variable thicknesses and the modeling/virtual prototyping to reduce development time and cost.

FY2001: Demonstrate airframe sections tailored for structural efficiency, producibility, and field supportability and validate strength and stiffness predictions of tailored structures; 15% increase in structural efficiency; and 25% reduction of manufacturing labor-hours per pound of structure. Validate improved structural loads prediction accuracy to 75%.

Customer POC	Service/Agency POC		USD(A&T) POC
Mr. Ted Hundley	Mr. Robert Kennedy	Mr. William King	Dr. Donald Dix
USA Aviation Center	HQ USA AMCOM	ONR 351	DDR&E(AT)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
S&T Funding							
0602211A	47A	0.4	0.4	0.4	0.5	0	0
0602211A	47B	0.5	0.6	0.5	0.5	0	0
0603003A	313	1.4	4.8	6.3	5.5	0	0
Total S&T		**2.3**	**5.8**	**7.2**	**6.5**	**0**	**0**
Non-S&T Funding							
0607045A	DE60	0.5	0.5	0.5	0.5	0	0
Total Non-S&T		**0.5**	**0.5**	**0.5**	**0.5**	**0**	**0**

AP.15.00 Affordable/Supportable Rotary-Wing Vehicle Subsystems Technologies

Objectives. Develop the subsystems technologies associated with advanced, digitized maintenance concepts and real-time, on-board integrated diagnostics. These technologies include piezoelectric, inductive, and optical sensors; statistical and neural network signal processing algorithms; high-speed databases and storage processes; and intelligent decision aids. The collective objective of this DTO is to develop the hardware, software, and processes necessary to perform automatic detection of 60% of critical mechanical component failures and to reduce total maintenance labor 30% by FY05. Individual objectives include detecting early propagation of drive train component faults in the above-40-kHz acoustic emission range earlier and with greater accuracy than conventional vibration analysis; developing a 0- to 256-kHz laser interferometer for detecting high-frequency stress waves indicative of early fault development; developing an automated, onboard monitoring capability for oil-wetted components capable of detecting and trending small particles (<200 μm); improving reliability and reducing the weight and cost of health and usage devices by integrating microelectromechanical sensors such as temperature, pressure, and acceleration into a single, compact, multiplexed unit; developing intelligent software and signal processing techniques to ensure onboard data integrity; and providing an integrated platform for system-level diagnostics evaluation and integration with the maintenance infrastructure.

Payoffs. The efforts under this DTO contribute to rotary-wing-vehicle, system-level payoffs of a 20% increase in mission reliability, a 20% decrease in major accident rates, and a 21% reduction in system O&S costs over current technology (FY05). The major technology goal is to realize a 35% reduction in maintenance costs per flight hour per installed shaft horsepower.

Challenges. Multipurpose, multispectral, accurate, reliable, and low-cost sensors capable of withstanding the temperature, loads, contamination, and vibration environment of helicopters need to be developed. Detection and analysis of high-frequency emissions are essential to early detection and prediction of failure propagation. Advanced signal processing and real-time neural nets are necessary to handle the high-data-rate streams. Differentiating ferrous and nonferrous particles in high-temperature solutions in less than 200-μm range and developing onboard analysis are critical to long-term component condition determination. Integrating multisensors into durable and low-cost packages, installation mounting, location, and data transfer rates and integrity are vital to the acceptance and use of health and usage monitoring. Real-time data processing and intelligent decision aids are necessary to accomplish system-level diagnostics and prognostics.

Milestones/Metrics.

FY1998: Demonstrate seeded fault validation testing.

FY1999: Demonstrate 0- to 256-kHz laser interferometer.

FY2000: Demonstrate an automated, onboard oil diagnostics system that provides real-time alerts of large-particle detection (500 μm) and trends of small particle buildup.

FY2001: Integrate multisensor design for embedded diagnostics and prognostics.

FY2002: Conduct aircraft modifications for advanced diagnostics and prognostics for onboard systems integration on an operational helicopter.

FY2003: Integrate, flight test, and evaluate onboard integrated diagnostic suite.

Customer POC	Service/Agency POC		USD(A&T) POC
Mr. Ted Hundley	Mr. Robert Kennedy	Mr. William King	Dr. Donald Dix
USA Aviation Center	HQ USA AMCOM	ONR 351	DDR&E(AT)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602211A	A47A	0.7	0.7	0.7	0	0	0
0603003A	313	0	0	1.3	3.5	6.0	5.5
	Total	**0.7**	**0.7**	**2.0**	**3.5**	**6.0**	**5.5**

AP.16.00 Rotary-Wing Vehicle Signature Reduction Technologies

Objectives. Develop and integrate state-of-the-art technologies onto a rotary-wing platform for the demonstration of tactically significant and affordable improvements in survivability. In particular, infrared, visual, and electro-optical signature reduction technologies, electronic warfare and decoy countermeasures, and advanced aircrew situational awareness and tactics will be synergistically integrated to demonstrate a 60% increase in rotary-wing probability of survival in a multispectral threat environment.

Payoffs. Threat weapon systems are becoming increasingly sophisticated and are consistently challenging state-of-the-art technology developments. It is widely recognized that neither passive signature reduction nor active countermeasures alone can effectively counter the threat systems on the battlefield today or the ones we expect to encounter in the future. Integration of active countermeasures, namely jammers and decoys, and passive IR, visual, and EO signature reduction techniques, along with advanced aircrew situational awareness, will allow Army rotary-wing vehicles to compete on the advanced threat digitized battlefield of the 21st century.

Challenges. Integration of state-of-the-art technologies onto a rotary-wing vehicle, while keeping it affordable and maintainable, is a constant challenge. The most significant challenge faced during the execution of this DTO will be to identify the correct "mix" of active and passive countermeasures that provide the needed amount of survivability yet are still affordable in terms of cost and weight as well as reliable and maintainable in the field regimes where Army helicopters operate. Significant effort will be expended to advance today's state-of-the-art technology—particularly in the IR, visual, and EO signature reduction areas—to achieve, along with advanced active countermeasures and cockpit situational awareness technologies, a 60% increase in rotary-wing probability of survival.

Milestones/Metrics.

FY1999: Develop multispectral airframe coatings compatible with radar absorbing materials/structures and low-cost, lightweight thermal insulative materials.

FY2000: Demonstrate full-scale engine exhaust suppression concepts.

FY2002: Develop select state-of-the-art active/passive countermeasures and aircrew situational awareness concepts.

FY2003: Integrate passive signature reduction technologies onto demonstrator platform.

FY2004: Integrate active countermeasures and cockpit situational awareness technologies onto demonstrator platform.

FY2005: Operational flight test FSTP demonstrator in fully instrumented threat range against multispectral (RF, IR, visual/EO, acoustic) threat weapons/sensors; demonstrate 60% increase in rotary-wing aircraft probability of survival.

Customer POC	Service/Agency POC		USD(A&T) POC
Mr. Ted Hundley	Mr. Robert Kennedy	Mr. William King	Dr. Donald Dix
USA Aviation Center	HQ USA AMCOM	ONR 351	DDR&E(AT)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602211A	47A	1.1	1.4	0.8	0.8	0	0
0603003A	313	0	0	0	0	1.7	5.3
	Total	**1.1**	**1.4**	**0.8**	**0.8**	**1.7**	**5.3**

AP.17.00 Hydrocarbon Scramjet Missile Propulsion

Objectives. Develop and demonstrate air-breathing, storable-fuel scramjet propulsion technologies for missile (and aircraft) applications at speeds from Mach 4 to Mach 8. Goals have been established for specific impulse (Isp), specific thrust (Fn/Wa), and durability commensurate with projected requirements for expendable hypersonic air vehicles with a projected IOC of 2015. Program goals are to demonstrate, by 1998, stable scramjet combustor operation from Mach 4 to Mach 8 with 90% of the final Isp goal; by 2000, 95% of final Isp goal; by 2001, scramjet structural durability for 12 minutes; and by 2003, integrated engine performance at 100% of the final Isp goal.

Payoffs. A Mach 8 hypersonic cruise missile could travel 750 nmi in 12 minutes, reducing flight times by a factor of seven below those of current missile systems. Mach 8 cruise operation could also increase terminal kinetic/penetrating energy by a factor of eight. In addition, the use of a scramjet engine would lead to a missile sufficiently small in size and weight to allow it to be carried by a fighter aircraft and the use of storable fuels would provide a launch-on-demand operational capability. The combination of long range and high speed would enable the destruction of time-critical targets from safe standoff launch positions. The high cruise speed also would make the missile essentially invulnerable to countermeasures. This development activity supports Precision Force and Joint Theater Missile Defense JWCOs through the ability to destroy targets quickly and efficiently from long standoff ranges. In addition, it supports the *Joint Vision 2010* requirement of Precision Engagement through the ability to precisely attack key enemy forces or capabilities. It addresses mission needs for hard and deeply buried target defeat capability, lethal suppression of enemy air defenses, theater missile defense, countering mobile targets, and global and prompt conventional strike capability. This technology demonstration could also satisfy some of the requirements addressed under DTO WE.59.02, Hypersonic Weapons Technology Demonstration. The hydrocarbon scramjet propulsion technology base developed under this effort could also enable transition opportunities for reusable hypersonic vehicles with global reach.

Challenges. The major technology barrier is the ability to design an expendable, affordable, fixed-geometry, hydrocarbon-fueled scramjet engine capable of accelerating an air-launched missile from Mach 4 (end of rocket boost after aircraft launch) to Mach 8 hypersonic cruise. Specific challenges include (1) starting the engine at end of boost; (2) maintaining fuel combustion through the intermediate Mach numbers from 4 to 8 in a fixed-geometry engine flowpath, with emphasis on fuel ignition and piloting and efficient fuel injection and mixing; (3) effectively managing the flowpath pressure, shear/skin friction, and other energy losses during Mach 8 cruise; (4) providing thermal management of the integrated engine and airframe configuration throughout the flight corridor; and (5) developing materials and structural configurations that can provide the needed performance efficiency while withstanding the flowpath high-temperature oxidizing environment for the required flight times. An additional challenge is the realistic simulation of flight conditions in ground-based facilities. The challenges will be addressed by maturing the required technologies and by designing and fabricating a missile-sized scramjet engine, including the needed materials and structures, fueling methods, and controls. The engine will be ground tested for a full-flight lifetime (12 minutes) in simulated hypersonic flight conditions (Mach 4 to 8 at 30,000 to 100,000 feet).

Milestones/Metrics.

FY1998: Demonstrate stable combustor performance at Mach 4, 6, and 8 at 80% combustion efficiency; demonstrate cold-start feasibility; demonstrate fuel/materials compatibility at 1,800°F; demonstrate large, fuel-cooled, flight-weight panels for combustor. Achieves 90% of Isp goal.

FY1999: Complete subscale forebody/inlet performance test. Achieves 100% of inlet pressure recovery and mass capture.

FY2000: Demonstrate 85% combustion efficiency in heavyweight combustor. Achieves 95% of final Isp goal.

FY2001: Demonstrate combustor and inlet structural durability at simulated flight conditions for full trajectory over 12-min duration. Achieves 12-min durability goal.

FY2003: Demonstrate integrated engine performance. Achieves 100% of final Isp and Fn/Wa goals.

Customer POC	**Service/Agency POC**	**USD(A&T) POC**
Col Randy Hobbs, USAF	Mr. Richard Quigley	Dr. Donald Dix
ACC/DRP	AFRL-PR	DDR&E(AT)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602269F	1025	9.3	13.0	13.0	13.9	12.8	13.0
	Total	**9.3**	**13.0**	**13.0**	**13.9**	**12.8**	**13.0**

AP.18.00 Improved JP–8 Fuel

Objectives. By FY99, demonstrate the benefits of an improved JP–8 fuel ("JP–8+100"). The goal of the JP–8+100 program is a detergent/dispersant additive package that results in a 100°F increase in thermal stability, which yields a 50% increase in heat sink. The additive package (added at a concentration range of 100–300 parts per million) will significantly reduce gums, varnishes, and coke in main burner fuel nozzles, manifolds, augmentor sprayrings/bars, and other fuel system components, with a cost goal of less than $0.001 per gallon of fuel. Deposition in critical fuel system components such as main burner fuel nozzles can lead to poor spray patterns, causing improper combustion and potential combustor and turbine damage. Deposition in augmentor sprayrings/bars can result in augmentor no-lights and low-frequency rumble. Reduction of deposition will thus reduce maintenance costs.

Payoffs. Development of JP–8+100 will result in the return of the thermal margin for the F–22 (and future upgrades) through a 100°F increase in fuel thermal stability and a 50% increase in fuel heat sink. These advances will result in increased fuel efficiency, reduced emissions, and higher performance capabilities for current and future weapons systems. On a Joint Strike Fighter fuel system, for example, studies indicate that 320 pounds of takeoff gross weight (TOGW) could be saved by reducing recirculation with JP–8+100 and by reducing bleed air demand 16%. Increased heat sink in the F–15 improves hot-day operability, can eliminate the need for hot-fuel recirculation, and provides additional thermal margin for advanced avionics upgrades. In addition, for current and future weapon systems, the increased fuel thermal stability characteristics of JP–8+100 will result in less coke formation in engines and fuel systems, ultimately increasing reliability and mission capability rates and decreasing O&M costs. For example, the 173rd Fighter Wing at Kingsley Field in Oregon realized an $825,000 reduction in fuel-related maintenance items in FY96, relative to JP–8 in FY95. Reduced engine fouling and increased turbine engine nozzle cooling will also decrease weapon system signature, thereby increasing survivability.

Challenges. A major technical barrier is the lack of understanding of the fundamental and complex processes by which additives stop the formation of gums, varnishes, and coke in main burner fuel nozzles, manifolds, augmentor sprayrings/bars, and other fuel system components. Obtaining this understanding requires developing test methods that simulate aircraft fuel system conditions accurately enough to evaluate the effectiveness of candidate additives. Also needed is the assurance that candidate additives are compatible with both metallic and nonmetallic fuel system materials (to date over 200 materials have been tested). Another challenge is developing the methodology to quantitatively verify that the additives reduce deposition in fuel systems. The detergents/dispersants used in current candidate additives can emulsify dirt and water in ground fuel handling systems, thereby disarming current filter coalescers. For logistical reasons, fleet-wide conversion will depend on the development of a new generation of drop-in replacement filters/coalescers that are tolerant of detergents/dispersants yet provide the filtration and water removal required by current and future weapons systems.

Milestones/Metrics.

FY1998: Demonstrate +50% heat sink with two additional additive formulations for JP–8+100; demonstrate multifunctional DoD/commercial (API) filter elements effective with three +100 additives; demonstrate water reduction to 15 ppm and dirt reduction to 0.26 mg/L in extended API 1581 qualification test. These demonstrations achieve the +100°F thermal stability goal with an additive-compatible fuel handling system.

FY1999: Complete field demonstrations of DoD/API filter systems; quantify improvement in service life and cost savings realized in a 12-month field trial; quantify reduction in fuel-related maintenance and cost savings realized using new JP–8+100 formulations. These milestones achieve the quantification and validation of the cost savings achieved with JP--8+100.

Customer POC	Service/Agency POC	USD(A&T) POC
Mr. John Lavin	Mr. Richard Quigley	Dr. Donald Dix
AF/ILSP	AFRL-PR	DDR&E(AT)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602203F	3048	4.0	0.2	0	0	0	0
0603216F	2480	1.5	1.9	0.3	0	0	0
	Total	**5.5**	**2.1**	**0.3**	**0**	**0**	**0**

AP.19.00 High-Heat-Sink Fuels (JP–900/Endothermic)

Objectives. Demonstrate the heat sink (cooling) capacity and system performance of two fuels that are an enabling technology for advanced air-breathing propulsion systems: JP–900 and endothermic JP. JP–900 will provide about 700-Btu/lb heat-sink capacity (5X over JP–8) by remaining stable (no coking or fouling of fuel system components) up to 900°F. With endothermic capability, fuel will provide about 1,500-Btu/lb heat-sink capacity (12X over JP–8) by undergoing chemical change at temperatures up to 1,200°F.

Payoffs. These fuels have applications in indirect cooling for gas turbines and direct cooling for scramjet engines. For gas turbines, using the fuel to cool the cooling air (compressor bleed) enables better performance (higher turbine inlet temperatures (T41), lower specific fuel consumption (SFC)) at a fixed turbine metal temperature. For example, JP–900 performance allows a 2% SFC improvement at constant thrust by reducing bleed air requirements. Using an endothermic JP fuel as a heat sink in an Integrated High-Payoff Rocket Propulsion Technology (IHPTET) Phase II engine allows a 325°F increase in T41, which can result in a 5% increase in thrust-to-weight ratio with a 1% reduction in SFC while using Phase II materials. Fuel-cooling technology is complementary to advances in materials technology, and the respective benefits are additive. The cooled cooling air can also be used for other purposes; 300°F reductions in nozzle surface temperature with a resulting decrease in signature are possible with JP–900. In scramjet applications, this high-heat-sink capability (from a hydrocarbon fuel) will also enable Mach 6–8 scramjet propulsion for missiles and cruise vehicles, formerly thought possible only with logistically unacceptable hydrogen fuel. These advanced fuels will permit lower development, procurement, and life-cycle costs for advanced propulsion systems that require high levels of fuel heat sink.

Challenges. A major technical barrier to providing the required heat-sink capacity is preventing coking/fouling (caused by thermal degradation of the fuel as it is heated) in fuel system components, and thus assuring adequate system life. Another challenge is developing lightweight, safe, durable, affordable heat exchangers or fuel-cooled structures that can transfer heat to the fuel at temperatures/pressures beyond the capability of current components. A control challenge is balancing and controlling the fuel flow (engine requirement for propulsive energy) with the heat sink (cooling) requirement of the system. Finally, effectively injecting liquid, vapor, or supercritical fuel (with continually varying density, viscosity, enthalpy, and species) into the combustor is a technical challenge that must be overcome to have an effective propulsion system. All of these challenges are present for both JP–900 and endothermic JP; however, the endothermic fuel reactions make the problems more difficult to overcome.

Milestones/Metrics.

FY1999: Demonstrate fuel/air heat exchanger capable of operating with 900°F fuel. Achieves 5X heat sink goal for JP–900 in key component of cooled cooling air system.

FY2000: Demonstrate endothermic JP fuel system in a 400-hr subscale fuel system simulator test, incorporating heat exchanger, hot control valve, and fuel injector components. Achieves 12X heat sink and progress toward 2,000-hr life.

FY2001: Demonstrate endothermic JP fuel/air heat exchanger capable of operation with 1,200°F fuel. Achieves 12X heat sink and +20% heat duty/weight in key component of cooled cooling air system at limited life.

FY2003: Demonstrate endothermic JP fuel system life in a 2,000-hr subscale fuel system simulator test. Achieves 12X heat sink and life at reduced scale. Demonstrate operability of endothermic JP in coupled cooled cooling air/sector combustor system. Achieves 12X heat sink and effective combustion of hot fuel from cooled cooling air system.

Customer POC	Service/Agency POC	USD(A&T) POC
Mr. John Lavin	Mr. Richard Quigley	Dr. Donald Dix
AF/ILSP	AFRL-PR	DDR&E(AT)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602203F	3048	0.7	0.8	0.8	0.8	0.8	0.8
0603216F	2480	0	0	1.7	2.0	2.0	2.0
	Total	**0.7**	**0.8**	**2.5**	**2.8**	**2.8**	**2.8**

AP.20.00 DARPA Micro Air Vehicles Program

Objectives. Develop the necessary flight-enabling technologies and develop and conduct flight demonstrations of low-cost micro air vehicles (MAVs) capable of autonomous, sustained flight and the performance of useful military missions. MAVs are defined to be flight vehicles less than 15 cm in any dimension—at least an order of magnitude smaller than any current flight vehicles. They represent a new military capability. Fixed-wing MAVs, yet to be developed, will be capable of flight durations from 20 minutes to 1 hour, operation out to 3–10 km in range, and performance of missions that include on-demand, real-time, video reconnaissance and bio-chemical sensing. Hovering or flapping MAVs will be capable performing similar sensor-based missions in urban canyons and even in the interior of buildings.

Payoffs. MAVs will provide unprecedented situational awareness for small operational units, including Army, Marines, Special Forces, and intelligence. MAVs are intrinsically covert because of their small size. They will enable covert reconnaissance and surveillance for Scout missions and Special Operations Forces, effectively extending their range by up to 10 km. Currently, it may take several hours for small units to receive situational reconnaissance information from current UAV assets like the Predator. Unlike the Predator, MAVs will be owned and operated by small units at the platoon level and below and will enable real-time, on-demand reconnaissance, virtually eliminating the unacceptable latency associated with current assets. MAVs will also enable diverse missions such as remote tagging of enemy ground assets, covert placement of remote sensor packages to detect the movement of troops and equipment, and targeting information for remote fire operations.

Challenges. Sustained flight up to 1 hour and range out to 10 km in a 15-cm flight vehicle that may weigh only 50 grams poses formidable technology challenges in a number of important areas. These include low Reynolds number aerodynamics, MEMS-based flight controls, high-energy density propulsion and power systems, communication and navigation, onboard processing, and specially adapted sensors and payloads. With severe power, weight, and volume constraints, MAVs will require a high level of subsystem integration, with an unprecedented degree of component multifunctionality.

Milestones/Metrics.

FY1998: Award MAV systems developments contracts; award flight-enabling technology contracts.

FY1999: Demonstrate and flight test initial MAVs; demonstrate flight-enabling subsystems technologies.

FY2000: Complete flight tests of MAV systems; demonstrate field operation of MAVs; conduct system definition studies for advanced MAV systems.

Customer POC		Service/Agency POC	USD(A&T) POC
Maj John Blitch, USAF HQ USSOCOM, SOJ7-C	Col William Knarr, USAF TM TRADOC	Mr. William King ONR 351	Dr. Donald Dix DDR&E(AT)
COL Karl Gunzelman, USA Mounted Battlespace Battle Lab	Col Anthony Wood, USMC Marine Corps Warfighting Lab	Mr. Terry Neighbor AFRL-VA	
		Dr. James McMichael DARPA/TTO	

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602702E	TT-07	11.0	12.0	8.0	0	0	0
	Total	**11.0**	**12.0**	**8.0**	**0**	**0**	**0**

CHEMICAL/BIOLOGICAL DEFENSE AND NUCLEAR

Defense Technology Objectives for the Defense Technology Area Plan

Chemical/Biological Defense and Nuclear

CB.02.10 Joint Warning and Reporting Network II-34
CB.06.12 Advanced Lightweight Chemical Protection II-35
CB.07.10 Laser Standoff Chemical Detection Technology II-36
CB.08.12 Advanced Adsorbents for Protection Applications II-37
CB.09.12 Enzymatic Decontamination II-38
CB.10.07 Nuclear Hardness and Survivability Testing Technologies II-39
CB.12.01 Electronic System Radiation Hardening II-41
CB.13.07 Hard-Target Defeat II-42
CB.14.07 Prediction and Mitigation of Collateral Hazards II-44
CB.15.01 Balanced Electromagnetic Hardening Technology II-46
CB.16.12 Enhanced Respirator Filtration Technology II-47
CB.17.01 Survivability Assessments Technology II-48
CB.18.01 Integrated Comprehensive Weaponeering Capability II-49
CB.19.01 Chemical Imaging Sensor II-50

CB.02.10 Joint Warning and Reporting Network

Objectives. Demonstrate technology to support the Joint Warning and Reporting Network (JWARN) P^3I objective system that will seamlessly integrate into the Global Command and Control System (GCCS), including warning and reporting software, hazard prediction, and situation management. The technology will allow automated integration of sensors into the GCCS using secured two-way communications in compliance with the Automated Battlefield Management System (ABMS).

Payoffs. This technology will provide an automated capability to link, in real time, sensor data into the GCCS to permit situational awareness on multiple command levels allowing commanders to make the appropriate decisions. Information will be displayed at different levels of complexity, depending on the need, from a single sensor to all sensors overlaid onto the battlefield. In addition to the real-time displayed information, a projection of the threat can be provided through the use of the Hazard Prediction Tool (HPT). Real-time data can be integrated with other GCCS-available data (meteorological, geography, intelligence, etc.) through the HPT to provide a display of time-lapsed threat analysis that permits commanders to formulate strategic plans. In comparison to current capabilities, this technology will be lower in cost, higher in data handling capabilities (factor of 10 to 100), self-aware and self-organizing, modular in design for rapid upgrading, and able to provide information at greater speeds and in more detail.

Challenges. Demonstration of this technology on a simulated tactical network will require characterizing existing nondevelopmental items (NDI) sensor links (both hardware and software protocols), developing "hooks" into the warning and reporting software, merging existing hazard prediction efforts into the HPT, and developing hooks into the GCCS and ABMS. The characterization of the NDI sensor links is complicated by the rapid changes in the communication industry (low-to-moderate risk). Program integration will be required to ensure parallel development of the linkages or hooks between systems (low risk). The merger of the hazard prediction efforts will require the development of a software shell program that works on multiple computing platforms and can tailor the level of prediction based on the computational performance available (low risk). For the demonstration on the simulated tactical network, a simplified (limited number of features activated) version of the hooks and HPT will be used.

Milestones/Metrics.

FY1998: Identify hazard prediction efforts and requirements for computational performance and shell program; initiate tradeoff analysis for cost versus NDI sensor link performance; characterize 10 NDI systems as candidates for downselect for demonstration and tradeoff study.

FY1999: Complete tradeoff analysis; parameters are cost target of $300 per unit, 57.6-kb continuous wireless and 1-Mb continuous wired data transmission rate. Demonstrate using at least two different sensors and a minimum of 10 linkages.

Customer POC	Service/Agency POC	USD(A&T) POC
Mr. Doug Bryce	Dr. John Ferriter	Dr. Sal Bosco
MARCORSYSCOM(CSSLE)	ERDEC (TPCBD)	DATSD(CP/CBD)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602384BP	CB2	0.7	0.7	0	0	0	0
	Total	**0.7**	**0.7**	**0**	**0**	**0**	**0**

CB.06.12 Advanced Lightweight Chemical Protection

Objectives. Develop and demonstrate materials for a new generation of lightweight chemical/biological (CB) protective clothing ensembles based on selectively permeable membrane technology that will eliminate or reduce the use of carbon in CB clothing. The resulting advanced material system will be 20% lighter in weight than the battle dress overgarment material system, allow selective permeation of moisture while preventing the passage of common vesicant agents, provide protection against penetration by toxic agents in aerosolized form, and provide at least the current level of protection against toxic vapors and liquids. The ultimate objective will be to demonstrate a CB protective garment that replaces the standard duty uniform.

Payoffs. This DTO will reduce the logistics burden as a result of improved launderability, lighter weight, and reduced volume (less bulky); and significantly improve performance while in a mission-oriented protective posture (MOPP) as a result of significantly reduced thermal stress and bulk of uniform. Ultimately, incorporation of CB protection into standard duty uniform will provide continuous protection. This DTO supports Land Warrior, Air Warrior, Mounted Warrior, Joint Service Lightweight Integrated Suit Technology (JSLIST) P^3I, Advanced Development Clothing and Equipment, and Engineering Development Clothing and Equipment.

Challenges. The key technical challenge is the development of selectively permeable membranes suitable for all battlefield applications. Closure concepts and material that provide maximum protection must also be improved.

Milestones/Metrics.

FY1998: Scale up to pilot production quantities in commercial width, fabricate overgarments, and demonstrate their efficacy and durability.

FY1999: Integrate advanced membranes with lightweight shell fabrics and novel closure systems into a lightweight CB duty uniform concept. The CB duty uniform will be launderable, 30% lighter in weight, and less bulky than the JSLIST duty uniform/overgarment system, with equivalent durability, reduced logistics burden, and lower cost.

FY2000: Fabricate and demonstrate a lightweight CB duty uniform that is 30% lighter with the same or better protection.

Customer POC		Service/Agency POC	USD(A&T) POC
CPT Jon Carroll, USA	LTC Mike Lanphere, USA	Mr. Bill Brower	Dr. Sal Bosco
US Infantry Center	JSIG	SARD-TT	DATSD(CP/CBD)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602384BP	CB2	0.5	0.5	0.6	0	0	0
	Total	**0.5**	**0.5**	**0.6**	**0**	**0**	**0**

CB.07.10 Laser Standoff Chemical Detection Technology

Objectives. Provide a standoff laser integrated chemical and bioaerosol detection capability for protection of fixed sites, reconnaissance, and other battlefield applications.

Payoffs. Demonstrate capabilities in field testing with sufficient laser power and detector sensitivity to detect agents at a distance of 20 km (a 400% increase from the FY96 baseline), evaluate sensitivity for "dusty" chemical agent detection, enhance protection at fixed sites against CB agents, and provide wind shear detection. This DTO supports Joint Service Chemical Warning and Identification LIDAR (light detection and ranging) Detector, Joint Service NBC Reconnaissance System, and Airbase and Shipboard Chemical and Biological Defense.

Challenges. Demonstration of the existing laser standoff chemical detector (LSCD) in all joint service scenarios requires expansion of current azimuth and elevation scanning limits (low risk) and enhanced information display (low risk). Minimization of system response time will require upgrading to a real-time algorithm or display (low-to-moderate risk). Maximization of system ranges will require upgrading to a larger telescope (low risk) and higher energy, tunable CO_2 laser (moderate risk). Although a laser having the exact specifications for this application has not yet been developed, recent experiments indicate that there are at least three viable laser architectures suitable for development. The feasibility of adding wind shear detection depends on demonstrating detection of abrupt variations in natural aerosol returns (moderate risk). The feasibility of adding improved mustard detection capabilities depends on developing and demonstrating 8-μm laser technology (high risk). The feasibility of adding dusty agent detection capabilities requires the characterization of optical properties of such particles (low-to-moderate risk) and modeling the LIDAR performance (low risk). In addition, substantiation of the theoretical analysis on dusty agent detection capabilities depends on the generation and testing of an appropriate simulant (moderate risk).

Milestones/Metrics.

FY1998: Evaluate the feasibility of adding wind shear detection; begin the design of the brassboard for increased range and sensitivity.

FY1999: Initiate brassboard build for a multipurpose detector.

FY2000: Demonstrate brassboard capabilities in field testing with sufficient laser power and detector sensitivity to detect agents at a distance of 20 km (a 400% increase from the FY96 baseline); evaluate sensitivity for dusty chemical agent detection.

Customer POC		Service/Agency POC	USD(A&T) POC
LTC Mike Lanphere, USA	COL Stephen Reeves, USA	Dr. John Ferriter	Dr. Sal Bosco
JSIG	PM-NBC Defense Systems	ERDEC (TPCBD)	DATSD(CP/CBD)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602384BP	CB2	1.0	0.8	0	0	0	0
0603384BP	CB3	1.7	3.3	5.4	0	0	0
	Total	**2.7**	**4.1**	**5.4**	**0**	**0**	**0**

CB.08.12 Advanced Adsorbents for Protection Applications

Objectives. Develop advanced adsorbent materials to enhance the chemical agent filtration capabilities of current single-pass filters as well as regenerative filtration systems under development.

Payoffs. Advanced adsorbents will result in smaller, lighter weight filtration systems with reduced logistical requirements and reduced combustibility. Development of a noncombustible adsorbent is desirable to eliminate the possibility of a filter fire in the event of overheating resulting from malfunctioning of system components.

Challenges. Non-charcoal-based materials suitable for collective protection needs and for use in regenerable filters need to be identified.

Milestones/Metrics.

FY1998: Complete investigations of relationships between adsorption performance versus adsorbent property; select desired pore structure, surface characteristics, and impregnant reactivity for effective adsorption of chemical warfare agents by single-pass filters.

FY1999: Prepare candidate adsorbent materials exhibiting the desired properties; initiate agent sorption assessments.

FY2000: Complete performance evaluations of candidate adsorbent materials; select the best adsorbent materials for each application.

FY2002: Complete agent filtration demonstration testing of the best adsorbents to validate fulfillment of performance goals. Suitability of adsorbent material will be demonstrated for use in military collective and individual protection system applications such as armored vehicles, ships, aircraft, shelters, and respirators.

Customer POC		Service/Agency POC	USD(A&T) POC
Mr. Roger Labataille	COL Stephen Reeves, USA	Dr. John Ferriter	Dr. Sal Bosco
PEO-Ground Systems Integration	PM-NBC Defense Systems	ERDEC (TPCBD)	DATSD(CP/CBD)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602384BP	CB2	1.0	1.1	0.9	1.1	1.2	0
	Total	**1.0**	**1.1**	**0.9**	**1.1**	**1.2**	**0**

CB.09.12 Enzymatic Decontamination

Objectives. Develop and demonstrate a new generation of chemical and biological warfare agent decontaminants that are nontoxic, noncorrosive, environmentally safe, and lightweight (freeze-dried concentrate).

Payoffs. Enzyme-based systems have the potential to reduce the logistical burden by 25- to 50-fold. High-activity G-agent enzymes have been identified and characterized. Several V-agent and H-agent enzymes have been identified, but their activity will need to be improved.

Challenges. The major technical challenges are to identify appropriate enzymes that are reactive with all nerve and blister agents, which may be genetically engineered for large-scale or rapid production, and are noncorrosive, environmentally safe, and usable for sensitive equipment (i.e., non-aqueous)

Milestones/Metrics.

FY1998: Evaluate candidate enzymes for reactivity with V and H agents.

FY1999: Optimize enzymes for V and H agents.

FY2000: Select the best-candidate V- and H-agent enzymes; acquire commercially available enzymes to enhance effectiveness (e.g., cyanidase). During their development, enzyme components will be evaluated for potential use in surface decontamination of sensitive equipment and other applications.

FY2001: Produce sufficient V- and H-agent enzymes to optimize their use in foam-based dispersion systems.

FY2002: Demonstrate the efficacy of enzymatic decontamination systems for G-, H-, and V-type agents in foam.

Customer POC		Service/Agency POC	USD(A&T) POC
LTC Mike Lanphere, USA	COL Leonard Izzo, USA	Dr. John Ferriter	Dr. Sal Bosco
JSIG	USA Chemical School	ERDEC (TPCBD)	DATSD(CP/CBD)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602384BP	CB2	0.8	0.8	0.8	0.8	0.9	0
	Total	**0.8**	**0.8**	**0.8**	**0.8**	**0.9**	**0**

CB.10.07 Nuclear Hardness and Survivability Testing Technologies

Objectives. (1) Develop the hardening technologies, methodologies, modeling, and nonnuclear test capabilities necessary to ensure the continued safety, security, and effectiveness of nuclear delivery systems (aircraft, missiles, reentry vehicles, bombs, etc.); and (2) provide the means to validate/revalidate these system's survivability and operability in a proliferant nuclear threat environment. Underground nuclear testing was a major means used to validate system survivability and vulnerability. But with the cessation of underground nuclear testing, full-scale subsystem/system hardening validation and survivability testing of both new and existing nuclear delivery systems has been eliminated. Present above-ground ionizing radiation simulation facilities cannot provide the fluence, spectrum, or test area necessary to test systems larger than 2,500 cm^2. Present blast, shock, and thermal test facilities also cannot produce the "true" nuclear effects environment. To ensure the continued safe, secure, and effective operations of our nuclear delivery systems, the existing hardening technologies, methodologies, modeling, and above-ground simulation facilities must be improved.

Payoffs. Improvements in hardening technologies, methodologies, modeling, and simulation test capabilities will increase the confidence in certifying the survivability of both existing and new nuclear delivery systems and the confidence in certifying new systems.

Challenges. Technical challenges include (1) improving simulator fluence area products by 400%; (2) increasing soft x-ray debris shields by 10X; (3) increasing simulator power flow by 50%; (4) developing nonideal airblast simulation test capabilities into the large blast/thermal simulator (LB/TS); and (5) correlating past underground nuclear test data with above-ground, hardware-in-the-loop, and modeling data.

Milestones/Metrics.

FY1998: Transition new nuclear system physical security technologies to the Air Force and Army.

FY1999: Twofold improvement in hot-x-ray test capability available at the DECADE Radiation Test Facility (DRTF).

FY2000: Threefold improvement in debris-free, cold-x-ray test capability available at the DRTF.

FY2001: 50% increase in high-dose, hot-x-ray test capability available at the DRTF.

FY2002: Twofold improvement in high-dose, hot-x-ray test capability available at the DRTF.

FY2003: Additional twofold improvement in debris-free cold-x-ray test capability available at the DRTF.

Customer POC		Service/Agency POC	USD(A&T) POC
Mr. Franco Cristadoro USAF ALC/NWTE	Dr. Barry Hannah USN SSP	Mr. Richard Gullickson DSWA/ES	Mr. Fred Celec ATSD(NCB)
Mr. Charlie Dobson USASSDC	Dr. Ted Hardebeck STRATCOM		

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602715H	AB	39.0	0	0	0	0	0
0602715BR	AB	0	35.2	34.5	30.9	31.1	31.4
0602715H	AC	8.6	0	0	0	0	0
0602715BR	AC	0	8.6	7.3	7.5	8.4	8.6
0602715H	AE	13.0	0	0	0	0	0
0602715BR	AE	0	12.8	13.0	14.8	15.4	15.8
0602715H	AF	0.5	0	0	0	0	0
0602715BR	AF	0	1.0	1.2	1.5	1.6	1.6
0602715H	AL	2.4	0	0	0	0	0
0602715BR	AL	0	2.4	1.8	1.6	2.1	2.2
	Total	**63.5**	**60.0**	**57.8**	**56.3**	**58.6**	**59.6**

CB.12.01 Electronic System Radiation Hardening

Objectives. Develop enabling technology to support the fabrication of radiation-hardened electronics and photonics, and develop test/design protocols to validate system survivability using above-ground tests. The electronics- and photonics-enabling technologies include advanced materials and design or process methods for deep submicron technology. The test/design protocols include identification of the minimum test set for system survivability verification. The technology developed by this DTO supports systems such as MILSATCOM, SBIRS, GPS, and USSTRATCOM Weapons and C^4I systems. This enabling technology forms the basis from which DTO SE.37.01, High-Density, Radiation-Resistant Microelectronics, produces final products for space and missile systems.

Payoffs. The payoffs from this DTO include (1) affordable technology and state-of-the-art electronics and photonics, and (2) cost-effective protocols to support system hardening and survivability verification to enable DoD systems to survive and perform their mission in natural and nuclear-weapons-generated radiation environments. This type of electronics technology is required to validate the survivability of space and missile systems such as MILSATCOM EHF, SBIRS–Low, and GPS–2F.

Challenges. The challenges include maintaining circuit radiation robustness as size and power are reduced and performance is increased for each new generation of microelectronics, and verifying or validating system survivability without underground tests.

Milestones/Metrics.

FY1998: Demonstrate and test radiation-hardened, 0.5-μm silicon-on-insulator microelectronics for 4X reduction of weight and power; validate spacecraft and missile interceptor protocols.

FY1999: Demonstrate radiation-hardened submicron (0.35-μm) technology for 16X reduction in weight and power; demonstrate an optical material systems-level analysis predictor; deliver a validated sensor protocol; deliver a draft reentry system protocol.

FY2000: Demonstrate deep-submicron (0.25-μm) technology for radiation-hardened, low-power microelectronics technology for 100X reduction in weight and power; deliver a draft advanced-sensor-response protocol.

FY2001: Demonstrate technology for 16-Mb SRAM, 3000k gate array, and 32-bit digital signal processor.

FY2002: Develop final protocols for reentry systems and sensor systems.

FY2003: Develop electronic design automation technology to demonstrate a system-on-a-chip for the next generation of military space systems.

Customer POC		Service/Agency POC	USD(A&T) POC
Dr. Ted Hardebeck STRATCOM	Capt Andrew Richardson, USAF USAF SMC	Mr. R. C. Webb DSWA/ESE	Mr. Fred Celec ATSD(NCB)
Mr. A. Kuehl USASMDC			

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602715H	AF	15.7	0	0	0	0	0
0602715BR	AF	0	16.1	19.0	20.5	20.9	21.4
	Total	**15.7**	**16.1**	**19.0**	**20.5**	**20.9**	**21.4**

CB.13.07 Hard-Target Defeat

Objectives. Deliver to the warfighter an end-to-end deliberate planning capability for the defeat of tunnel facilities. This capability will include the ability to characterize a facility through the fusion of multisensor data and reverse engineering to identify critical functional nodes and potential vulnerabilities; the ability to identify functional disruptions and time to reconstitute when complete destruction of the facility is impossible or undesirable; the ability to assess numerous attack strategies in an automated fashion; improved automated capabilities to assess bomb damage; and the identification of maximum lethality potential of conventional weapons, beyond which other means, such as nuclear weapons, will be necessary. The lethality of several advanced weapon concepts resulting from the hard and deeply buried target defeat capability acquisition program and related service efforts will also be evaluated as part of this program.

Payoffs. The payoffs from this DTO include (1) providing the theater commander a tool to readily define optimal attacks against several types of tunnel facilities; (2) providing the ability to assess whether an available tunnel attack option will provide the desired military objectives, including estimates for loss of facility function and time to repair; and (3) assessing advanced sensor and weapon concepts designed to advance the hard-target defeat capability.

Challenges. The fundamental difficulty in targeting tunnel structures is the inability to directly penetrate the rock overburden to place the desired weapon effects within the central facility. This necessitates attacking by other means, which includes the following challenges: (1) accurately characterizing the layout and function of an underground facility with only limited data from available sensors; (2) identifying weaknesses that could be effectively exploited with current weapons, and the length of time required to repair; and (3) developing advanced weapon and warhead effects to provide adverse (damaging) environments as far into the facility as possible.

Milestones/Metrics.

FY1998: Complete version 1.0 of an automated engineering tool (a tunnel module built within the Munitions Effects Assessment (MEA) tool) to identify and exploit vulnerabilities in underground facilities. It includes blast, fragmentation, and fire effects, their propagation, and their effects on underground subsystems and components, including blast doors, vehicles, and equipment.

FY1999: Complete tunnel testbed facility (simulated missile operations facility) at Nevada Test Site; develop signature database.

FY2000: Demonstrate a capability to deny and disrupt operational (missile) tunnel facilities for a minimum of 48 hr using current conventional weapons; develop and incorporate target reconstitution models. Begin construction on tunnel testbed #2 (WMD production/storage).

FY2001: Complete MEA Tunnel Module Version 2.0 (Missile Ops Tunnels). Prepare attack plans for tunnel testbed #2. Demonstrate the effectiveness of nuclear weapon capabilities in defeating deep structures using precise, low-yield attacks by HE simulation.

FY2002: Demonstrate a capability to deny and disrupt WMD production and storage facilities located in tunnels for at least 7 days with current and advanced conventional weapons. Encompass data into MEA Tunnel Module Version 3.0

FY2003: Construct testbed #3, a simulated C^2 facility.

Customer POC		Service/Agency POC	USD(A&T) POC
Dr. Barry Hannah USN SSP	LT James Papineau, USN Joint Special Operations Cmd	Dr. Kent Goering DSWA/PMT	Mr. Greg Hulcher USD(A&T)
Maj Skip Murray, USAF STRATCOM J541	Maj Buzz Sawyer, USAF USAF/XOR		

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602715H	AB	5.8	0	0	0	0	0
0602715BR	AB	0	6.6	6.5	6.2	5.3	4.0
0602715H	AC	4.2	0	0	0	0	0
0602715BR	AC	0	4.3	4.4	4.6	4.7	4.8
0602715H	AI	8.8	0	0	0	0	0
0602715BR	AI	0	8.8	9.8	9.8	9.9	10.4
	Total	**18.8**	**19.7**	**20.7**	**20.6**	**19.9**	**19.2**

CB.14.07 Prediction and Mitigation of Collateral Hazards

Objectives. Establish the capability to accurately predict the hazards to civilian and military populations when weapons of mass destruction (WMD) materials are released into the atmosphere by an event of military concern.

Payoffs. The tool provides the warfighter with the capability of predicting the amount of WMD material expelled and the subsequent downwind hazard from a conventional counterforce attack on WMD facilities. Additionally, the tool provides the warfighter the capability to predict hazards due to industrial or transportation accidents or terrorist incidents, as well as uncertainties in the predictions.

Challenges. The most severe technological barriers are the coupling of high-resolution (<1 km) weather predictions with atmospheric transport calculations, including scavaging effects of rainout/washout, and describing weather uncertainties. Other technology challenges in this DTO are WMD source dynamics, including the response of facilities, and the equipment containing WMD materials.

Milestones/Metrics.

FY1998: Improve weapon-related sources. Extend capability to model other sources (including accidents and terrorist devices). Validate the ability to predict long-range transport with dose errors of less than a factor of four and location and time-of-arrival errors of less than 20%.

FY1999: Integrate the natural hazard capability with the capability for predicting WMD hazard health impacts. Calculate mean doses and probabilities of detection or kill while estimating weather uncertainty.

FY2000: Demonstrate a significant improvement in the ability for long-range, high-resolution forecasting of WMD health hazards (rainout and scavenging). Validate capability to accurately predict long-range hazard transport with dose errors less than a factor of four and location and time-of-arrival errors less than 20%.

FY2001: Demonstrate an integrated, automated capability for predicting collateral hazards to human populations resulting from possible dispersal of chemical or biological agents and radiation released during or after attacks on WMD targets.

FY2002: Conduct end-to-end scaled tests for source models of damaged or destroyed WMD. Reduce source model errors by 2X.

FY2003: Validate prediction methodology using scaled tests of nuclear weapon storage facilities and hardened targets such as tunnels.

Customer POC		**Service/Agency POC**	**USD(A&T) POC**
LTC Hal Meyer, USA STRATCOM, J55	LTC Paul Oswald, USA PACOM J54K	Dr. Leon Wittwer DSWA/WEL	Mr. Walt Busbee DATSD(CP/CBD)
LTC Robert Neumann, USA USEUCOM			

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602715H	AC	0.9	0	0	0	0	0
0602715BR	AC	0	1.2	1.5	1.6	1.6	1.6
0602715H	AE	1.3	0	0	0	0	0
0602715BR	AE	0	1.4	1.3	1.2	0.8	0.8
0602715H	AF	4.4	0	0	0	0	0
0602715BR	AF	0	3.1	3.5	3.8	3.9	4.0
	Total	**6.6**	**5.7**	**6.3**	**6.6**	**6.3**	**6.4**

CB.15.01 Balanced Electromagnetic Hardening Technology

Objectives. By FY01, develop and demonstrate innovative and affordable technologies and methodologies for integrated hardening and testing of military systems against high-power microwave (HPM) and high-altitude electromagnetic pulse (HEMP) effects. Specific technology objectives of this baseline program include developing a PC-based EMP environment and coupling code, a PC-based EM protection tool, and complete development of a unified (EMP/HPM) protection and test methodology. This program responds to requirements identified by JCS and USD(A&T).

Payoffs. Integrated hardening against multiple battlefield threat environments (i.e., HPM and HEMP) will reduce hardening cost, size and weight, and procurement costs (design and test time), and provide residual protection against other EM threats (e.g., indirect lightning). Hardening cost reductions of up to 30% can be achieved if composite shielding materials become realizable. Cost savings of 20%–25% over the life of a system are also expected with the improved testing and maintenance/surveillance methodologies developed under this program.

Challenges. SECDEF has initiated a mandate to transition from a 25% COTS/75% MILSPEC equipment ratio in military systems to 75% COTS/25% MILSPEC. At the same time, budgets for military procurement are undergoing drastic reductions. A key challenge is to ensure that this COTS equipment is survivable to the wide range of existing and emerging battlefield electromagnetic (EM) environments. A further challenge is to produce improvements over existing technologies in one or more effectiveness metrics such as a 20% reduction in shielding effectiveness test cost and test time and a 15% reduction in the cost to harden COTS equipment power lines against EMP and HPM threat environments.

Milestones/Metrics.

FY1998: Develop a hardened ac power cord to enhance COTS equipment survivability. Reduce life-cycle costs up to 20%.

FY1999: Demonstrate new EMP/HPM hardening technologies/test techniques.

FY2000: Demonstrate integrated EMP/HPM test methods.

FY2001: Transfer proven EMP/HPM hardware and software technologies and test techniques to the services.

FY2002: Assess EM protection to emerging RF threats.

FY2003: Update MIL-STD-188-125 and MIL-STD-2169.

Customer POC	Service/Agency POC	USD(A&T) POC
Mr. Richard Cullen USSPACECOM	Mr. R. C. Webb DSWA/ESE	Mr. Fred Celec ATSD(NCB)
LTC P. K. Simmons, USA USSTRATCOM		

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602715H	AF	2.3	0	0	0	0	0
0602715BR	AF	0	2.5	2.5	2.5	2.5	2.6
	Total	**2.3**	**2.5**	**2.5**	**2.5**	**2.5**	**2.6**

CB.16.12 Enhanced Respirator Filtration Technology

Objectives. Exploit the latest filter technologies, including low-resistance, electrostatically charged, high-efficiency particulate aerosol (HEPA)-quality media and flexible, moldable, carbon-adsorbent structures, to develop a filter system capable of meeting all the filter requirements of the Joint Service General-Purpose Mask (JSGPM). These requirements include a lower breathing resistance and lower profile.

Payoffs. The Enhanced Respirator Filtration Technology DTO was initiated in FY96. Major accomplishments in FY96 included the development and evaluation of a bonded-carbon sorbent and the identification and preliminary screening of candidate low-resistance, HEPA-quality, electrostatic filtration media. In addition, an in-house test capability for assessing particulate filter media performance was established, and a mold was designed and fabricated to produce a contoured filter bed for the JSGPM design concept. In FY97, baseline screening of candidate electrostatic filtration media was completed and the most promising candidate selected. Molding formulations and processes were also optimized in FY97 to enhance sorbent gas-life performance. The main accomplishment this fiscal year (FY98) has been the completion of baseline gas-life and airflow resistance testing on the candidate sorbent media. Baseline data indicate that the selected filtration technology is capable of achieving the STO metric objectives. This DTO is currently scheduled to transition to the JSGPM program in 1Q FY99.

Challenges. The design and evaluation of candidate filter concepts for the JSGPM mask that is capable of meeting C2 canister agent vapor and aerosol filtration requirements represent the major obstacle of this DTO.

Milestones/Metrics.

FY1998: Demonstrate a mask filter capable of providing full-threat NBC protection while offering a 50% reduction in airflow resistance and a 33% reduction in overall profile.

Customer POC	Service/Agency POC	USD(A&T) POC
LTC Mike Lanphere, USA JSIG	Dr. John Ferriter ERDEC (TPCBD)	Dr. Sal Bosco DATSD(CP/CBD)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602384BP	CB2	0.9	0	0	0	0	0
	Total	**0.9**	**0**	**0**	**0**	**0**	**0**

CB.17.01 Survivability Assessments Technology

Objectives. Develop and maintain state-of-the-art models and hardware-in-the-loop (HWIL) technology in order to perform operability, survivability, vulnerability, and connectivity assessments for current and proposed systems in combined nuclear effects environments. This baseline program applies DSWA expertise in support of warfighting CINCs and service needs for affordable and responsive solutions to meet survivability requirements. These same tools are applied to evaluate and analyze potential mitigation solutions for systems that must operate during and through a nuclear engagement. This program responds to requirements identified by Joint Chiefs of Staff, combatant CINCs, services, and other DoD organizations.

Payoffs. System assessments will provide the warfighter with critical information for the acquisition, operation, and maintenance of weapon systems that must be employed in a combined nuclear effects environment. Without this information, the survivability of critical C^4 and weapon systems would be uncertain.

Challenges. The conduct of timely, accurate, and relevant assessments of components, systems, networks, and systems-of-systems requires the development of robust tools for the evaluation of atmospheric effects. Furthermore, analytical tool development is based on a small sample size of empirical test data. Additionally, the tools require a myriad of numerical calculations to provide a relatively accurate assessment.

Milestones/Metrics.

FY1998: Complete initial USSPACECOM Tactical Warning/Attack Assessment Transition; develop a jamming module for the COMLNK analysis code; develop the initial operational magnetic bubble analysis tool for trapped radiation.

FY1999: Conduct GPS operability assessment; develop the advanced early-time trapped radiation analysis tool.

FY2000: Demonstrate automated process for performing operability assessments; begin the integration of high-altitude phenomenology into the space weather model.

FY2001: Conduct advanced data communications assessment; demonstrate network analysis tool.

FY2002: Assess operability connectivity of the NORAD/USSPACECOM advanced C^2 systems for operation in nuclear weapons effects.

FY2003: Assess the evolving TMD C^3 architectures for operation in nuclear weapons effects; assess the operability of future DII architectures to support strategic warfighter needs.

Customer POC		Service/Agency POC	USD(A&T) POC
Mr. Richard Cullen USSPACECOM	LTC P. K. Simmons, USA USSTRATCOM	Mr. Bill Summa DSWA/ES	Mr. Fred Celec ATSD(NCB)
Dr. Les Pierre BMDO			

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602715H	AF	10.3	0	0	0	0	0
0602715BR	AF	0	9.9	9.9	9.6	9.5	9.7
	Total	**10.3**	**9.9**	**9.9**	**9.6**	**9.5**	**9.7**

CB.18.01 Integrated Comprehensive Weaponeering Capability

Objectives. Develop an integrated comprehensive weaponeering capability (ICWC) that allows the warfighter to conduct pre-attack planning and post-attack assessment for the full spectrum of weapons and targets.

Payoffs. The ICWC provides a standardized weaponeering framework greatly increasing weaponeering efficiency while minimizing warfighter training requirements. It expedites cross-service weaponeering and joint planning. The ICWC architecture provides cross-platform interoperability and a common look and feel independent of weapons or targets including WMD targets.

Challenges. The ICWC has two critical challenges. First, a wide and diverse set of legacy and new weaponeering tools must be integrated into a single look and feel. Second, the ICWC must be available to a wide range of geographically distributed weaponeers across multiple services and allies. Other key requirements include compatibility with GCCS; compatibility with service systems such as CTAPS, AFATDS, and JWARN; usability on a wide range of platforms from PC-class to large workstations; and compatibility with intelligence community deliberate planning tools.

Milestones/Metrics.

FY1998: Finalize basic architectures concept for ICWC I; select initial candidate weaponeering tools for ICWC I.

FY1999: Demonstrate ICWC I during a mini-exercise; increase weaponeering throughput and reduce training requirements by 2X; increase functional integration to 25%.

FY2000: Deliver the warfighter ICWC I with initial set of weaponeering capabilities that have a common look and feel; begin ICWC II with additional tools and enhanced functional integration.

FY2001: Demonstrate ICWC II during a mini-exercise; increase weaponeering throughput and reduce training requirements by 2X and 5X, respectively.

FY2002: Deliver ICWC II; begin ICWC III with the final set of tools and full functional integration.

FY2003: Demonstrate ICWC III during an operational exercise; increase weaponeering throughput by 10X; reduce training requirements by 20X; deliver ICWC III.

Customer POC		Service/Agency POC	USD(A&T) POC
LTC Hal Meyer, USA	LTC Steve Perez, USA	Dr. Leon Wittwer	Mr. Walt Busbee
STRATCOM, J55	EUCOM, J5-N/CP	DSWA/WEL	DATSD(CP/CBD)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602715H	AC	4.1	0	0	0	0	0
0602715BR	AC	0	4.4	5.3	4.5	4.5	4.5
	Total	**4.1**	**4.4**	**5.3**	**4.5**	**4.5**	**4.5**

CB.19.01 Chemical Imaging Sensor

Objectives. Demonstrate a lightweight, wide-area, passive standoff imaging detection system capable of rapidly detecting chemical agent vapors for the purpose of contamination avoidance, reconnaissance, and facilities evaluation. The final system will operate at 360 Hz with a 256 x 256 focal plane array (FPA) and is scheduled for transition to development in FY03. This DTO will focus on development of ultra high speed interferometers, integration of off-the-shelf FPAs, and development of a signal processing algorithm.

Payoffs. The chemical imaging sensor (CIS) will allow rapid evaluation of large areas for CW contamination and provide detailed information as to position of a CW agent cloud. Current single-pixel designs have an extremely limited field of view (typically 26 m at a distance of 1 km). In addition they cannot scan at sufficient speeds for proposed high speed applications (i.e., tactical helicopter, high-speed aircraft, and hemispherical scanning applications). The CIS will be capable of operating at fields of view at least 250 times greater than current systems. In addition, scan speeds will be increased by almost two orders of magnitude for extremely high-speed applications. The potential deployments include fixed sites, ground vehicles, UAVs, helicopters, high and low aircraft, and even low-Earth-orbit configurations.

Challenges. Proposed deployment of the CIS includes many ground and airborne scenarios that require high-speed operation. Speeds of at least 360 scans per second are required in many airborne operations in order not to "blur" the data. A significant effort is required to run an imaging spectrometer at these high speeds. The proposed spectrometer will contain, at least, a low-density array of 9 to 16 pixels with higher density arrays being incorporated as they become available. The most significant current challenges are signal processing hardware and software, high-density FPA development, and high-speed interferometry. Commercially available interferometers typically operate at a few scans per second, with ten being a typical number. A CIS operating at 360 Hz with a 256 x 256 FPA will require about 1 TFLOP of computing power. Extrapolating current speed increases of high-speed computers into future signal processing hardware is expected to be available commercially in about 5 years that can handle the CIS.

Milestones/Metrics.

FY1998: Demonstrate 9-pixel spectrometer at 30 Hz (offline processing of data).

FY1999: Demonstrate real-time operation at 30 Hz.

FY2000: Demonstrate 16-pixel spectrometer at 100 Hz (offline processing of data).

FY2001: Demonstrate real-time operation at 100 Hz.

FY2002: Demonstrate 16-pixel spectrometer at 360 Hz.

Customer POC		Service/Agency POC	USD(A&T) POC
LTC Mike Lanphere, USA	COL Stephen Reeves, USA	Dr. John Ferriter	Dr. Sal Bosco
JSIG	PM-NBC Defense Systems	ERDEC (TPCBD)	DATSD(CP/CBD)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602384BP	CB2	1.1	1.5	1.9	2.1	2.8	0
	Total	**1.1**	**1.5**	**1.9**	**2.1**	**2.8**	**0**

INFORMATION SYSTEMS TECHNOLOGY

Defense Technology Objectives
for the Defense Technology Area Plan

Information Systems Technology

IS.01.01 Consistent Battlespace Understanding II-52
IS.02.01 Forecasting, Planning, and Resource Allocation II-54
IS.03.01 Integrated Force and Execution Management II-56
IS.10.01 Simulation Interconnection II-58
IS.11.01 Simulation Information Technologies II-60
IS.12.01 Simulation Representation II-62
IS.15.01 Assured Distributed Environment Support II-64
IS.17.01 Defensive Information Warfare II-66
IS.20.01 Universal Transaction Communications II-68
IS.21.01 Assured Communications II-70
IS.22.01 Network Management II-71
IS.23.01 Digital Warfighting Communications II-73
IS.24.01 Multimode, Multiband Information System II-75
IS.28.02 Intelligent Information Technology II-76
IS.29.02 Software Technology for High-Performance Computing II-78
IS.30.02 Advanced Embedded Software/System Engineering Technology II-79
IS.32.02 Information Presentation and Interaction II-81
IS.33.02 Embedded High-Performance Computing II-83
IS.34.01 Joint Force Air Component Command Battle Management II-85
IS.38.01 Antenna Technologies II-87
IS.40.01 Individual Combatant and Small-Unit Operations Simulation II-89
IS.46.01 Advanced Logistics Program II-91
IS.47.01 Command Post of the Future II-92
IS.48.01 Agent-Based Systems for Warfighter Support II-94
IS.49.01 Smart Networked Radio II-96
IS.50.01 Advanced Cooperative Collection Management II-98

IS.01.01 Consistent Battlespace Understanding

Objectives. Provide warfighters with tools to improve his understanding of the battlespace (i.e., critical, tailored battlespace information including enemy, friendly, temporal, and spatial information), while maintaining consistency of view across echelons, joint unit types, and battlespace position.

Payoffs. This DTO will provide fully automated situational assessment over a distributed and federated architecture to innovatively present enemy intent and potential actions. A database structure and interfaces for tailored 3D/4D visualization applications will be provided to aid ease of cognition. The products produced under this DTO overcome isolated exploitation of and disjointed fusion of observations from different sensor types; the depiction of aging, conflicting, or uncertain data; data omissions; and insufficient depth of understanding. These products will facilitate rapid, effective decisions, resulting in improved force synchronization, reduced casualties, and faster realization of operational objectives.

Challenges. This program will need to address a number of issues: (1) spatial and temporal registration across a plethora of sensor observations; (2) identifying appropriate features needed to develop multidiscipline; (3) developing unified object database and transforms necessary to tailor those objects for different users; (4) developing suitable strategy and providing appropriate mechanism for attaching value to information and data by different users and processes required to prioritize and contextualize exploitation and fusion management; and (5) developing dynamic controllers with distributed agents to unify and synchronize multiple (duplicative) service nodes processes, provide enterprise security, and identify and adjudicate data and product discrepancies. Because this DTO seeks to unify various information production processes and products that may not be amenable to external interface and control, there are technical risks in the development of model transforms. Model fragment combinations for composing situational models from situational fragments themselves are products of heterogeneous fusion processes. Retaining data integrity will be extremely challenging.

Milestones/Metrics.

FY1998: Develop dynamically maintained sensor observation history for multidiscipline fusion, context-sensitive situational assessment tools, uncertainty presentations, discontinuities, and temporal/spatial anomalies. Demonstrate ground and Joint Force Air Component Command ground targeting situational assessment information production and presentation. Demonstrate battle picture (greater than 1 x 2 m) for collaborative visualization and planning.

FY1999: Demonstrate joint battlespace awareness and visualization capability providing locally consistent, accurate, comprehensive, and timely battlespace picture (i.e., "drill down" to source and credible information used to infer the situation and establish uncertainty values).

FY2000: Demonstrate automated integrated situational assessment across a distributed federation of databases and processes such that information updates to one database node is propagated to all appropriate replications in other nodes in less than 1 min (plus delays from communication latency).

FY2001: Demonstrate the ability to access and employ foreign, digitized/nondigitized commercial data. Incorporate data from additional sensor types in multisensor fusion process with 20% increase in accuracy and completeness of information. Complete integration of automated capabilities across services, other disciplines, and operations, including logistics and operations other than war.

FY2002: Demonstrate the ability to provide long-range, positive identification and classification of airborne targets (nationality, airframe type, ownership, and intent). This technology will cue on-board shooter resources for efficient and effective utilization, support beyond-visual-range weapons engagement, reduce/eliminate fratricide, and avoid engaging neutrals and noncombatants.

FY2003: Demonstrate a three-dimensional optical memory, write once–read many (WORM) prototype configuration using two-photon absorption (sugar cube). This revolutionary approach will meet the information explosion by increasing storage capacities of gigabits to terabits and improving access times from microseconds to nanoseconds.

Customer POC		Service/Agency POC	USD(A&T) POC
Mr. Garry Barringer ASC^{2}A/CCT (HQ ACC)	CAPT Rick Williams, USN SPAWAR PD-13A/X	Dr. Steven Flank DARPA/ISO	Mr. Iftikhar Jamil DDR&E(IT)
Mr. Victor Gonzalez NIMA-TR	COL Douglas MacGregor, USA USA BCBL		

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
S&T Funding							
0602232N		0.4	0.4	0.4	0	0	0
0602702F	4594	0	2.8	0.7	0	0	0
0602782A	779	0.7	1.0	0.6	0	0	0
0603750D	P523	1.5	2.0	3.0	3.0	0	0
0603760E	CCC-02	24.8	38.0	35.0	0	0	0
0603772A	101	3.9	5.6	5.3	0	0	0
0603726F	2810	1.0	1.0	1.0	2.0	2.0	2.0
0603789F	2335	0.5	0.6	0.2	0	0	0
0603789F	4072	1.0	1.0	1.0	1.0	1.0	1.0
Total S&T		**33.8**	**52.4**	**47.2**	**6.0**	**3.0**	**3.0**
Non-S&T Funding							
0603617F	2321	1.8	1.9	1.6	0.8	0	0
Total Non-S&T		**1.8**	**1.9**	**1.6**	**0.8**	**0**	**0**

IS.02.01 Forecasting, Planning, and Resource Allocation

Objectives. Dynamically synchronize force operations by collaborative execution monitoring, repair, and retasking of shared assets across echelons, missions, components, and coalition forces. Both national-level decision makers and warfighters will be provided with a proactive planning process with the ability to rapidly fuse and assess data and generate options and alternatives. Decision makers will more rapidly and accurately assess crisis or combat situations; develop multiple, high-quality response options; present the situation and options for decision; and rapidly plan the allocation and assignment of resources.

Payoffs. A national-level crisis management system (Project Genoa) will allow mitigating and preemptive strategies to be developed and implemented more rapidly, thus allowing the use of military forces to be reduced with the attendant saving of resources (dollars and lives)—the ultimate payoff for the warfighter: he does not have to deploy and engage in combat. In the event of conflict, warfighters can then plan the allocation and assignment of resources to shape expected actions within the enemy's decision cycle, reduce planning cycle times, and deny the enemy the time and means to respond with a counterattack plan. This DTO will reduce casualties and fratricide, provide rapid battle-activity response, and reduce by 50% overall planning and replanning time.

Challenges. The extreme multidimensionality and chaotic nature of this crisis management problem domain makes this a complex system that requires an individual program focus rather than relying on abstract or generalized solutions. The development of intelligent agents to assist humans in the system by providing some automation is complicated by the diverse nature of the largely unstructured data that exist in open and classified databases throughout the agencies of the national security community and other open sources. The filtering, visualization, and organization of qualitative information in a fast, flexible manner to provide overview or detailed inspection of crisis dynamics are essential—and challenging. In planning and resource allocation, the primary technical challenges are (1) overcoming the problems associated with applying combinatorics to large space searching with computer algorithms; (2) obtaining and encoding relevant domain information and integrating available data sources; (3) finding effective interfaces, evaluation metrics, and data structures to give human planners insight into and control over automated planning processes; (4) integrating planning, scheduling, and execution systems; (5) developing collaboration and coordination tools for human and automated planning systems; and (6) intelligently filtering the planning information to expand the planning envelope to include low-bandwidth elements (e.g., enroute Joint Force Air Component Command).

Milestones/Metrics.

FY1998: Demonstrate multimodal interface to system, seamless access to classified databases, intelligent agents, information visualization, initial crisis model tools, initial option generation, and presentation tools 50% faster, 20% better quality, and 50% faster coordination time. Perform integrated case-based generative techniques for planning, scheduling, and evaluation 5X faster, 10X reduction in time needed to reach closure on alternatives, and 5X speedups in advanced scheduling performance.

FY1999: Demonstrate a second-generation system with speech transcription in simulated user environment 100% faster, 30% better quality, and 100% faster coordination time. Demonstrate analysis tool that can support 3X the number of combat options developed and evaluated by the division commander and staff. Demonstrate 100X speedup in planning and scheduling algorithms for force employment/deployment and 10X–100X increase in size of plans constructable in a fixed amount of time.

FY2000: Demonstrate focused replanning, triggered by semiautomated execution monitoring agents, in interleaved plan and execution processes showing 10X reduction in time required for responding to plan breakdowns.

FY2001: Demonstrate 10X speedup in enroute planning and adaptive replanning.

FY2002: Demonstrate autonomous agent-based planning and execution monitoring systems that reduce the staff requirements of the in-theater air operations center staff by 40%.

FY2003: Demonstrate intelligent, self-organizing, adaptive agent-based C^2 systems that learn and can be rapidly composed to support full-spectrum operations thus reducing both time to field and cost of acquisition of C^2 systems by 50%.

Customer POC		Service/Agency POC	USD(A&T) POC
Mr. Garry Barringer ASC^{2}A/CCT (HQ ACC)	CAPT Rick Williams, USN SPAWAR PD-13A/X	MAJ Douglas Dyer, USA DARPA/ISO	Mr. Iftikhar Jamil DDR&E(IT)
Mr. Jens Jensen USCINCPAC	COL Douglas MacGregor, USA USA BCBL	Mr. J. Brian Sharkey DARPA/ISO	

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602232N		1.3	1.3	1.3	0	0	0
0602301E	ST-11	7.7	5.0	0	0	0	0
0602702E	TT-03	7.6	6.6	0	0	0	0
0602702F	5581	1.9	1.6	1.9	2.2	2.3	2.4
0602782A	779	1.7	2.1	2.3	0	0	0
0602784A	H71	0.3	0.3	0.3	0	0	0
0603728F	2532	2.0	0.7	1.3	2.0	2.0	2.0
0603760E	CCC-01	1.7	0	0	0	0	0
0603772A	101	2.6	3.4	3.1	0	0	0
0603761E	CST-01	4.9	0	0	0	0	0
	Total	**31.7**	**21.0**	**10.2**	**4.2**	**4.3**	**4.4**

IS.03.01 Integrated Force and Execution Management

Objectives. Address the technologies needed to dynamically synchronize force operations by collaborative execution monitoring, repair, and retasking of shared assets across echelons, missions, components, and coalition forces. The intent is to provide control of coherent joint, simultaneous operations to optimize dynamic use of resources without preempting initiative.

Payoffs. The Integrated Force and Execution Management (IFEM) DTO will provide cognitive and visualization support to the warfighter, collaboration support tools, and automated processes. Specifically, this DTO addresses technologies required to provide warfighters with the ability to monitor, control, and coordinate real-time events inappropriate or impractical for traditional planning and forecasting activities; the ability to accomplish dynamic, continuous synchronization of operations through collaborative execution monitoring, plan-repair, and retasking of shared assets across echelons, missions, and forces; and knowledge-based cues for rules of engagement in offensive, defensive, evasive, and deceptive actions. The activities of this DTO's programs directly support the JWSTP objectives for Information Superiority, Joint Readiness and Logistics and Sustainment of Strategic Systems, and Precision Force. IFEM will implement a capability to perform enhanced wargaming faster than real time.

Challenges. Required technologies include advanced applications such as modeling and simulation tied to geo-information systems, uncertainty visualization, spatial- and temporal-based reasoning, multivariable conflict resolution, knowledge bases, neural nets, Petri nets, constraint-based and goal-directed reasoning, improved speed and capacity hardware, display and man–machine interface (MMI) innovations, real-time distributed/collaborative planning and negotiation, intelligent agents for alerts and for data mining, search and retrieval, mathematical modeling, real-time geo-referenced imagery, automatic target recognition (ATR) and intent analysis, and nodal analysis.

Milestones/Metrics.

FY1998: Demonstrate the capability to monitor multiple-echelon plans; perform real-time plan deconfliction across missions and near-real-time battle damage assessment.

FY1999: Provide automated implementation of tactical contingency plans and synchronization with ongoing elements, and provide collaborative execution monitoring among echelons/forces; incorporate uncertainty measures into plan repair functions; integrate decision support for ISR and logistics operations linked with ongoing battle; develop capability to incorporate signature/spectrum management and effects of sensor position options into ongoing battle; extend collaboration capabilities to brigade level and below.

FY2000: Demonstrate a tactical collaborative infrastructure to support battle planning, rehearsal, and combat force management. Demonstrate in-stride retasking, retargeting, and weaponeering for multiple dispersed units, including collaborative sensor detect and track, automated target assignment and engagement, and cooperative engagement and target handoff.

FY2001: Provide 4D representation of battle execution management; fully coordinate operations across the force, resulting in faster adjustment of mission plans, a reduction in casualties and fratricide, and improvements in force synchronization.

Customer POC		Service/Agency POC	USD(A&T) POC
Mr. Garry Barringer	COL Douglas MacGregor, USA	Mr. Brian Charnick	Mr. Iftikhar Jamil
ASC^{2}A/CCT (HQ ACC)	USA BCBL	USA CECOM	DDR&E(IT)

CAPT Rick Williams, USN
SPAWAR PD-13A/X

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
S&T Funding							
0602120A	H16	1.2	1.7	1.7	2.0	0	0
0602232N		0.7	0.9	0.5	0.6	0	0
0602782A	779	1.0	2.0	3.0	0	0	0
0603772A	101	2.8	4.2	3.9	0	0	0
0603789F	2335	0.5	0.6	0.2	0	0	0
Total S&T		**6.2**	**9.4**	**9.3**	**2.6**	**0**	**0**
Non-S&T Funding							
0603617F	2321	1.8	1.9	1.6	0.7	0	0
Total Non-S&T		**1.8**	**1.9**	**1.6**	**0.7**	**0**	**0**

IS.10.01 Simulation Interconnection

Objectives. (1) Develop an advanced runtime infrastructure (in time, data distribution, and large-scale federation management) to support high-level architecture (HLA) federations. (2) Develop automated tools to support federation development, including automation of the end-to-end process of identifying candidate simulations, developing HLA object models, and planning testing and operating federation events. (3) Investigate innovative techniques for supporting scaleable executing systems using an HLA to include systems other than simulations (e.g., C^4I systems). (4) Develop an automated HLA compliance testing capability.

Payoffs. This DTO supports the interoperability and reuse of simulations, and supports or augments applications. The program will provide users the technical standards and infrastructure to connect joint and component simulations, in a composable fashion, to support the functional areas of training and other operations, acquisition, and analysis. The same infrastructure and interfaces can be used for a wide variety of simulation applications. This will allow users of applications to benefit from improvements in infrastructure without having to pay for them or having to upgrade their applications—substantially decreasing time and manpower to support user applications. This critical capability facilitates the use of M&S for enhanced battlefield understanding, integrated force management, and predictive planning (Reference DTOs IS.01.01, .02.01, and .03.01); and will augment decision-making processes.

Challenges. The major technical challenges include establishing the architectural design and standards and security approach to facilitate the interoperability of simulations across a broad range of simulations in DoD; developing the supporting infrastructure software to apply the architecture to simulation application with the needed levels of performance; innovatively developing automated tools to make use of the architecture cost effectively; and extending the architecture to provide advanced time management, data distribution, and federation management services.

Milestones/Metrics.

FY1998: Design and develop innovative runtime infrastructure software demonstrating increased performance (25% improvement) and broad-based portability (reduce cost of porting by 25%); extend HLA services to address user needs, to include live systems (systems other than simulations), for advanced time, data distribution, and federation management (increasing user base by 10%); demonstrate technologies to support larger scale federations (10% increase) and compliance testing capability.

FY1999: Develop prototype for initial automated tools to support federation development testing (reducing time to create a new federation by 20%) and advanced system planning and runtime management tools; improve compliance testing capability to support the efficient operation of large-scale applications (20% less manpower).

FY2000: Apply increased advanced integrated automation to federation development and operation, demonstrating additional (20%) reduced costs to create a new federation.

FY2001: Demonstrate runtime infrastructure advances using next-generation software and hardware to increase (20%) performance for the same cost, using commercial software to replace 50% of custom software.

FY2002: Advanced support software will demonstrate prototype version of automation of the end-to-end process of identifying candidate simulations; define runtime data exchange requirements, network and computer resource requirements, configuration testing, operation, and monitoring of federation operation.

FY2003: Application of advanced technology will support actual application of end-to-end automated support to programs using HLA to support applications, demonstrating actual improvements in man-power requirements (25% less) and timing (20%).

Customer POC		Service/Agency POC	USD(A&T) POC
CAPT Drew Beasley, USN JSIMS JPO	CAPT Jay Kistler, USN NAVMSMO	Mr. W. H. (Dell) Lunceford DARPA/ISO	Dr. Ann Miller DDR&E(IT)
Col Michael Fallon, USMC MCCDC-OSI	CAPT Wm. (Bill) Molloy, USN Joint Warfighting Center	Mr. Gary Yerace DMSO	
Lt Col Carol Lynn Judge, USAF AFAMS	COL Henry Ruth, USA AMSO		

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0603832D	P476	30.5	25.0	25.3	23.6	24.1	24.6
	Total	**30.5**	**25.0**	**25.3**	**23.6**	**24.1**	**24.6**

IS.11.01 Simulation Information Technologies

Objectives. Provide the services and DoD agencies the technologies and standards necessary to develop simulations that provide consistent, reliable, and credible results.

Payoffs. The properties of a robust end-to-end modeling and simulation (M&S) development process will be established to ensure that operationally valid and consistent simulations are built in compliance with the DoD goals of credibility, reusability, interoperability, and efficiency. Technologies required to support the realization of this process include conceptual models of the mission space (CMMS)—authoritative functional descriptions that serve as the basis for simulation design and implementation; authoritative data sources (ADS)—a defined set of data sources recognized as authoritative; M&S resource repository (MSRR)—a mechanism for easy access to and sharing of simulation and data set information; and an embedded verification, validation, and accreditation (VV&A) process with supporting tools to achieve quality assurance. The VV&A process will focus on the establishment of credibility and mitigation of risk associated with software development. These collective efforts will serve to support DARPA's Synthetic Theater of War (STOW) ACTD and Advanced Simulation Technology Thrust (ASTT) programs and future M&S applications including the Joint Simulation System (JSIMS) and the Joint Warfare Simulation (JWARS).

Challenges. Developing coherent, complete, and consistent simulations is an extensive task. DoD M&S spans a wide range of missions, from conventional warfare to operations other than war. M&S must simulate activities from system acquisition to mission planning, rehearsal, and training.

Milestones/Metrics.

FY1998: Prototype CMMS library ready for JSIMS, Warfighters Simulation 2000, National Air Space Model, and JWARS. Produce DoD VV&A recommended practices guide (RPG) with links to VV&A tool set for acceptability definition, fidelity assessment, and validation activities. Complete pilot studies on impacts of security policies; initiate studies of M&S VV&C procedures and guidelines; develop M&S cataloging and registration specification as standard for online resource repositories and MSRR implementation.

FY1999: Prototype version of online CMMS repository including functional descriptions for analysis and training available for engineering and engagement level of detail in acquisition and OT&E-related simulation; produce DoD VV&A/C RPG enhancements to focus on incorporating concepts of risk assessment, decision making, return on investment, and cost metrics. Prototype VV&A tool concepts.

FY2000: At least 50% of major simulation program developers will have contributed to populating CMMS. CMMS library used by warfighter to collect, evaluate, and eventually validate doctrine, functions, tactics, techniques, and procedures. (Techniques for modeling complex data structures initiated in FY96 demonstrated and completed.) Produce VV&A tools.

FY2001: Development of common semantics and syntax and associated data interchange formats (DIFs) for campaign-level representations of environment, units and systems, and operations and human behavior.

FY2002: CMMS will represent DoD activities. Warfighters have worldwide access to conceptual models of DoD processes. Authoritative data will be available for representations of most synthetic environments, portions of units and systems, operations, and human behavior.

FY2003: Development of common semantics and syntax (CSS) and associated DIFs for representations of environment, units and systems, and operations and human behavior for all levels of warfighting incorporating the greater degree of detail and fidelity required.

Customer POC		Service/Agency POC	USD(A&T) POC
CAPT Drew Beasley, USN JSIMS JPO	COL Henry Ruth, USA AMSO	Mr. W. H. (Dell) Lunceford DARPA/ISO	Dr. Ann Miller DDR&E(IT)
Dr. Jim Metzger JWARS Office	Col Michael Fallon, USMC MCCDC-OSI	Mr. Gary Yerace DMSO	

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0603832D	P476	13.3	18.7	18.7	20.2	21.1	21.6
Total		**13.3**	**18.7**	**18.7**	**20.2**	**21.1**	**21.6**

IS.12.01 Simulation Representation

Objectives. Enable developers and users of M&S applications to represent the natural environment, the performance and capabilities of warfighting systems, and human behaviors (individual and group) in a manner that promotes cost-effectiveness, ready access, interoperability, re-use, and confidence.

Payoffs. This DTO will enhance the realism of models and simulations used in military training, acquisition, and analysis by providing authoritative representations of (1) static and dynamic, natural, and manmade environments (including weapon effects), and related effects on human and system performance; (2) the performance and capabilities of warfighting systems and their effects on natural and manmade environments; and (3) human behavior (individual and group). Representations of the terrain, ocean, atmosphere, and space require large volumes of diverse authoritative data assimilated and integrated over time and space in order to simultaneously account for large numbers of significant environmental conditions and effects in a consistent and correlated manner over numerous heterogeneous simulations. These efforts will specifically support DARPA's Synthetic Theater of War (STOW) ACTD and Advanced Simulation Technology Thrust (ASTT) programs and joint modeling and simulation system developments like JSIMS, JWARS, JCOS, JLOTS, improved computer-generated forces (CGFs), and C^4ISR applications, as well as DoD's battlefield visualization program. Coordination of efforts is essential with the Sensors, Electronics and Battlespace Environment JWCO efforts, ASTT, and the Rapid Terrain Visualization (RTV) and Battlefield Awareness and Data Dissemination ACTDs to ensure operational effectiveness and consistency.

Challenges. Major challenges include rapid database generation and target modeling, near-real-time interaction of consistent and correlated representations, and multiresolution modeling of complex, consistent, and correlated environments. Efficient models, a flexible architecture, and wide-bandwidth communications are needed to provide accurate and believable simulated representation of the battlefield situation at multiple locations for bomb damage assessment and commander's situational awareness. The major technical challenge for the representation of human behavior includes providing variable human behavior for friendly, enemy, and nonhostile personnel. These representations must reflect human capabilities and limitations, cognitive processses, and factors that influence performance such as stress, fatigue, and experience—to include CGFs that exhibit platform-based as well as statistical-based behavioral modeling, logistical effects, and command forces (CFOR) models through division level.

Milestones/Metrics.

FY1998: Test and evaluate the capability to generate an integrated feature/elevation terrain surface for 2,500 km^2 area in 72 hr; field the Master Environment Library System to include an air and space models and algorithms catalog; enhance system representations; interface with the environment and human behavior; extend CFOR command entities to battalion level; demonstrate rapid modeling of structures and critical battlefield systems; demonstrate rapid generation of CGF adaptive behaviors; develop tools and technical methods to acquire knowledge and better represent human behavior; complete interchange specification for environmental source data and integrated databases; develop and initiate prototype semiautomated forces architecture for assembling primitive behavioral elements into customized tactical behaviors.

FY1999: Demonstrate capability to generate and interchange integrated, consistent synthetic environments (terrain, oceans, and atmosphere) within 72 hr; demonstrate use of the virtual interactive target to populate the battlespace with targets and use physics-based weapon effects models to calculate weapon-specific damage to them; develop knowledge base reflecting variable human behavior at individual level; extend representations of effects of human C^2 decision-making processes in

company- and battalion-level surrogates; extend the models and algorithms catalog to all environmental domains.

FY2000: Transition interchange specification for environmental databases to designated office of primary responsibility for configuration management and user support; develop intitial capability for timely generation of integrated database for space M&S.

FY2001: Demonstrate capability to generate and interchange integrated, consistent synthetic environments (terrain, oceans, atmosphere, and space) at multiple resolutions within 72 hr; expand human behavior knowledge base to incorporate variable human behavior at organizational unit level and for large-scale logistical effects.

FY2002: Expand knowledge base to incorporate variable human behavior at the enemy and nonhostile force level; initiate capability to apply and manage dynamic changes in multiresolution environments for planning and operational purposes.

FY2003: Develop tools to enable dynamic, scaleable (micro-to-macro) adjustments to the synthetic environmental representations in simulations running in real time; extend representations of C^2 decision-making process to brigade, division, and corps surrogate levels.

Customer POC		**Service/Agency POC**	**USD(A&T) POC**
CAPT Drew Beasley, USN JSIMS JPO	Dr. Donald Resio JLOTS	Mr. W. H. (Dell) Lunceford DARPA/ISO	Dr. Ann Miller DDR&E(IT)
Dr. Jim Metzger JWARS Office	COL Henry Ruth, USA AMSO	Mr. Gary Yerace DMSO	
Dr. Susan Numrich JCOS	LTC David Vaden, USA TRADOC DCSSA	Mr. Walter Zimmers DSWA	
Col Michael Fallon, USMC MCCDC-OSI			

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602308A	C90	0.8	0.8	0.8	0.9	0	0
0602715H	AE	4.5	5.1	6.2	6.7	6.8	7.0
0603832D	P476	13.1	21.5	21.7	22.0	21.9	22.6
0603761E	CST-01	11.9	13.8	0	0	0	0
	Total	**30.3**	**41.2**	**28.7**	**29.6**	**28.7**	**29.6**

IS.15.01 Assured Distributed Environment Support

Objectives. Develop and demonstrate a globally distributed, heterogeneous information infrastructure to provide warfighters at all echelons immediate and location-transparent access to information. This infrastructure may be derived from multiterabyte databases spread over a thousand nodes and involve execution and sharing of up to one-half million processes, supporting all phases of mission planning and execution. This allows users to craft their C^4I information environment from the full set of assets connected through the grid. It will be dynamically reconfigurable to accommodate crisis loads, outages, or changes in information needs. It will support collaboration among all elements of planning, decision making, and execution monitoring and assessment, including information discovery and retrieval in massive, heterogeneous, distributed environments.

Payoffs. This DTO will provide the ability to support (1) rapid deployment of C^4I elements while maintaining full reachback capability to in garrison resources; (2) immediate and location-transparent access to and flow of information from sensor to shooter; and (3) a uniform information backbone built on a combination of fixed, mobile, airborne, and space assets that are interconnected by a variety of communications media with widely varying throughput, delay, and error characteristics. The allocation of information resources will be dynamically reconfigured within minutes to respond to crisis situations or accommodate failures or anomalous behavior in parts of the system. The information infrastructure will support deployed operations with a small footprint and maximum reachback to in-garrison resources and provide for the seamless integration of processing and communications systems, plus associated information services and applications as described in the Advanced Battlespace Information System (ABIS). Emerging COTS products and industry standards will be used where adequate and augmented where insufficient to implement the ABIS vision capability. This DTO relates to DTOs IS.21.01 and A.13, Satellite C^3I/Navigation Signals Propagation Technology.

Challenges. Technical barriers include system state management to support dynamic reconfigurability for the formation of virtual collaboration teams; scalability of resource control mechanisms for up to 10,000 objects across 100 nodes; algorithms to maintain quality-of-service parameters across a widely disparate communications backbone; and dynamic binding of heterogeneous processes and databases across a multicluster infrastructure.

Milestones/Metrics.

FY1998: Demonstrate incorporation of mobile computing nodes into the infrastructure. This includes operation over more error-prone communication channels, protocols to allow entry/departure (within 2 minutes) and reentry into the configuration, and resource management mechanisms to allow allocation and binding of 1,000 processes and associated data across the hybrid fixed and mobile configurations. Examine the exploitation of commercial public network infrastructures using virtual private networking (VPN) and advanced encryption methods to support certain classes of information system interconnections.

FY1999: Implement up to four virtual, collaborating, planning teams with shared access to up to six collaborative planning domains, with full traceability from strategy to task; demonstrate the ability to reconfigure a 15-node cluster within 5 min based on the quality-of-service parameters.

FY2000: Demonstrate the ability to support automated workflow management across a multicluster configuration of locally netted workstations.

FY2001: Demonstrate workflow management capability that is optimized for crisis response allowing a user to specify critical items and policies. Upon specification of parameters, the workflow management system will activate and maintain the situation over 10 wide area networked clusters.

FY2002: Demonstrate adaptive reconfiguration of a 100-node infrastructure to support dynamic crisis response.

Customer POC

Mr. Garry Barringer
ASC^{2}A/CCT (HQ ACC)

CAPT Rick Williams, USN
SPAWAR PD-13A/X

COL James Bessler, USA
TRADOC

Service/Agency POC
Mr. Les Anderson
SPAWARSYSCEN D411

Mrs. Gladys Reichlen
DARPA DISA AITS-JPO

USD(A&T) POC
Mr. Marshall Potter
DDR&E(IT)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602232N		1.2	1.2	1.2	0	0	0
0602301E	ST-19	5.2	0.1	0	0	0	0
0602702F	5581	2.3	2.2	1.7	1.8	1.9	0
0603728F	2530	0.8	0.5	0.6	0.8	1.2	0
0603760E	CCC-01	8.4	0	0	0	0	0
0603760E	CCC-02	0.1	0	0	0	0	0
0603761E	CST-02	4.0	0	0	0	0	0
	Total	**22.0**	**4.0**	**3.5**	**2.6**	**3.1**	**0**

IS.17.01 Defensive Information Warfare

Objectives. Develop and demonstrate technologies to defend the availability, integrity, and confidentiality of warfighter information infrastructure in a dynamic battlefield environment. These technologies will monitor the system health relative to an objective policy, modify allocation of resources to accommodate any changes or anomalous behavior in a manner that provides graceful degradation of performance for systems under attack, increase the number and type of faults the information system can tolerate, and minimize recovery time and residual effects of the recovery mechanisms. These capabilities will be integrated into a balanced system defense targeted at next-generation DARPA functional capabilities in areas such as C^2 (e.g., Joint Force Air Component Command (JFACC)), planning (e.g., Genoa), information dissemination (e.g., Battlefield Awareness and Data Dissemination (BADD)), and advanced logistics (e.g., Advanced Joint Planning (ALP)).

Payoffs. The program will release a library of application-embedded network security services; and prototype Common Object Request Broker Architecture (CORBA)-compliant domain and type enforcement software for secure location interoperability. It also will demonstrate integrated security support in a prototype extensible operating system, demonstrate prototype design tools for inferring system-level security properties in composed systems, demonstrate a primitive survivable immune system for responding to attacks and intrusions, and demonstrate resource allocation mechanisms for an adaptive system of systems. A general security architecture will be established for a reference architecture (called the Advanced Information Technology Services) that will be common to many DARPA Information Systems Office projects. Several prototype security services will be demonstrated in an experimental testbed environment. This DTO supports DTOs IS.21.01 and A.12, Information Dominance.

Challenges. A primary technical challenge is to effectively integrate the great variety of security mechanisms designed to protect against attack, detect and respond to attack, and manage the mechanisms themselves. Additional challenges include assessing the degree of assurance achieved, securing the core network services (i.e., DNS) and routing protocol exchanges, and synthesizing diversity within the community-used components.

Milestones/Metrics.

FY1998: Release a library of application-embedded network security services; demonstrate middleware for end-to-end, fault-tolerant, real-time services on LAN; and prototype CORBA-compliant domain and type enforcement for secure location interoperability.

FY1999: Demonstrate the use of an intrusion, detection, and isolation protocol (IDIP); coordinate the operation of defensive information warfare (DIW) technologies, the automatic change of security posture to perceived threat level, and the interoperability of a robust security protocol suite; conduct red team exercise(s) to assess survivability of large-scale systems and networks.

FY2000: Include completing prototype network management implementation for crisis mode operation; demonstrate techniques for general three-way tradeoffs among fault tolerance, real time, and security; demonstrate network response to damage to 20% of their security resources by recognizing the damage, returning to a secure state, and repairing 90% of the damage within 5 min of the onset.

Customer POC

Mr. Garry Barringer
ASC^{2}A/CCT (HQ ACC)

Mr. Dennis Bauman
SPAWAR PD16

Col Michael Fallon, USMC
MCCDC-OSI

COL James Bessler, USA
TRADOC

CAPT Rick Williams, USN
SPAWAR PD-13A/X

Service/Agency POC

Mr. Les Anderson
SPAWARSYSCEN D411

Dr. David Tennenhouse
DARPA/ITO

USD(A&T) POC

Mr. Marshall Potter
DDR&E(IT)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602232N		0.6	0.4	0.4	0	0	0
0602234N		1.2	1.6	0	0	0	0
0602702F	4519	1.0	1.0	1.0	0	0	0
0602301E	ST-19	1.3	0.3	0	0	0	0
0602301E	ST-24	40.7	47.1	2.6	0	0	0
0603760E	CCC-01	14.1	20.0	25.0	0	0	0
0603794N	X2091	0.7	0.7	0.7	0	0	0
	Total	**59.6**	**71.1**	**29.7**	**0**	**0**	**0**

IS.20.01 Universal Transaction Communications

Objectives. Develop, integrate, and apply technology for wireless links/nodes, networking, and applications support that will enable mobile, wireless users to access and utilize the full range of information services available in the defense information infrastructure (DII) without the accompanying infrastructure of the civilian world. The earlier years (1998-2000) are primarily 6.2 exploratory development followed by a planned 6.3a ATD in the outyears (2000-03), which will capture the earlier results and integrate them into a seamless capability across the wired and mobile wireless environment.

Payoffs. This DTO will provide warfighters, including dismounted and small-unit operations, the ability to exchange information, unimpeded by differences in connectivity or interface characteristics; provide information throughput and connectivity to meet most warfighter needs; provide full multimedia services; provide high-capacity, flexible, tactical communications extensions to serve all categories of users; provide seamless connectivity across multiple media; and provide automated features to mitigate the effects of manmade and naturally disturbed environments on wireless communications.

Challenges. Technical barriers include development of efficient protocols for high-population, high-capacity mobile networks; multimedia over low-data-rate channels; overcoming current limitations in data rates, link quality, range, power consumption size, connectivity, and multimedia services in the mobile, wireless environment; providing the ability to support self-organizing networking for mobile multihop network users; maintaining required quality of service; and supporting applications within available bandwidth in sporadic, disconnected operations. Challenges include eliminating fixed infrastructure requirements while improving multipath, antijam, and low-probability-of-detection capabilities. More effective dynamic spectrum utilization will continue to be a technical challenge as military spectrum availability continues to shrink.

Milestones/Metrics.

FY1998: Demonstrate wireless Internet gateways' adaptive nodes with 1-2-Mbps data rates, adaptive handheld multimedia nodes capable of variable data rates of 100 kbps to several Mbps, and location-dependent information dissemination technique. Demonstrate 30-Mbps quadrature amplitude modulation (QAM) CMOS wireless modem. Demonstrate integrated networking and untethered node technologies that improve information transfer for dismounted up through task force operations.

FY1999: Demonstrate survivable, multihop advanced wireless networking over high-data-rate untethered nodes; demonstrate adaptive computing techniques and adaptive multimedia transfer over heterogeneous networks.

FY2000: Demonstrate out-of-band control/signaling channel access for mobile, multihop networks; demonstrate hardware and software for a high-speed (1–2 Mbps at 10 km), wireless IP/ATM network based on digital beamforming. Using M&S techniques, demonstrate high-performance mobile wireless networks capable of self-organizing up to 10,000 nodes in a 100 mi^2 area within minutes, with ability to automatically reroute if part of networks is attacked. At node level, demonstrate wireless nodes capable of data rates up to 1 Mbps at 10 km in benign environments and at least 100 kbps in presence of 30-dB path loss.

FY2001: Integrate next-generation technologies into Land Warrior program. Metrics for Land Warrior improvements include 6-dB improvement in LPI/LPD, 10-dB improvement in antijam, 15% increase for peer-to-peer link range with 64 kbps minimum throughput.

FY2002: Demonstrate seamless connectivity and robust networking across multiple, dissimilar wireline and wireless systems, allowing exchange of information unimpeded by differences in connectivity or interface characteristics.

FY2003: Demonstrate adaptive addressing to allow connections to users completely independent of knowledge of their location.

Customer POC	**Service/Agency POC**		**USD(A&T) POC**
COL Benjamin Fletcher, USA	Mr. Gary Blohm	Mr. Robert Ruth	Mr. Iftikhar Jamil
USA BCBL	USA CECOM	DARPA/ISO	DDR&E(IT)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602232N		0.4	0.4	0	0	0	0
0602301E	ST-19	14.9	18.8	24.6	0	0	0
0602782A	H92	0.7	1.2	2.3	2.6	0	0
0603006A	247	0	0	0	0	8.0	8.0
0603006A	257	0	0	4.8	4.9	5.9	5.6
	Total	**16.0**	**20.4**	**31.7**	**7.5**	**13.9**	**13.6**

IS.21.01 Assured Communications

Objectives. Develop and demonstrate technologies that will assure adequate communications resources for the warfighter that will be guaranteed available, adaptable, and scalable to meet dynamically changing demands and that can be successfully defended against physical, electromagnetic, and information warfare (IW) threats. This DTO involves technology development to detect and characterize attacks at the network and lower transport layers

Payoffs. The warfighter will be provided with a high degree of confidence regarding communications connectivity throughout all phases of battle, without worrying about the different operational levels of security found in joint and coalition operations. This DTO will support global logistics information and tracking of warfighter resources in real-time and ensure support for the existing C^2 operational scenarios. Future scenarios will involve globally distributed command and operations centers and globally distributed collaborative planning and execution cells to lower in-theater footprint as required by the ABIS vision and the current direction of the newly formed Air and Space C^2 Agency.

Challenges. Current technical challenges include security management for asynchronous transfer mode (ATM); algorithms for real-time dynamic bandwidth allocation; and algorithms for global virtual private network management.

Milestones/Metrics.

FY1998: Following successful development and testing, upgrade Tactical End-to-End Encryption Device to support ATM cell encryption using Baton technology; exploit cell-agile Fastlane encryption devices in joint service testing; exploit Turbo and Trellis coding to realize 4–6 dB of coding gain on radio transmissions.

FY1999: Combine advanced signal compression and spread-spectrum techniques to enhance LPI/D/E performance on radio transmissions. Assess performance and realizability of combined spatial processing (adaptive array antenna) and time-frequency processing techniques to enhance directivity of transmission, jam resistance, processing gain, and emission reduction.

FY2000: Demonstrate advantages and implementability of above techniques on in-house testbed. Expected performance metrics: variable data rates for spread-spectrum communications between 600 bps and 2 Mbps, processing gain up to 30 dB (temporal) and 100 dB (temporal and spatial combined), bandwidth efficiency doubled, and average interference mitigation of 20-80 dB (scenario dependent).

FY2001: Design adaptive processing and waveform techniques to protect radio transmissions with just-in-time detection and mitigation of various nonlinear and nonstationary interferences expected from a dynamic battlespace environment to ensure information transmission integrity and fidelity.

Customer POC	**Service/Agency POC**	**USD(A&T) POC**
Col Buster McCrabb, USAF	Mr. Daniel McAuliffe	Mr. Iftikhar Jamil
ASC^2A	AFRL	DDR&E(IT)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602702F	4519	0.1	1.1	1.3	2.6	0	0
0603253F	666A	2.1	2.4	1.0	1.1	0	0
	Total	**2.2**	**3.5**	**2.3**	**3.7**	**0**	**0**

IS.22.01 Network Management

Objectives. Develop network management technology to provide a robust theater-level capability in support of joint service needs. Managing the behavior of large, fast networks is now beyond the ability of either users or communication system vendors. Because of this shortcoming, DoD has no capability to analyze or predict the performance of the system it is currently fielding, let alone the far larger systems that are being planned. Specifically, the developed network management system technology will provide improved utilization of network resources through efficient, proactive management of all components of the information system; peer-to-peer management between existing domain managers; performance optimization capable of dynamically adapting to changes in network resources and information flow requirements; and robust management of network infrastructure to deliver priority-ordered, graceful degradation, and service restoration (self-healing) after outages. Metrics and algorithms to detect surreptitious behavior within the network and strategies to mitigate their effects will be developed. Effective planning tools to automate and assist in the design and implementation of very large networks will also be developed. This DTO will support the development of the Joint Communications Network Planning and Management System (JCNPMS) and the Joint DII Control System–Deployed (JDIICS–D) through appropriate technology transfer.

Payoffs. FY98 goals are to demonstrate (1) standards-based network management of global asynchronous transfer mode (ATM) and Internet protocol internetworks integrated into a Joint Task Force (JTF) environment, and (2) peer-to-peer interoperability between different network management systems, including commercial and allied systems. This DTO will support the development of the Joint Communications Network Planning and Management System (JCNPMS) through appropriate technology transfer.

Challenges. Managing the behavior of large, fast networks is now beyond the ability of both users and communications systems vendors. Because of this shortcoming, DoD has no capability to analyze or predict the performance of the systems it is currently fielding, let alone the far larger systems that are being planned. Technical barriers associated with this area include interoperability protocols and procedures for functioning in a heterogeneous architecture; developing machine-based algorithms for fault detection/isolation and circuit restoral; detection of and immunity to surreptitious behavior; stability under large, dynamically changing network conditions including mobile networks; and integration of multilevel security mechanisms.

Milestones/Metrics.

FY1998: Demonstrate standards-based network management of global ATM and Internet protocol internetworks integrated into a JTF environment for network stability and availability.

FY1999: Transition integrated management system prototypes developed for the DISN LES environment to a tri-service global network management facility for a 50% reduction in operational manpower. Simulate 2,000 highly mobile entities routing open shortest path first (OSPF) and BGP in real time. Prototype new methods for computing optimal routing with real-time speed.

FY2000: Demonstration of multilevel security networking and management for 50% reduction in operational manpower.

FY2001: Complete integration into various legacy systems, resulting in increased availability.

Customer POC		Service/Agency POC	USD(A&T) POC
Col Buster McCrabb, USAF ASC^{2}A	CAPT Rick Williams, USN SPAWAR PD-13A/X	Mr. Robert Kaminski AFRL	Mr. Iftikhar Jamil DDR&E(IT)
Mr. John Nunziato PM WIN-T		Dr. David Tennenhouse DARPA/ITO	

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602301E	ST-19	11.5	13.7	29.0	81.0	9.0	0
0602702F	4519	1.4	1.0	0	0	0	0
0603789F	2335	1.4	0.4	1.0	1.4	0	0
	Total	**14.3**	**15.1**	**30.0**	**82.4**	**9.0**	**0**

IS.23.01 Digital Warfighting Communications

Objectives. Exploit emerging commercial devices and communications technologies in support of Robust/Tactical/Mobile Networking (DTO A.02) to provide commanders and warfighters with global, seamless, nonhierarchical adaptive networks for multimedia communications in a dynamic battlefield. The major thrusts of this DTO are to (1) supplement, enhance, and in some cases replace legacy military communications systems unable to keep pace with the rapidly increasing demand for communications bandwidth and global coverage in support of force projection and split base operations; (2) evolve an integrated communication infrastructure using commercial protocols and standards to achieve global tri-service interoperability through integration of land, air, space, and sea networks into a global asynchronous transfer mode (ATM) infrastructure; and (3) continue joint ATM bandwidth on-demand experimentation to support multimedia information requirements through a DS 3 (i.e., 44.736 Mbps) Leading Edge Services (LES) connection to other service laboratories.

Payoffs. In FY98, the program will build on the ATM switching inserted into Army Mobile Subscriber Equipment, extend field demonstrations of the Air Force Secure Survivable Communications Network, and continue the Navy shipboard communications program to support joint and allied JMCOMS inter-/intra-ship multimedia requirements. During the same period, it will extend direct broadcast satellite technology in joint service exercises, leading to the Global Broadcast Services (GBS). The program will also conduct joint experiments with high-capacity trunk radios to support a variety of wide bandwidth trunk requirements. As part of the FY98 DIVXXI advanced warfighter exercise, GBS hardware will be deployed to support DARPA's Battlefield Awareness and Data Dissemination ACTD (DTO A.07). Tactical applications of terrestrial personal communications system (PCS) technology will be demonstrated by exploiting emerging commercial code division multiple access (CDMA) technology for Army, Air Force, and Marine Corps applications. The program will also demonstrate space crosslink technology via two maneuvering air platforms. In FY98 and FY99, the program will test a radio access point to extend ATM services to mobile forward tactical units. By FY00, the goal is to demonstrate next-generation mobile Internet protocol services connecting tactical internetworks for littoral and expeditionary warfare between Marine Corps, Navy, and Army tactical net radio networks in support of DARPA's Airborne Communications Node (ACN) Program (see DTO A.02). In FY01, ATM multimedia interconnection between Army radio access point (RAP) and Navy shipboard commanders afloat will be demonstrated using airborne relays from DTO A.02, Robust/Tactical/Mobile Networking.

Challenges. This initiative overcomes technical issues associated with incorporating emerging commercial standards into a battlefield environment. In addition, several technical barriers must be overcome for the tactical user to take advantage of immediate access to information related to his battlefield awareness. The design of protocols able to adapt to rapidly varying conditions of the battlespace must be addressed. This includes error detection and correction technologies that will allow low-error-rate performance over high-error-rate links (10^{-3}-bit error rate). This project also addresses the ability of disadvantaged links to support multimedia information services by improving the performance of time-sensitive protocols.

Milestones/Metrics.

FY1998: 20X increase in tactical operational communications range, exchange of multimedia information content where none was possible before, and operation with highly mobile users who previously could only communicate at the halt. Begin joint experiments with high-capacity trunk radios to support a variety of mobile subscriber services on land and at sea.

FY1999: Demonstrate a UAV on-board switch supporting battlefield networking requirements. Communication resource management will address both connectionless- and connection-oriented traffic. Test an RAP to extend ATM multimedia services to forward tactical units. Tests will be conducted between Army and Navy shipboard elements.

FY2000: Demonstrate next-generation mobile Internet protocol services connecting tactical internetworks for littoral and expeditionary warfare among Marine Corps, Navy, and Army combat net radio networks.

FY2001: Demonstrate multimedia connectivity between Army RAP and Navy shipboard joint commanders in conjunction with the DARPA ACN Program and DTO A.02.

FY2002: Integrate information-for-the-warrior-system components into the Air Mobility Command operational tanker/airlift control center (i.e., provide in-transit visibility).

FY2003: Perform test and evaluation of information-for-the-warrior system installed in operational Air Mobility Command airlifter; demonstrate mission effectiveness in conjunction with integration of all mission tanker/airlift control center corporate databases (i.e., provide situation awareness).

Customer POC		Service/Agency POC	USD(A&T) POC
Col Buster McCrabb, USAF ASC^{2}A	CAPT Rick Williams, USN SPAWAR PD-13A/X	Mr. Paul Sass USA CECOM	Mr. Iftikhar Jamil DDR&E(IT)

COL Benjamin Fletcher, USA
USA BCBL

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602232N		4.6	4.4	0	0	0	0
0602702F	4519	2.8	5.6	5.4	5.1	5.6	7.7
0602782A	779	0.3	0.5	0.5	0.5	0	0
0602782A	H92	0.3	1.0	0	0	0	0
0603006A	247	0.3	2.8	0	0	0	0
0603006A	257	7.5	4.3	0	0	0	0
0603789F	2335	0	0	1.4	2.5	3.1	2.3
0603789F	4216	1.3	2.4	2.5	2.7	2.7	2.8
0603401F	3784	0.3	0.3	0.4	0.5	0	0
	Total	**17.4**	**21.3**	**10.2**	**11.3**	**11.4**	**12.8**

IS.24.01 Multimode, Multiband Information System

Objectives. Develop the technical foundation for the next-generation warfighter communications architecture for future digital radio and integrated avionics suites. Hardware and software architectural designs and communications technical building blocks will be prototyped and examined on test assets. Products developed will be transitioned to form the starting point for the next-generation joint tactical radio (JTR) acquisition. Developed hardware and software assets will be used to provide the testbed for further development of modular building blocks (Ref. IS.50.01) that will be inserted into the JTR during spiral acquisition cycles.

Payoffs. A six-waveform, over-the-air demonstration was performed as part of the Task Force XXI AWE. Included were legacy waveforms such as SINCGARS, UHF satellite communications, Have Quick I and II, improved HF radio, and GPS. Payoff is seen by developing modular technology needed for insertion during spiral acquisition cycles for the multiband, multimode, integrated information transmission system that meets joint service requirements for future digital radio and integrated avionics suites. Payoffs include an affordable, flexible, interoperable communications system with reduced logistics requirements and much higher capacity.

Challenges. Technical barriers include the development of high-performance wideband RF front ends, high-speed digital signal processors (DSPs), certification of software-based type I cryptography, and an industry/DoD joint radio architecture. Another challenge is cost-effective algorithm development and software development tools. New algorithms are needed to support knowledge engineering and AI-based adaptation to both environment and network loading conditions to maximize performance. The lead time for certification of cryptographic systems may be a limiting factor in the insertion of new software-based cryptographic modules in the spiral development model.

Milestones/Metrics.

FY1998: Completion of a narrowband programmable test asset (SPEAKeasy Model–1 terminal) will be pursued, including adding CYPRIS-based INFOSEC data and DAMA capabilities. Pursue advanced INFOSEC developments for use in follow-on programs such as ACN and JTR. Initiate efforts (by Army) to investigate nonlegacy wideband radio networking waveforms and protocols.

FY1999: Add a wideband waveform to the test asset to determine the performance characteristics under bus and processor stressing conditions. Evaluate first advanced development module (Advanced INFOSEC Module (AIM)) of the technologies being developed for spiral implementation.

Customer POC	**Service/Agency POC**	**USD(A&T) POC**
Col Buster McCrabb, USAF	Mr. Wayne Bonser	Mr. Iftikhar Jamil
ASC^2A	AFRL	DDR&E(IT)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0603789F	2335	2.7	2.2	0	0	0	0
0602601F	8809	0.4	0.3	0	0	0	0
	Total	**3.1**	**2.5**	**0**	**0**	**0**	**0**

IS.28.02 Intelligent Information Technology

Objectives. Enable a new level of battlespace awareness and information dominance by developing technology to access, analyze, understand, and integrate information from the vast flood of diverse, multimedia data sources now available to the warfighter. Future crisis and battlefield situations will be rich with sensor imagery, video data, message traffic, news broadcasts, massive databases, and Web-like data sources containing extensive and critical information about the changing battlefield situation. This DTO will develop and demonstrate new technology to extract information from images; extract and integrate facts, in multiple languages, from diverse text, radio, and video sources; integrate information from large collections of dynamically changing, inconsistent, structured and semistructured heterogeneous databases; and rapidly build and use comprehensive knowledge bases to interpret and reason about the changing battlespace situation.

Payoffs. The technology being developed under this DTO will allow the warfighter to rapidly obtain and assimilate information and knowledge relevant to the decisions that must be made in the crisis or conflict situation at hand. History is replete with examples in which commanders lost battles because the relevant information or knowledge that they needed existed but was not available to them when they needed it. This technology will allow the commander to obtain the data and knowledge he needs, when he needs it, in order to support his warfighting decisions. The technology from this DTO feeds system DTOs including IS.34.01, A.07, Battlefield Awareness and Data Dissemination ACTD, and A.17, Joint Task Force ATD.

Challenges. The challenges inherent in this program are to (1) increase the semantic level of integration to create information at the right level of abstraction to meet users needs; (2) present the user with accurate information when the sources may have substantial errors; (3) integrate information from large numbers of dynamically changing, inconsistent, heterogeneous databases, unstructured text, and image files; (4) provide rapid, accurate, automated site monitoring using EO and SAR imagery from UAVs; and (5) create large knowledge bases in short periods of time.

Milestones/Metrics.

FY1998: Demonstrate (1) automated site monitoring with 50% reduction of manual processing; (2) completely automated transcription, extraction, and indexing process across TV, radio, and text feeds taking less than 1 hr for a 30-min broadcast; (3) identification and tracking of three out of five new topics across the same feeds; and (4) information integration using multiple-mediator systems across tens of heterogeneous data sources.

FY1999: Demonstrate transcription of four languages from diverse media/sources with 80% accuracy, and fully automatic photogrammetric registration from EO and SAR images; construct high-resolution 3D building models 10X faster and roads 100X faster than manual; demonstrate large-scale information associate integrating information from 50 heterogeneous data sources; compose 5,000-axiom knowledge base in less than 1 month.

FY2000: Transition algorithms for news understanding systems to JPO leading-edge services and to a selected intelligence community testbed; demonstrate adaptive visualized battlefield decision making using uncertain, incomplete information across 100 or more heterogenous sources.

FY2001: Demonstrate data-intensive intelligent information integration for multilevel intelligent agent collaboration.

FY2002: Demonstrate 100% productivity increase through dynamic data mining for multidimensional event pattern models in large-scale temporal analysis systems.

FY2003: Demonstrate pattern-centered learning algorithms that provide automatic data extraction from intelligence warehouses.

Customer POC	**Service/Agency POC**	**USD(A&T) POC**
Mr. Garry Barringer ASC^{2}A/CCT (HQ ACC)	Mr. Les Anderson SPAWARSYSCEN D411	Mr. Marshall Potter DDR&E(IT)
Col Philip Yff, USAF Joint Staff/J4	Dr. David Gunning DARPA/ISO	

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602301E	ST-11	32.1	31.0	17.0	0	0	0
0602702F	4594	3.0	3.5	4.7	4.6	5.0	5.1
0602702F	5581	0.4	0.8	1.8	2.0	2.4	3.3
0603728F	2527	0.1	0	0	0	0	0
0603728F	2532	0.1	0.6	0.8	0.7	0.7	0.7
0603726F	2810	1.0	1.0	1.0	2.0	2.0	2.0
0602232N		0.7	0.7	0.7	0	0	0
	Total	**37.4**	**37.6**	**26.0**	**9.3**	**10.1**	**11.1**

IS.29.02 Software Technology for High-Performance Computing

Objectives. Develop and demonstrate software tools, languages, etc., to enable the cost-effective application of high-performance computers to new domains, such as mission rehearsal, ATR, decision aids, and modeling and simulation (M&S) for command and control.

Payoffs. Applications such as satellite image data processing, battle damage assessment, multisensor and information fusion, and automated cooperation among multiple intelligent agents are prime candidates for high-performance computers. By parallelizing and optimizing engineering codes and by capturing and setting up system design knowledge bases and automated re-synthesis, system design times can be significantly reduced, leading to end-user, field-modifiable systems. This capability will facilitate future intelligence, surveillance, and reconnaissance warfighter missions predicted for the battlefield of the twenty-first century.

Challenges. Conventional computers have limits on computational throughput that are overcome through the use of high-performance parallel computers. HPC power is available at the desktop and, potentially, on the battlefield; however, these machines encompass a wide variety of differing architectures, and software tools and methodologies required to harness the full power of these machines have been sorely lacking. This DTO addresses these challenges through the development of architecture-independent scalable software libraries, high-performance languages, and runtime services that enable data and task parallelization. These machines also produce more efficient and optimized algorithms for robust, adaptive network communications.

Milestones/Metrics.

FY1998: Demonstrate HPC++ supporting both task and data parallelism and release for public use; enable scalable structural dynamics applications with scalable library for sparse symmetric Eigen problem; demonstrate scalable versions of new iterative solvers for radar cross section modeling.

FY1999: Demonstrate HPF II supporting task-parallel applications such as Advanced Distributed Simulation; release scalable versions of defense-critical engineering software—MSC NASTRAN and CENTRIC Spectrum.

FY2000: Predict response-time performance throughout the design and coding phases for real-time and information processing HPC applications to within 98% of actual performance.

Customer POC		Service/Agency POC	USD(A&T) POC
Col Buster McCrabb, USAF ASC^{2}A	Maj Craig Olsen, USAF Joint STARS	Dr. David Tennenhouse DARPA/ITO	Mr. Marshall Potter DDR&E(IT)
Maj Joseph Chapa, USAF ESC/AWO	Mr. Michael Taber B2 SPO/YSSW	Dr. Northrup Fowler III AFRL-IFT	
Col Charles Cornell, USAF NRO			

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602301E	ST-11	0	11.0	32.0	0	0	0
0602301E	ST-19	7.5	3.2	0	0	0	0
	Total	**7.5**	**14.2**	**32.0**	**0**	**0**	**0**

IS.30.02 Advanced Embedded Software/System Engineering Technology

Objectives. Develop, demonstrate, and transition state-of-the-art, applications-specific software architecture and software and system engineering technology to address the $30 billion annual DoD expenditure on embedded software-intensive systems. This will be accomplished by integrating COTS software, new tools and environments, and process technologies, thereby significantly improving development and re-engineering productivity and product quality for legacy and embedded systems.

Payoffs. Progress on this DTO will make the delay and cost of effecting an incremental change to a large software system proportional to the size of the change as opposed to the size of the system—one of the major goals of the DARPA- and AF-sponsored Evolutionary Design of Complex Software (EDCS) program. Achievement of this goal will allow DoD C^3 and weapons systems to be modified to meet unforeseen needs rapidly, at low cost, and with high assurance. The ability to statically evolve system implementation will be improved by replacing selected components with components of enhanced capabilities.

Challenges. Design rationale needed to support evolution is usually lost and is rarely captured in useful form (e.g., electronic/automated). Design management tools to support Web-based evolutionary development do not exist. Representation at higher conceptual levels than code such as architectural and behavioral specification languages are nonstandard and incomplete. Recertification is a major bottleneck to an evolutionary life cycle. Programming languages do not promote evolution by maintaining design flexibility to the point of code execution and by supporting both incremental development and high performance. Code generation capabilities do not support families of applications with multiple architectures. This DTO is also addressing problems related to (1) organizations' inability to use technology effectively because of a lack of defined processes; (2) a lack of standard engineering (and acquisition) approaches to software development, resulting in poor prediction and control; and (3) a need in much of the practitioner community for help in assessing and selecting among alternatives (e.g., with respect to tools, languages, processes) or evaluating impact.

Milestones/Metrics.

FY1998: Demonstrate 10% reduction in life-cycle costs by early detection of faults and omissions in software architectures and low-level designs; demonstrate 30% reduction in maintenance costs due to reuse of testing and analysis artifacts developed during design and testing; demonstrate 50% improvement in faults per thousand lines of code due to systematic use of static and dynamic analysis techniques. Demonstrate use of Web to integrate rationale, system models, and implementation. Issue government guidelines on risk management practices based on Software Engineering Institute work.

FY1999: Demonstrate open, Java-based, distributed, extensible workflow execution environment using WWW. Demonstrate Web-based toolkit of representation, analysis, and generation tools. Harmonize international standards with the Capability Maturity Model (CMM). Demonstrate safe upgrade on F–16 AMAS algorithms.

FY2000: Demonstrate process for incremental recertification of evolutionary systems. Analyze data to demonstrate acceleration of effective technology adoption for organizations that follow an explicit adoption process; release Version 2 of the Software Acquisition CMM and Software Risk Evaluation Guidebook.

FY2001: Demonstrate the ability to more rapidly perform field-adaptable changes to incorporate new warfighting capabilities or interoperability requirements; demonstrate the ability to use architecture specifications to encapsulate interface and protocol requirements.

FY2002: Demonstrate the potential of user-centered, knowledge-based design technology to reduce development time and life-cycle costs of complex, software-intensive embedded weapon systems by 50% over the FY95 baseline.

FY2003: Demonstrate significant reduction in programming and testing activities through the automated generation of code from its architecture, thereby doubling life-cycle productivity.

Customer POC		Service/Agency POC	USD(A&T) POC
Col Buster McCrabb, USAF ASC^{2}A	Mr. Bruce Kress B2 SPO/YSDA	Dr. David Tennenhouse DARPA/ITO	Mr. Marshall Potter DDR&E(IT)
Mr. Steve Schroeder Arnold Eng & Tech Ctr	Lt Col Christopher Mears, USAF HQ USAF/REOR	Dr. Northrup Fowler III AFRL-IFT	
Mr. C. Rocky Byars Joint STARS (WR-ALC)	Capt James Crissey, USAF Space & Missile Sys Center	Mr. Robert Wasilausky SPAWARSYSCEN	
Col Charles Cornell, USAF NRO		Ms. Glenda Turner OUSD (Policy)/DDIA	

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602234N		3.3	4.9	2.6	0	0	0
0602301E	ST-11	15.9	14.0	7.0	0	0	0
0602301E	ST-22	16.6	17.1	17.6	0	0	0
0602702F	5581	6.1	5.2	5.7	6.3	6.4	7.2
0603728F	2527	1.0	2.3	2.4	2.4	2.4	2.5
0603728F	2532	0.3	0.7	0.4	0.5	0.6	0.6
	Total	**43.2**	**44.2**	**35.7**	**9.2**	**9.4**	**10.3**

IS.32.02 Information Presentation and Interaction

Objectives. Develop and demonstrate advanced concepts to allow warfighter interaction with a global information system in a naturally expressive, timely, and flexible manner. Activities include infrastructure support for collaborative decision making and battle damage assessment; interactive faster-than-real-time wargaming; warfare assessment; battlefield data fusion; synthetic visualization for mission scheduling, planning and rehearsal, simulation, and training; enhanced battlefield situational awareness using presentation technology for stereoscopic three-dimensional viewing; and more natural modes of system interaction such as speech and gestures.

Payoffs. This initiative attempts to overcome the inherent limitations of current C^2 systems and offers the warfighter major improvements in the ability to see, understand, and interact, in real time, with critical worldwide information. Situational awareness will improve by 50%, and dynamic war planning/replanning activity will occur in 50% of current timelines.

Challenges. The challenges of this DTO include (1) hyper-exponential growth in content-capturing and organizing multimedia information increasing in three dimensions—number of sources, number of items per source, and sizes of individual items; (2) content interpretation-extending functionality beyond text search, across disciplines, and among media types; (3) semantic interoperability coherently accessing autonomous digital objects and services among heterogeneous repositories; and (4) finding nonnative sources and using information in foreign disciplines and languages.

Milestones/Metrics.

FY1998: Demonstrate 6-million pixel data wall with simultaneous interaction of collocated users using spoken input and electronic "grease pencil" interfaces; demonstrate collaborative virtual worlds applications for mission planning and rehearsal; demonstrate English language query and retrieving text in at least two foreign languages; demonstrate translingual query entering; demonstrate domain-specific spoken language translation for coalition forces.

FY1999: Demonstrate integration testbed by evaluating statistically based semantic analysis capabilities across four repositories; demonstrate automatic extraction and translation of document summaries; demonstrate more cost-effective and deployable data-wall implementations for multitude of applications (e.g., JFACC testbed, AF Battle Management and Information Warfare battle labs).

FY2000: Demonstrate gesture interpretation with spoken input as synergistic C^4I interface; demonstrate federated repository functionality among at least 100 repositories; evaluate scalability and interoperability of repository designs; demonstrate shared, time-varying visualization models; demonstrate automated tool suggesting appropriate workflow as nature of team's task evolves.

FY2001: Deploy a prototype with cross-repository information analysis; demonstrate integrated prototype with adaptive session management, semantic retrieval of situational information from multimedia archives, and sharing role-based active objects; demonstrate integrated interaction for pairs of languages with performance greater than an average interpreter; integrate usability tests for hearing in field and command centers and demonstrate reduction of hearing errors by greater than 60%; demonstrate robust natural language processing of speech utterances; achieve 90% performance relative to text input.

FY2002: Conduct operational evaluation with USMC in Capable Warrior and Command Center of Future/Third Fleet. Enhance analyst's productivity. Demonstrate information protection environment with scalable architecture framework to predict, deter, detect, and recover from information attacks.

FY2003: Complete development of 3D visualization environment for AF SPACECOM satelite teleoperation applications, which provides more intuitive, realistic means for humans to interact with satellite systems.

Customer POC		Service/Agency POC	USD(A&T) POC
Col Buster McCrabb, USAF ASC^{2}A	Capt Mike Mills, USAF AirIntelAgcy/XRRT	Dr. David Tennenhouse DARPA/ITO	Mr. Marshall Potter DDR&E(IT)
Col Charles Cornell, USAF NRO	Maj Mike Peel, USAF AFSPACECOM	Dr. Northrup Fowler III AFRL-IFT	
Mr. Raul Salas USAF IW Battle Lab		Mr. Robert Wasilausky SPAWARSYSCEN	

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602234N		1.9	2.2	2.2	0	0	0
0602702E	TT-06	2.1	0	0	0	0	0
0602301E	ST-11	5.0	2.0	1.0	0	0	0
0602301E	ST-19	29.2	45.0	39.0	36.0	20.0	0
0602702F	4594	2.0	0.3	3.3	0.2	1.8	1.8
0602702F	5581	1.4	1.6	2.2	1.9	2.2	2.7
0603726F	2810	1.9	2.0	2.0	2.4	2.3	2.4
0603728F	2530	0.2	0.6	0.9	0.9	0.9	1.0
0603728F	2532	0.1	0	0	0	0	0
	Total	**43.8**	**53.7**	**50.6**	**41.4**	**27.2**	**7.9**

IS.33.02 Embedded High-Performance Computing

Objectives. Develop innovative computational models, methods, and mechanisms that explore the limits of computing; define models of computation for nontraditional approaches; explore potential computational mechanisms; validate those mechanisms through experimentation; explore the limits of deep submicron, silicon-based technology; and predict the behavior and limits of new computational modalities.

Payoffs. The goal is to provide timely, affordable, and easily upgradable technology to meet the high-speed computational demands of the military while leveraging and influencing the efforts of the commercial sector. This DTO will provide the technology for improving automatic target recognition (ATR) from air, space, ground, and sea vehicles and weapons and for improving other high-computation tasks such as sensor, data, and knowledge fusion for situational awareness. In particular, this DTO will (1) benchmark and demonstrate technology improvements by inserting embedded program elements (hardware and software) into real military-embedded applications (e.g., STAP, ATR, UUV, UYS–2A); (2) establish the use of common components across multiple service applications addressing military computational intensive problems; (3) develop new memory architectures that will allow data-starved defense applications to manage the placement and flow of their data as well as allow them to manipulate data in the memory subsystem itself; (4) adapt popular platform-independent design tools (such as MatLab and Khoros) for use in DoD signal and image processing applications; and (5) develop system software capable of satisfying mission demands on assets whose performance may vary by as much as 5X.

Challenges. The DoD requirement for computational capabilities of 1 TFLOP/ft^3 (2X over today's systems) and communications of 4-8-Gbps/link is a significant challenge. Meeting computational and communication requirements under the constraint of size, weight, power, and costs results in a need for heterogeneous COTS-based solutions capable of being scaled along several dimensions. The extremely dense packaging required by deeply embedded systems is not being addressed by the commercial sector. The long delay in accessing main-memory severely constrains performance of object-oriented databases and other pointer-based unstructured codes. In particular, memory bandwidth within memory chips and subsystems often greatly exceeds bandwidth to the processor, and cached data are not always reused, negating the advantage of moving it into high-speed subsets of the memory hierarchy. There is a need to support interactive C^{4}I applications and real-time embedded processing through a common operating system interface.

Milestones/Metrics.

FY1998: Develop HPC domain-specific tools with Khoros visualization environment and MPI and real-time reference implementation. Design and simulate amorphous array concepts with >1,000 elements.

FY1999: 1-GFLOP/4-GFLOP fixed-point DSP chip insertion into multi-DSP board designs. Investigate feasibility of porting military problems to quantum mechanical computing. Conduct IRAM evaluations. Demonstrate hardware-accelerated, distributed, shared memory on workstation clusters.

FY2000: Determine degree to which a physical realization of quantum computing is possible. Demonstrate real-time scheduling algorithms for dynamic process reallocation. Determine feasibility of porting defense applications to biomolecular computation.

FY2001: Demonstrate the impact of intelligent memories on database performance. Demonstrate OS support for mixed workloads of hard, soft, and non-real-time applications.

FY2002: Demonstrate 2X improvements in the performance of three large defense applications (i.e., DDB, MSTARS, and HDI).

Customer POC		Service/Agency POC	USD(A&T) POC
Col Buster McCrabb, USAF ASC^{2}A	Maj Craig Olsen, USAF Joint STARS	Dr. David Tennenhouse DARPA/ITO	Mr. Marshall Potter DDR&E(IT)
Maj Joseph Chapa, USAF ESC/AWO	Mr. Michael Taber B2 SPO/YSSW	Dr. Northrup Fowler III AFRL-IFT	
Col Charles Cornell, USAF NRO		Mr. Robert Wasilausky SPAWARSYSCEN	

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602234N		1.3	1.2	1.2	0	0	0
0602301E	ST-19	48.3	58.3	42.7	34.5	13.0	0
0602301E	ST-24	0.1	0	0	0	0	0
	Total	**49.7**	**59.5**	**43.9**	**34.5**	**13.0**	**0**

IS.34.01 Joint Force Air Component Command Battle Management

Objectives. Develop, integrate, evaluate, demonstrate, and transition technology and systems that enable new air operations planning, execution, and assessment concepts of operations. The Joint Force Air Component Command (JFACC) program will revolutionize command and control of joint and coalition air forces by transforming air operations planning capabilities from a reactive, sequential system to one providing continuous, near-real-time predictive planning; visually oriented distributed, collaborative decision support; and rapid response to dynamic situations. This DTO will use and extend planning technology and infrastructure developed under other DTOs (e.g., IS.02.01) and will provide technology to the Advanced Joint Planning ACTD (F.02)

Payoffs. JFACC will (1) respond to new campaign objectives in hours rather than days by moving from schedule-driven cyclic operations to knowledge- and decision-driven continuous operations; (2) reduce the time to prosecute high-priority, time-critical targets from hours to minutes through implementation of comprehensive preplanned options and maintenance of real-time comprehensive situational awareness; (3) reduce by 50% sorties canceled or delayed due to logistics shortages, lack of target information, or loss of key mission support elements through detailed knowledge of ISR, logistics, and planning constraints; (4) shorten air campaign phases by up to 50% through effective and responsive selection and prosecution of preidentified and emerging high-value targets; and (5) decrease in the in-theater footprint for an air operations center by a factor of ten through the employment of distributed collaboration technology.

Challenges. Technical barriers include (1) advanced knowledge representations integrating all elements of the air operations domain (objectives, tasks, activities, strategies, tactics, priorities, intelligence, and campaign status); (2) scaleable architecture of planning, execution, and assessment software agents that provide continuous, cross-functional decision support in dynamic and unpredictable situations; (3) flexible modeling and analysis framework and components for rapid battlespace characterization, center-of-gravity analysis, strategy formulation, and course-of-action evaluation; and (4) integrated visualization, collaboration, and workflow management services that provide a seamless user environment for distributed teams and agents performing collective work.

Milestones/Metrics.

FY1998: Demonstrate common plan representation capable of defining an air operations plan with 10,000 objects; generate information needs specification using ISR planning tool in <5 min. Support on-line collaboration among virtual teams at four distributed sites. Begin initial implementations of scaleable multiagent architecture, flexible modeling/analysis framework and components, and integrated user environment. Evaluate JFACC in distributed service R&D and battle lab environment (collaboratory).

FY1999: Demonstrate ability to develop alternate operational options (sets of alternate tasks and activities that can achieve the same objective end state) for a limited regional conflict in less than 1 hr. Support automated workflow for continuous interleaved planning, execution, and assessment for 1,000 interrelated processes. Evaluate enhanced implementations of multiagent architecture, components, and user environment in operationally relevant context.

FY2000: Generate initial assessment of probability of end-state attainment within 10 min of task definition. Perform center-of-gravity analysis to identify critical target systems within 10 min. Enact final implementations of architecture, components, and environment. Continue to develop and enhance components and evaluate in operational setting.

FY2001: Replan task/activity to neutralize an individual time critical target within 2 min of identification. Generate a single-thread air operations plan for 500 targets in less than 30 min. Complete implementations and transition of architecture, components, and environment.

Customer POC	**Service/Agency POC**	**USD(A&T) POC**
Mr. Garry Barringer	Col Robert Plebanek, USAF	Dr. Ann Miller
ASC^{2}A/CCT (HQ ACC)	DARPA/ISO	DDR&E(IT)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602702F	5581	0.2	0.2	0.2	0	0	0
0603728F	2530	0.6	1.1	0.6	0.5	0	0
0603760E	CCC-01	28.1	37.1	24.4	10.0	0	0
	Total	**28.9**	**38.4**	**25.2**	**10.5**	**0**	**0**

IS.38.01 Antenna Technologies

Objectives. Develop and demonstrate affordable antennas and RF signal distribution technology meeting future requirements for line-of-sight (LOS) and satellite communications (SATCOM) (e.g., high-data rate, low-observable, on-the-move operation) on a variety of space, air, surface, and under-surface vehicles. Technical efforts will emphasize consolidating multiple communications functions into wideband, low-observable antenna apertures and RF signal distribution components while mitigating electromagnetic interference (EMI).

Payoffs. This DTO will result in increased data rates, increased link availability, reduced number of antennas (weight, volume, coverage improvements), reduced P_d (e.g., RCS, IR, visual), and improved survivability (i.e., on-the-move (OTM) operation)

Challenges. The primary technical challenges that will be addressed to achieve this objective include developing (1) structurally integrated, low-observable, wideband antennas (structural integrity versus signature versus bandwidth versus radiation pattern); (2) multifunction signal distribution architectures (dynamic range versus bandwidth versus power handling); (3) electronics for co-site EM interference mitigation (isolation versus settling time versus bandwidth); and (4) OTM structural mounting and inertial navigation capability (speed/maneuverability versus link availability).

Milestones/Metrics.

FY1998: Demonstrate affordable 1D multifunction SATCOM phased array as part of the Navy Submarine Communications ATD. This will enable multiple SATCOM signal beams to be transmitted and received simultaneously via 1D phased-array steering that will significantly reduce the array cost. Demonstrate broadband, high-power, co-site interference cancellation as part of the Multifunction EM Radiating System (MERS) ATD and the Communications Integration and Cancellation Mitigation (CICM) ATD. This will enable a reduction of co-site EM interference of up to 50 dB in less than 100 μs). Demonstrate multiband antenna technology for VHF/UHF radio communications. This will reduce the number of required antennas. Demonstrate structure-tuned, optically switched reconfigurable antenna. Demonstrate reconfigurable multifunction communications navigation integration (CNI) antenna as part of the Navy/Army SERAT demonstration. This conformal antenna technology will enable a single antenna structure to service three unique CNI functions, reducing the number of antennas by 3X.

FY1999: Demonstrate OTM wideband (45 Mbps at X-band), triple-beam, phased-array antenna technology with full-duplex operation demonstration as part of the Digital Battlefield Communications ATD (part of DTO IS.23). This technology will allow high-capacity, OTM radio access point operation with multiple simultaneous transmissions in mobile environments. Demonstrate low-cost antenna technology for airborne communications systems capable of receiving high-data-rate communications via satellites in support of the Global Broadcast System (GBS) program. Conduct shipboard tests of the MERS ATD, validating performance of affordable, structurally integrated, multifunction antenna system servicing at least four disparate communications systems. This technology will enable a 3X reduction in the number of antennas located topside on the next-generation surface combatant.

FY2000: Demonstrate OTM self-steering antenna capability for SHF land-based SATCOM terminals. This technology will enhance link availability for land-based SATCOM. Demonstrate low-cost antenna technology for airborne communications systems capable of transmitting and receiving high-data-rate communications via satellites in support of the GBS program.

FY2001: Demonstrate OTM self-steering antenna capability for EHF land-based SATCOM terminals.

Customer POC		Service/Agency POC	USD(A&T) POC
Col Buster McCrabb, USAF	CAPT Rick Williams, USN	Mr. Stephen Hart	Mr. Iftikhar Jamil
ASC^2A	SPAWAR PD-13A/X	SPAWARSYSCEN D856	DDR&E(IT)

COL Benjamin Fletcher, USA
USA BCBL

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
S&T Funding							
0602232N		3.4	2.4	0	0	0	0
0602702F	4519	2.3	0	0	0	0	0
0602702F	4600	0.2	0	0	0	0	0
0602782A	H92	2.8	3.3	2.2	2.3	0	0
0603006A	247	2.6	2.1	5.5	3.3	0	0
0603792N	R1889	10.5	4.5	0	0	0	0
Total S&T		**21.8**	**12.3**	**7.7**	**5.6**	**0**	**0**
Non-S&T Funding							
0603430F	4056	0.3	0	0	0	0	0
Total Non-S&T		**0.3**	**0**	**0**	**0**	**0**	**0**

IS.40.01 Individual Combatant and Small-Unit Operations Simulation

Objectives. Develop a high-level, architecture-compliant individual combatant simulation system across the research, development, and acquisition (RDA), advanced concepts and requirements (ACR), and training exercises and military operations (TEMO) domains.

Payoffs. This DTO will refine RDA, ACR, and TEMO simulation requirements for individuals and small units, and create a multisensory, real-time networked simulation of the battlefield that immerses the individual combatant in three-dimensional geographical space using virtual reality technologies. A dismounted-infantry-computer-generated-forces capability will be developed to support up to a platoon of dismounted entities. Coordination of efforts is essential with the MOUT ACTD, Land Warrior future Close Combat Tactical Trainer (CCTT–DI) P^3I upgrades, and DARPA's small-unit operations (SUO) to support the M&S requirements for those programs.

Challenges. Technical barriers include human representation and visualization of individuals and weapon states, human performance modeling, and human system interfaces that are unencumbered and elicit realistic performance, networked simulations for interoperability with other dissimilar simulations, computer-generated forces that contain realistic individual and unit-level behaviors with C^3I representation, synthetic terrain with relevant resolution and fidelity to allow operations in a tactically correct manner, and instrumentation for high-precision engagement simulation to allow for data capture and analysis.

Milestones/Metrics.

FY1998: Refine RDA, ACR, and TEMO simulation requirements; create a multisensory, real-time networked simulation of the battlefield; develop a baseline dismounted-infantry-semiautomated-forces capability to include MOUT behaviors.

FY1999: Provide modeling and simulation tools to facilitate the design and analysis of alternatives for the Land Warrior program; develop an initial prototype capability for individual and small-unit synthetic forces capable of representing doctrinally correct USMC behaviors. Develop an initial capability for field instrumentation for the individual soldier that enables entity state, position location, and weapon employment information to be transmitted and collected across diverse terrain types.

Customer POC		Service/Agency POC	USD(A&T) POC
LtCol John Blair, USMC MCCDC T&E Div	COL Brian Pentecost, USA USAIS-DOT	Ms. Traci Jones STRICOM	Dr. Ann Miller DDR&E(IT)
COL Timothy Bosse, USA USA DBBL	COL Henry Ruth, USA AMSO	Mr. George Solhan MARCORSYSCOM(AWT)	
COL Philip Hamilton, USA PM-Soldier			

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602308A	C90	1.4	0	0	0	0	0
0602618A	H80	0.7	0	0	0	0	0
0602716A	H70	0.9	0	0	0	0	0
0602786A	H98	1.5	0.9	0	0	0	0
0603640M	C2223	0.2	0.7	0	0	0	0
	Total	**4.7**	**1.6**	**0**	**0**	**0**	**0**

IS.46.01 Advanced Logistics Program

Objectives. Demonstrate the feasibility of a fully automated end-to-end logistics system to improve logistics support to the warfighter.

Payoffs. The Advanced Logistics Program (ALP) will develop the advanced information systems technology to gain control of the logistics pipeline; enable the warfighter to project and sustain overwhelming combat power sooner; permit forces and materiel to be deployed, tracked, sustained, and redeployed more effectively and efficiently with reduced reliance on large DoD inventories; and provide users at any level the ability to effectively interact during planning, execution, and link operations with logistics staff elements at all echelons, across selected functional areas, and at selected commands.

Challenges. Technical barriers include (1) automating the generation of detailed logistics support plans in response to changing operational requirements in crisis situations; (2) developing sentinels that can understand explicit plan assumptions and expectations, sample and interpret execution data, detect deviations, trigger replanning processes, and monitor the execution space, infrastructure, and assets; and (3) integrating simulation into real-time planning processes.

Milestones/Metrics.

FY1998: Create optimized ship and airload stow plans within 10 min with dynamic adjustment based on in-transit visibility of assets during execution.

FY1999: Create one logistics plan in 4 hr without operator intervention. Demonstrate capability across all echelons and selected functional areas and commands. Provide natural language voice interface to logistics source databases to support worldwide query of in-transit visibility/total asset visibility (ITV/TAV) data with standard telephone hardware. Provide object base visualization of logistics plans and state conditions.

FY2000: Provide generalized time-phased force deployment data (TPFDD) data structure that supports dynamic changes during execution and links between logistic assets and plans they support.

FY2001: Create one logistics plan in 1 hr without operator intervention, and demonstrate capability across all echelons and selected functional areas and commands. Issue execution orders within 1 min of approval, both automatically and with human interaction. Monitor execution and identify deviations within 15 min of real-world data update and replan within 15 min. Demonstrate ability of users at any level to effectively interact during planning and execution.

Customer POC	**Service/Agency POC**	**USD(A&T) POC**
Col Philip Yff, USAF Joint Staff/J4	Mr. J. Brian Sharkey DARPA/ISO	Dr. Graham Law ADUSD(ATI)
Col Michael Fallon, USMC MCCDC-OSI	Mr. Carroll Childers MARCORSYSCOM(AWT)	

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602702E	TT-10	21.2	21.7	10.6	10.0	0	0
0603712S	3	4.3	5.0	5.5	6.1	0	0
	Total	**25.5**	**26.7**	**16.1**	**16.1**	**0**	**0**

IS.47.01 Command Post of the Future

Objectives. Provide the commander and his staff with an environment that will expand their cognitive processes while enhancing their ability to make decisions and direct their execution. The command post of the future (CPoF) will provide a means to rapidly visualize, interpret, integrate, and analyze information about the battlespace while decreasing the uncertainties, unknowns, and fragmented pictures of the battlespace. In order to facilitate this visualization, advanced concepts will be developed and integrated in human–computer interface (HCI) technologies, interactive 3D visualization techniques, uncertainty presentations, temporal presentations, natural-language processing, knowledge-base querying technologies, collaborative planning, teleconferencing, shared-map planning, and electronic white boards.

Payoffs. This program will provide the operational commander and his immediate staff in the command center with improved capabilities to perform their crucial functions. In particular, they will be able to (1) more rapidly recognize, understand, and explore the implications of changes in the battlespace; (2) focus their experience, judgment, and training to allow "naturalistic decision making" that directly links perceptions of the battlespace, decision making, and battle management; (3) develop and communicate the commander's estimate and concept of the operation both throughout the command center itself and to those virtually present in the center; (4) project the commander's virtual presence into the battlespace to enhance communication and comprehension; and (5) increase the speed of the C^3I cycle, particularly those activities centered in the command center itself. Overall, the payoffs will be measurable improvement in the speed and quality of C^3I. The development and integration of these technologies will be in conjunction with operational units: USMC-Special-Purpose Marine Air-Ground Task Force (experimental), a Marine Expeditionary Unit (MEU) size force of 3,500; and the U.S. Army 525th MI Brigade (airborne) with a force size of 1,100; and the 18th Airborne Corps with force size of 70,000. This DTO supports DTO M.02, Extending the Littoral Battlespace ACTD.

Challenges. Specific challenges facing this DTO include adapting to changing contexts (e.g., operating environments, missions), organizations (virtual organizations), and different users and modes of use by the same user; protecting against information warfare; assessing and evaluating success in defeating these adversary operations; developing the CPoF to support joint operations while relying on many legacy systems, which at the JTF component level are service specific; developing the ability of the CPoF to work in well-organized coalitions (e.g., NATO, Korea) and less well-structured ad hoc coalitions; and improving C^2 while dealing with potential operational missions—better battlespace visualization, information-enabled organizations, adaptive decision making, agile battle management, and significant increases in force effectiveness and efficiency. Tradeoffs between the need for C^2 processing speed, completeness of information, robustness of system, currency of information, capacity to project future situations, agility and quality of decisionmaking, and battle management will be crucial.

Milestones/Metrics.

FY1998: Complete initial systems engineering and system design of CPoF prototypes; conduct a continuous series of experiments with operational users.

FY1999: Complete development of initial CPoF capability using near-term technology.

FY2000: Report on consolidated design recommendations based on experimental studies.

FY2001: Complete CPoF prototype hardware and software integration and testing.

FY2002: Demonstrate fully integrated CPoF within joint exercise.

Customer POC		Service/Agency POC	USD(A&T) POC
Mr. Garry Barringer	Col Anthony Wood, USMC	Dr. David Gunning	Mr. Iftikhar Jamil
ASC^{2}A/CCT (HQ ACC)	Marine Corps Warfighting Lab	DARPA/ISO	DDR&E(IT)

COL Douglas MacGregor, USA
USA BCBL

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0603760E	CCC-02	3.2	12.0	18.0	22.0	12.0	0
	Total	**3.2**	**12.0**	**18.0**	**22.0**	**12.0**	**0**

IS.48.01 Agent-Based Systems for Warfighter Support

Objectives. Develop control strategies and standards that will support the rapid development of intelligent agents to support the warfighter in collecting information from large-scale, globally based systems. Currently, capabilities such as information on demand, mission planning, and mission execution monitoring require warfighters to specify detailed queries, conduct offline analysis, and manually manipulate data and communications links. Intelligent agents will allow users to delegate tasks using high-level, abstract commands and expect to receive appropriate information products, decision support, and action. The goal is to reduce by a factor of 10 the amount of time warfighters spend manipulating information systems rather than focusing on the mission.

Payoffs. Control strategies will be identified for effective interagent collaboration and efficient use of the communication infrastructure, and standards will be defined for interfacing agents with conventional applications and architectures. By offloading automatable tasks, warfighters will gain critical time for decision making and acting. Intelligent agent technology is cost effective and scaleable because applications are small and inexpensive but can easily be combined to form larger applications. Agents are also robust because they can plan around new problems and negotiate solutions. Agents are taskable because they operate autonomously with known user preferences to achieve goals. Intelligent agents will result in scaleable, low-cost software that significantly enhances warfighter productivity in an information-rich environment. This DTO will provide technology that will support other DTOs such as IS.46.01 and IS.34.01.

Challenges. Technical barriers include lack of (1) models of communication and cooperation to ensure agents collaborate effectively and integrate with existing applications, (2) control strategies to guard against consumptive, dangerous, or chaotic agent behavior, (3) appropriate user interfaces and problem-solving methods to adequately act on the user's behalf, and (4) engineering tradeoffs for cost-effective system development and performance.

Milestones/Metrics.

FY1998: Develop generic control strategies limiting network resource utilization; demonstrate maximum 10% CPU utilization for a robust agent system.

FY1999: Develop generic models of agent collaboration and show 50% cost reduction in new agent system development; demonstrate in Joint Force Air Component Command and Advanced Logistics Program domains.

FY2000: Demonstrate 10-min access to weather, enemy and friendly unit positions and intentions, and threat weapons systems capabilities from the dynamic database and other networked information sources; show that required user interaction is limited to 1 min.

FY2001: Demonstrate appropriate user interfaces and problem solvers. Demonstrate 1,000 constraints on military operations that can be maintained during a 4-hr mission planning and execution period. Demonstrate system robustness as 100 constraints are simultaneously violated by an external event.

FY2002: Demonstrate in a field exercise user-acceptable semiautomated mission planning and near-real-time battle tracking. Demonstrate automatic operations order generation and distribution within 1 min.

Customer POC
Col. Buster McCrabb, USAF
ASC^{2}A

Mr. J. Frank Wattenbarger
USSOCOM/SAOC-DT

Service/Agency POC
Maj Douglas Dyer, USAF
DARPA/ISO

Dr. Northrup Fowler III
AFRL-IFT

USD(A&T) POC
Mr. Marshall Potter
DDR&E(IT)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0603760E	CCC-01	3.0	14.1	16.2	12.8	10.0	0
0603728F	2532	0.1	1.1	0.7	0	0	0
	Total	**3.1**	**15.2**	**16.9**	**12.8**	**10.0**	**0**

IS.49.01 Smart Networked Radio

Objectives. Provide modular building blocks (hardware and software) for the next-generation warfighter tactical radio systems to raise the level of assurance, protection, and transparency in wireless communications and information support services. These building blocks will represent functional upgrades to the multiband, multimode, integrated information transmission system developed under DTO IS.24.01 and will provide increased functionality in the areas of smart adaptivity, advanced wideband waveforms, high-performance and efficient signal and information processing techniques, intelligent link establishment, and adaptive networking. These are to be demonstrated and inserted during spiral acquisition cycles of the next-generation joint tactical radio to realize the payoffs in a timely and cost-effective manner for all services.

Payoffs. The SPEAKeasy approach (IS.24.01) to the next-generation multiband, multimode, software programmable joint tactical radio will be used as a baseline for evolution to an affordable, flexible, interoperable tactical communications system with reduced logistics requirements and much higher communications capability. Expanding on the earlier technology solution, the smart networked radio will add a more carefree (operationally seamless) and protected communications capability to these payoffs through the development and application of advanced wideband waveforms, enhanced signal and information processing, and mobile networking technologies that would enable the radios to automatically sense and adapt to an ever-changing environment (noise/interference, propagation, or networking) and to user demands for service. Higher data throughput, quality of service, and speed of service will be provided through the application of advanced networking protocols.

Challenges. DTO IS.24.01 stressed narrowband legacy communications requirements and developed a solid baseline for further development in several areas. New challenges for the smart networked radio will include (1) knowledge engineering and an artificial intelligence (AI)-based engine for multivariate control, required to convert situation inputs to timely adaptation commands; (2) mechanism(s) within the radio to perform timely link and network environment sensing and assessment, and resource management and control; (3) effective "order-wire" communications and collaborations between network manager(s) and corresponding radio agents; (4) effective and efficient interference/intrusion detection and mitigation techniques and algorithms; (5) high-data-rate, bandwidth-efficient low-probability-of-intercept detection/exploitation and antijam waveforms, with adaptable parameters; (6) wideband, high-data-rate-networked, spread-spectrum waveforms, providing graceful performance degradation via adaptive protocols; and (7) advanced networking protocols, providing high quality of service and speed of service within tactical multinode on-the-move networks.

Milestones/Metrics.

FY1998: Complete evaluations on the application of the AI-based processor, other adaptive transform and filtering techniques, and various reconfigurable and adaptive computing engines to support the design of the smart networked radio. Expected performance metrics include 4–6-dB coding gains and 2 GFLOP processing speed per radio.

FY1999: The Air Force will initiate an ATD on smart networked radio to demonstrate new capabilities and improvements to programmable radios. Enhanced performance capabilities expected to be transitioned from IS.20.01 include three simultaneous wideband channels of 3 Mbps (3 MHz) each in one radio. A new Army wideband waveform should be mature enough by late FY99 for limited network field testing, using multiple copies of the Digital Integrated Laboratory (DIL) wideband radios to be purchased that year.

FY2000: Under the Smart Networked Radio ATD, advanced waveforms and signal processing techniques that have been developed in the in-house AF applied research program on smart radio technol-

ogy will be incrementally integrated into and demonstrated on a SPEAKeasy model, the CECOM DIL wideband radio, or any suitable successor model. A highly bandwidth-efficient, covert, spread-spectrum waveform and some selected adaptive interference excision techniques are first to be demonstrated. Expected performance metrics: variable data rates for spread-spectrum communications between 2 kbps and 2 Mbps and processing gain up to 300 dB; bandwidth efficiency doubled (double the available channels within same bandwidth); average interference mitigation of 20 dB.

FY2001: Demonstrate the ability to reduce the size, weight, power, and co-site interference problems that may occur. Demonstrate smart networked radio capability that senses and adapts to the channel to provide lower power operation, reduced transmission time, and higher capacity. Expected performance metrics: 10-GFLOP processing speed per radio; just-in-time detection and mitigation of nonlinear, nonstationary interference.

FY2002: Demonstrate the ability to roam between different networks (internetworking) and user-friendly operations. Expected performance metrics: error-free handovers across network boundaries; carefree operations with natural man–machine interface to establish link for different services.

FY2003: Demonstrate or participate in field exercises as required. Transition all needed technologies to fielded or developing joint training readiness exercises. Develop improvement plan for smart networked radio and a future technology transition plan.

Customer POC		Service/Agency POC	USD(A&T) POC
Col Buster McCrabb, USAF ASC^{2}A	COL James Schroeder, USA TSM Tactical Radio	Mr. Don Upmal USA CECOM	Mr. Iftikhar Jamil DDR&E(IT)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602702F	4519	1.0	1.7	1.6	1.4	1.5	1.3
0603006A	247	2.7	3.0	0	0	0	0
0603789F	2335	0	0.3	1.4	1.4	1.2	1.4
	Total	**3.7**	**5.0**	**3.0**	**2.8**	**2.7**	**2.7**

IS.50.01 Advanced Cooperative Collection Management

Objectives. Develop and transition technologies that advance the state of the art in collection management by enabling the intelligence, surveillance, and reconnaissance (ISR) confederation to operate in a time-compressed cooperative collection capacity necessary for synergistic collections, time-critical targeting, and dynamic battlefield awareness. Specific technology areas supporting this goal are agent technologies, objective expression, algorithms for planning and scheduling, and performance measurement. In the area of information management, the advanced cooperative collection management (ACCM) program will develop and transition technologies and processes for continuous interactive feedback to the requester on the status of the information need satisfaction; coordination between strategic, operational, and ISR planning; generation of subordinate priorities for support; and computer-aided management of information needs. To support collection strategy development, ACCM will develop and transition technologies and processes to decompose information needs into technical specifications for tasking based on user priorities, conduct performance analysis to determine strategies for maximum military utility for the ISR confederation, develop alternative strategies for tasking and determine the feasibility of these strategies, and compose optimal, timely deployment and execution strategies to include platform trajectories, sensor schedules, and exploitation loading. The program will demonstrate and evaluate ACCM capabilities with airborne sensors (including high-altitude endurance (HAE) UAVs), national technical means, and ground-based assets. The end goal of ACCM is to transition enabling technologies for information management, collection strategy development, and multiasset synchronization initially to DTO A.05, Integrated Collection Management ACTD, and to users of the joint collection management tool.

Payoffs. The ACCM program will benefit the warfighter by tightly integrating the ISR management process for optimal requirements satisfaction and response to real-time or ad hoc information needs. ACCM will considerably shorten the operations planning to information product delivery times by providing automated and semiautomated collection management capabilities in the areas of information management, strategy development, and multiasset synchronization. Together, these capabilities will ensure near-real time information support to the joint forces commander. Current ISR management processes and asset planning systems exist within stove-piped, hierarchical environments that are not capable of supporting the dynamic, time-compressed planning and execution cycles necessary to meet the requirements of *Joint Vision 2010.* Consequently, the ISR management process—from information-need generation to tasking, collection, exploitation, and dissemination—must be tightly integrated into the operational cycles and optimized for requirements. ACCM will achieve the synchronization of operations, collection, and exploitation planning through developing and transitioning the capabilities to synchronize collection, exploitation, and fusion of information to optimally satisfy selected strategies; determine the feasibility of tasking through the continuous coordination with ISR assets; and provide coordination and feedback within a collaborative operations environment. Goals for operational metrics include (1) 100% feedback to information requestors on the probability of collection support, (2) response of ISR systems to information requirements within minutes-to-hours instead of the current hours-to-days, (3) reduction from 3 days (current timeline) to 1 hour for strategy development and coordination of synchronized collections by multiple assets for cross-mission precision geolocation, and (4) increased response to ad hoc requests for ISR support from 20% to 90%.

Challenges. The technical barriers to advanced cooperative collection management are near-real-time information support to the ACCM process (e.g., asset availability and status, information retrieval), dynamic planning, collaborative decision making, reference architecture, human–computer interface, and distributed operations.

Milestones/Metrics.

FY1998: Determine measures of military utility within the joint SEAD scenario.

FY1999: Demonstrate single-asset-to-task multiasset synchronization.

FY2000: Demonstrate and transition initial ISR strategy builder for DIA's Integrated Collection Management (ICM) ACTD (DTO A.05); demonstrate multiasset synchronization necessary for cross-mission SIGINT operations.

FY2001: Transition final strategy builder to ICM ACTD; conduct simulation-driven evaluation of integrated ACCM by operational sponsor.

FY2002: Perform initial operator evaluation of ACCM capabilities in exercise; transition multiasset synchronization capabilities to collection management migration systems; conduct final operator evaluation of ACCM capabilities in exercises.

Customer POC	**Service/Agency POC**	**USD(A&T) POC**
Ms. Marsha Hart	CDR Carol Thompson, USN	Dr. Charles Perkins
DIA	DARPA/ISO	ADUSD(SP)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0603760E	CCC-01	4.6	10.0	10.0	10.0	10.0	0
	Total	**4.6**	**10.0**	**10.0**	**10.0**	**10.0**	**0**

GROUND AND SEA VEHICLES

Defense Technology Objectives
for the Defense Technology Area Plan

Ground and Sea Vehicles

GV.01.06 Future Scout and Cavalry System II-102
GV.02.06 Future Combat Vehicles II-104
GV.03.00 Ground Vehicle Electronic Systems II-106
GV.04.00 Advanced Ground Vehicle Mobility Systems II-108
GV.05.00 Ground Vehicle Chassis and Turret Technologies II-110
GV.06.02 Surface Ship Integrated Topside Concepts II-111
GV.07.02 Surface Ship Advanced Electrical Power System II-112
GV.08.01 Surface Ship Automation II-113
GV.09.02 Submarine Advanced Machinery Support System II-114
GV.10.01 Submarine Signature Control II-115
GV.11.02 Submarine Electric Drive System II-116
GV.12.01 Mission-Reconfigurable Unmanned Undersea Vehicle II-118
GV.13.00 Integrated Hit/Kill Avoidance Optimization II-119
GV.14.00 Reconnaissance, Surveillance, and Targeting Vehicle II-120
GV.15.00 Tactical Mobile Robotics II-122

GV.01.06 Future Scout and Cavalry System

Objectives. Demonstrate the operational potential of a scout vehicle integrating advanced mobility, survivability, lethality, sensor, and C^4I technologies with increased deployability so that three Future Scout and Cavalry Systems (FSCSs) can be transported on a C–17 aircraft. Specifically, this collaborative program with the UK will demonstrate this through virtual prototyping, demonstrator hardware testing, and user field experimentation.

Payoffs. Increased deployability on a C–17 aircraft will provide 50% more deployability for enhanced force projection than that currently attained by the M3A3 Bradley Cavalry Fighting Vehicles. Advanced sensors with an increased target identification range (50% over second-generation FLIR as a baseline) and decreased target detection time (from 90 seconds, based on a manual system with man in the loop, to 20 seconds) provide for enhanced real-time target acquisition, identification, prioritization, and dissemination in day, night, and all-weather conditions, which effectively provides in excess of 50% increase in lethality of force. A reduction of 30% in vehicle signature (based on test results with and without application) results in a reduction in the probability of being detected, acquired, and engaged in all vehicle signatures and an enhanced ability to conduct silent watch (operating vehicle electronic systems with main power shutdown). This effort also provides several other future operational capabilities including enhanced mobility to keep pace with mounted combat troops to facilitate destroying the enemy; protection of the dismounted force using a medium-caliber weapon capable of defeating the primary light armored vehicle threat and secondary threats such as infantry with body armor and defensive structures; and greater survivability through an optimized suite of detection, warning, hit, penetration, and kill avoidance measures.

Challenges. Technical barriers include integration of all capabilities into a configuration constrained by the requirement to fit three FSCSs on a C–17 aircraft (223 inches long by 142 inches high with vehicle target weight of 28.3 tons) at required protection levels; avoiding weight increase during vehicle maturation; development of an integrated target acquisition and sensor suite; data and sensor fusion using FLIR, CCTV, radar, laser, acoustic, and battlefield management information from external sources to synthesize target tracks and acquisitions; development and integration of signature treatments; development and integration of lightweight techniques to defeat kinetic energy and chemical energy threats; development and integration of mobility components such as band track, semiactive suspension, and potential electric drive systems that provide a mobility differential with reduced signature over the supported force and potential threat vehicles; gun system accuracy; gun/weapon station integration; high-speed data communication; and effective soldier–machine interface.

Milestones/Metrics.

FY1998: Design advanced crew stations and develop and allocate FSCS ATD design tradeoffs down to subsystems.

FY1999: Build crew station simulators and initiate a vehicle-level systems integration laboratory.

FY2000: Develop detailed design and begin subsystem fabrication.

FY2001: Complete subsystem fabrication, perform vehicle demonstrator fabrication and integration, and verify increased deployability on a C–17 aircraft (50% more than M3A3); increase target identification range (50% over second-generation FLIR); decrease target detection time (from 90 to 20 sec).

FY2002: User evaluates robust demonstrators to validate improved battlefield performance.

Customer POC	Service/Agency POC	USD(A&T) POC
Mr. Alan Winkenhofer	Dr. Richard McClelland	Dr. Donald Dix
Armor Center DFD	TACOM-TARDEC	DDR&E(AT)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
S&T Funding							
0602601A	H91	2.5	2.4	0	0	0	0
0603005A	440	2.6	24.5	54.6	68.5	6.8	0
0603005A	441	2.8	4.8	3.4	4.8	0	0
0603005A	497	4.5	0	0	0	0	0
Total S&T		**12.4**	**31.7**	**58.0**	**73.3**	**6.8**	**0**
Non-S&T Funding							
0603654A	018	2.0	0	0	0	0	0
Total Non-S&T		**2.0**	**0**	**0**	**0**	**0**	**0**

GV.02.06 Future Combat Vehicles

Objectives. Focus science and technology efforts to demonstrate (in both the virtual and the real world) capabilities for future combat vehicles encompassing Future Infantry Vehicle, Army After Next, and Future Combat System Integrated Concept Teams (ICTs) requirements. Ongoing technology assessments, by capability area, will lead to technology down-selects. The key to the decision process is to define functional requirements, translate these into a virtual prototype advanced concept environment (supported by STO IV.S.05, Virtual Prototype Integrated Infrastructure), then conduct simulations that evaluate the synergistic effect of parametrics and optimum design combinations of lethality, survivability, mobility, electronics, C^2, and other key interfaces. The product of these analyses are potential optimized point designs. The longer term objective is to demonstrate technology product availability and maturity in a system integration lab (SIL), in field experiments and testbeds, and finally in a vehicle that integrates the full range of selected technology products for both technical and user evaluation.

Payoffs. Future combat vehicles will be up to 50%–70% lighter than current vehicle designs with greater payload capability (supported by STO III.G.New03, Lightweight Chassis/Turret Structures) and can be operated by a reduced crew (supported by STO III.G.18p, Advanced Electronics). The vehicle will also be capable of 100% increased cross-country speed, 50% increased acceleration, and 40%–60% increased fuel economy (supported by DTO GV.04.00, Advanced Ground Vehicle Mobility Systems; DARPA Combat Hybrid Power System (CHPS); STO IV.C.01, Integrated High-Performance Turbine Engine Technology). The crew and vehicle will have hemispheric protection against any KE/CE threats (supported by DTO GV.13.00, Integrated Hit/Kill Advoidance Optimization). The future combat vehicles will be capable of line-of-sight lethality up to 5 km and non-line-of-sight lethality out to 10 km (supported by STO IV.I.New03, ETC and EM Armament for Direct Fire, Missiles, and STO III.G.13, Combat Kinetic Energy Missile Technology).

Challenges. The lethality and survivability technology barriers are the specific power, specific energy, and efficiencies that energy storage and electrical-pulse-forming components need to attain to be integratable within the constraints of the combat vehicle. Mobility barriers are the engine volumes, active suspension and transmission components, high-power demands, volume and weight of electrical energy storage components, and efficiency of electrical power conditioning devices. Survivability barriers include the integration of an active protection system providing significant standoff from threats and efficient lightweight armor protection.

Milestones/Metrics.

FY1998: Demonstrate state-of-art combat hybrid power system in SIL environment (DARPA CHPS program

FY1999: Develop energy storage and pulse power components for CHPS (DARPA); SIL demonstration of CHPS (DARPA).

FY2000: Demonstrate advanced components for combat hybrid power system in SIL environment (DARPA CHPS program).

FY2001: Define detailed capabilities and technology goals for future infantry vehicles.

FY2003: Construct virtual prototypes to validate requirements; begin system design, and validate in SIL 25% less crew, 20% increase in fuel economy, and 40% increase in cross-country speed in FY04; continue ongoing SIL validation, and integrate validated technologies into a structure leading to an FY06 demonstration of 50% reduced crew workload, 20% increase in fuel economy, and 100% increase in cross-country speed.

Customer POC	Service/Agency POC	USD(A&T) POC
Mr. Alan Winkenhofer	Dr. Richard McClelland	Dr. Donald Dix
Armor Center DFD	TACOM-TARDEC	DDR&E(AT)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602601A	H91	0	0	0.7	0.7	1.0	3.7
0603005A	440	0	0	0	0.4	1.8	5.5
0602702E	TT-04	6.3	0	0	0	0	0
0603764E	LNW-01	19.2	20.0	5.0	0	0	0
	Total	**25.5**	**20.0**	**5.7**	**1.1**	**2.8**	**9.2**

GV.03.00 Ground Vehicle Electronic Systems

Objectives. Develop the crew interfaces and vehicle electronic architecture technologies that will enable the soldier to take advantage of the data generated on the digitized battlefield. These technologies will support the development of crew interfaces and electronic architectures required to operate and support future ground vehicles, including the Future Scout and Cavalry System (FSCS) ATD and the future combat vehicles, and lead to a seamless interface with the digitized battlefield. These technologies will also support the future combat vehicles integrated demonstration. Future combat vehicles technologies include helmet-mounted displays, head trackers, panoramic displays, cognitive decision aids, load management algorithms, automated route planning, and power management system.

Payoffs. The technologies will yield increased overall crew efficiencies with reduced crew size, increased system performance, and reduced cost ratio of electronics/software upgrades. Lighter combat vehicles with less volumetric crew requirements as well as operation under indirect vision conditions will be a direct result of implementing these technologies. These technologies will allow a 50% increase in overall crew efficiency, a 50% reduction in crew size, a 25% increase in system performance, a 50% reduction in the cost ratio of electronics/software upgrades for system upgrades, a 30% cost reduction per line of source code, and a 10X increase in electronic module performance.

Challenges. Technical barriers include full-up combat operations in closed hatch mode with indirect vision, hands-off control techniques (e.g., voice, expert systems, real-time control systems operating with a commercially based architecture). Also, adaption of commercial-based technologies to military requirements such as packaging requirements for shock, vibration, and EMI is challenging.

Milestones/Metrics.

FY1998: Demonstrate and deliver FSCS conceptual crew station simulator to Ft. Knox; FSCS crew station will demonstrate FSCS man–machine interface requirements. Integrate voice recognition and 3D audio into FSCS crew stations that will contribute to a 25% reduction in crew size and a 25% increase in system performance. Develop indirect vision/mobile crew station testbed. Demonstrate Embedded Map Server and Operating Services API.

FY1999: Demonstrate voice recognition and 3D audio working in mobile crew station testbed, and demonstrate offroad driving using indirect vision at 50% direct vision rate.

FY2000: Demonstrate offroad driving using indirect vision at full direct vision rate; demonstrate embedded FSCS training in the Vetronics System Integration Laboratory (VSIL) that will reduce training requirements by 20%.

FY2002: Reduce task execution timelines by 50%. Develop panoramic displays and integrate into mobile crewstation. Conduct an electric power consumption analysis for future combat vehicles. Upgrade VSIL to integrate high-power components and thermal analysis modeling tools. Complete tradeoff investigation of electronics packaging technologies and finalize approach.

FY2003: Demonstrate workload reduction metric using cognitive decision aids and load management algorithms. Validate future combat vehicles electronic integration via the VSIL. Demonstrate software, backplane architecture, and graphics objects in VSIL.

Customer POC	Service/Agency POC	USD(A&T) POC
Mr. Alan Winkenhofer	Dr. Richard McClelland	Dr. Donald Dix
Armor Center DFD	TACOM-TARDEC	DDR&E(AT)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602601A	H91	1.3	0	0.9	0.8	1.3	1.7
0603005A	497	1.3	7.4	8.7	6.0	6.6	6.6
	Total	**2.6**	**7.4**	**9.6**	**6.8**	**7.9**	**8.3**

GV.04.00 Advanced Ground Vehicle Mobility Systems

Objectives. Develop the most promising emerging technologies that can significantly improve the mobility of future combat vehicles. This DTO focuses on the mobility objectives, which includes power density, ride stability, track life, and track weight. Electric drive transmissions, electrically powered suspensions, track tensioners, band track, and nitrile rubber pads are technologies that provide leap-ahead capabilities that can initially be transitioned to future combat vehicles. Production of the future combat vehicle is planned circa 2015, and this DTO carries on the exploratory development of today's emerging technologies within that timeframe. Compact, high-efficiency engines in the 500–1,000-hp range will not be available commercially. The engine is a long-lead-time item in the development of a future combat vehicle, and this DTO begins the research and development required to deliver an FCS engine in 2015. Both turbine- and diesel-engine technologies will be considered. Suspension technology (electric and hydropneumatic, active and semiactive) is being developed to improve cross-country speed capability and ride quality. Nitrile rubber will be developed that could economically double track life. A track tensioning system that can improve fuel economy will be developed. Initially in this DTO, the advantages of electric drives will be explored through joint demonstration with DARPA and advanced through specific power electronics switch development. Later, electric drive will transition to the Army. In all, a suite of mobility technologies will be developed that can be applied and balanced for a specific vehicle system or concept.

Payoffs. This DTO offers a number of enhanced technologies, including advanced suspension systems that permit greater speed and maneuverability on the battlefield; reduced exposure; rubber band track that reduces noise and enhances stealth operation; reduced vehicle weight; less maintenance; nitrile rubber that improves durability; track tensioning system that provides greater track life; fuel savings from lower rolling resistance; propulsion system with less vehicle weight and volume; reduced fuel consumption; greater power-to-weight ratio for improved mobility; electric drives and power systems that meet demands of future high-energy weapons; and improved acceleration and maneuverability, again contributing to stealth operation.

Challenges. The technology barriers associated with the propulsion system are engine and transmission parameters including specific power, specific fuel consumption, and efficiency of current engines. Critical to the development and optimizing of electric drives is the capability of high-power electronic controls to operate at temperatures significantly higher than at present. Most significant barriers relate to the volume constraints of combat vehicle design. Suspension challenges of achieving the theoretically attainable improvements in cross-country speed are component response time, electric actuator size and weight, and preview sensor algorithm development.

Milestones/Metrics.

FY1998: Complete first generation of control algorithms and linear suspension.

FY1999: Demonstrate high-temperature (350°C) switch control circuitry.

FY2000: Finalize propulsion power density engine concept.

FY2001: Demonstrate SiC-based, 15-kW peak power inverter circuit operation at 400°C; demonstrate 100% increase in track pad life with nitrile rubber at a cost-effective production price.

FY2003: Demonstrate 25% improvement in ride quality with semiactive or active suspension.

Customer POC	Service/Agency POC	USD(A&T) POC
Mr. Alan Winkenhofer	Dr. Richard McClelland	Dr. Donald Dix
Armor Center DFD	TACOM-TARDEC	DDR&E(AT)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602601A	AH91	2.0	2.9	5.4	6.2	5.7	5.7
0603005A	441	0	0	0	0	5.2	11.1
0602705A	H94	0.5	0.5	0.6	0.7	0	0
	Total	**2.5**	**3.4**	**6.0**	**6.9**	**10.9**	**16.8**

GV.05.00 Ground Vehicle Chassis and Turret Technologies

Objectives. Demonstrate, through the Composite Armored Vehicle ATD, reduced vehicle structural and armor weight through the use of lightweight materials (composites) for structural and armor applications in ground combat vehicles as an integrated system with signature technologies incorporated. A goal is to demonstrate the feasibility of a composite structure and advanced armor solution for a 22-ton, air-transportable vehicle weighing at least 33% less than an aluminum-based structure and armor of equal protection. Other goals are to demonstrate manufacturability, repairability, durability, and large section cutout/joining of composites; integrate signature management techniques; and assess the affordability of composite structures for ground combat vehicle applications.

Payoffs. In FY94, the principal payoffs anticipated were 10% to 15% gross vehicle weight (GVW) reduction with integral signature management. In FY96 and FY97, original goals were exceeded. Individual piece parts weight savings ranged from 10% to 50%. This produced an average of 17% GVW reduction that was demonstrated on a 22-ton demonstrator with signatures significantly better than goals. In an actual combat system application, the magnitude of weight savings will make substantial improvements in vehicle deployability, cross-country mobility, reliability, and mission range for fixed combat loads. Conversely, a 7,400-pound (17% of 22-ton GVW) increase in mission capability (crew, fuel, armaments, survivability systems) would be possible for constant system mobility performance through the use of the lightweight materials for structure and armor.

Challenges. The technical barriers are in the manufacture of large thick-section composites and large section joining with complex cutouts, and in the incorporation of armor and signature management into an integrated structure with significant weight reduction. Another barrier is achieving an affordable integrated solution with combined structure, armor, and signature management that is also durable and repairable.

Milestones/Metrics.

FY1998: Demonstrate 6,000-mile durability of an integrated composite structure and armor and signature management techniques; validate 33% reduction in structure and armor weight.

Customer POC	Service/Agency POC	USD(A&T) POC
Mr. Alan Winkenhofer	Dr. Richard McClelland	Dr. Donald Dix
Armor Center DFD	TACOM-TARDEC	DDR&E(AT)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0603005A	440	3.4	0	0	0	0	0
	Total	**3.4**	**0**	**0**	**0**	**0**	**0**

GV.06.02 Surface Ship Integrated Topside Concepts

Objectives. Develop and demonstrate surface ship topside concepts having reduced signatures (specific signature levels are classified) to permit achievement of signature goals for future ships, controlled electromagnetic emissions, and improved sensor performance.

Payoffs. Potential payoffs relative to the notional Flight IIA upgrade to the DDG–51 class destroyers will be a 90% reduction in topside RCS/IR signatures and a 99% reduction in topside electromagnetic interference/emissions. Antenna blockage will be eliminated; this will permit reliable automatic operation of topside antennas.

Challenges. The major technical barriers to achieving the objectives are reliable high-quality, low-cost composite structures for enclosing and embedding antennas; frequency-selective surfaces/panels to achieve acceptable antenna performance while reducing RCS signatures; reliable methods to predict RCS/IR signatures of complex topside configurations taking into account secondary effects; multifunction communication antennas fully embedded in lightweight structures; and IR coating materials having long life in a marine environment. In addition, the added complexity of signature reduction for evolving threats such as HF and millimeter wavelength radars needs to be addressed.

Milestones/Metrics.

FY2000: (1) An enclosed mast/sensor that reduces RCS signature and improves sensor performance, (2) a low-signature multifunctional communication system fully integrated into a composite structure, and (3) a low-RCS/IR signature stack concept with fully integrated SATCOM antennas. Transition the enclosed mast sensor technologies to the LPD–17 design. Demonstrate the at-sea effectiveness of topside concepts that combine shaping, arrangements, antenna concepts, and other control techniques to obtain balanced and greatly reduced RCS/IR signatures.

FY2005: Demonstrate the effectiveness of low-cost, controllable RF/IR/visual coatings for large area coverage in at-sea environments. Transition the technologies developed for the advanced enclosed mast, the low-signature multifunctional communications system, and the low-RCS/IR signature stack concepts to the DD–21, LHX, and CVX platforms.

FY2010: Transition HF resonance control and RF/IR/visual large-area control techniques to future surface ship combatant designs. Demonstrate millimeter-wave signature control technique in an at-sea demonstration. Demonstrate an integrated and configurable virtual ship environment for the signature control engineering of the entire threat EM spectrum.

Customer POC	**Service/Agency POC**	**USD(A&T) POC**
LCDR Chris Cabel, USN	Mr. Jim Gagorik	Dr. Donald Dix
OPNAV N864D2	ONR 334	DDR&E(AT)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602121N		4.1	5.0	5.3	5.4	5.6	5.8
0603508N	R2224	2.1	1.7	0	0	0	0
	Total	**6.2**	**6.7**	**5.3**	**5.4**	**5.6**	**5.8**

GV.07.02 Surface Ship Advanced Electrical Power System

Objectives. Develop the technical basis for clean, quiet, uninterruptible electric power systems for future surface ships such as the SC–21 and CVX. The scope of this effort encompasses advanced power generation and distribution systems incorporating high-power, programmable, solid-state components.

Payoffs. This DTO will result in 100% uninterruptible ship power with a 40% reduction in weight, a 50% reduction in manning, and a 50% reduction in cost while supporting future ship signature and environmental requirements.

Challenges. Power generation efficiency requires breaking the thermal cycle efficiency barrier with fuel cells that can operate on widely available fuels in sufficient power densities for shipboard use. High-power-density power electronic building block (PEBB)-based conversion equipment requires packaging that simultaneously delivers EM compatibility, thermal material matching, and control circuits that can support high switching speeds with low total harmonic distortion. Fault detection and classification algorithms that consistently identify electrical faults in the microsecond timeframe are needed. Nonlinear control algorithms that can predict local and global system stability with incomplete overall system status knowledge must be developed. Networked communications with the bandwidth and reliability to implement intelligent control schemes must be designed to realize overall system implementation.

Milestones/Metrics.

FY2000: Demonstrate a zero emission, diesel-fed fuel cell module having 300% increase in power density and 30% increase in efficiency for ship service power generation. Demonstrate multifunctional PEBB-based shipboard electrical power conversion and auxiliary control equipment with networked intelligence and high bandwidth through switching speeds above 70 kHz; cost (also size and weight) reduced 10X and reliability and current density increased by 10X.

FY2005: Demonstrate an advanced, intelligent, reconfigurable, solid-state-based zonal electric power system architecture that has the capability to reconfigure in less than 10 ms.

FY2010: Demonstrate the viability of a zonal-architecture-based intelligent, reflexive, More Electric Ship concept.

Customer POC	**Service/Agency POC**	**USD(A&T) POC**
LCDR Chris Cabel, USN	Mr. Jim Gagorik	Dr. Donald Dix
OPNAV N864D2	ONR 334	DDR&E(AT)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602121N		3.3	4.3	4.4	4.4	4.5	4.6
0603508N	R2224	10.5	12.0	12.2	13.4	7.3	7.3
	Total	**13.8**	**16.3**	**16.6**	**17.8**	**11.8**	**11.9**

GV.08.01 Surface Ship Automation

Objectives. Develop the technical basis for affordable automation of hull, machinery, electrical, and damage control systems. The initial focus is on automated fire casualty control.

Payoffs. Surface ship automation will provide real-time situational awareness for critical ship-based systems, increase ship reliability and fight-through capability, decrease life-cycle costs, and significantly reduce manning requirements.

Challenges. The major technical barriers to achieving the objective are affordable sensors that are survivable, reliable, and intelligent; fault-tolerant, multifunctional networks; component-level architecture with the ability to recover from network fragmentation; affordable component-level control nodes; data reduction, transfer, and storage methods that will enable rapid transfer of information throughout the ship; validated predictive models of casualty situations; and robust control and actuation algorithms that provide rapid and reliable response.

Milestones/Metrics.

FY2000: Demonstrate automated damage control systems that reduce damage control manning for firefighting by 85%.

FY2005: Demonstrate a multifunctional (environmental conditions; structural, machinery, and personnel performance monitoring), wireless, sensor-based, intracompartment information network.

FY2010: Demonstrate intelligent, automated, reflexive control of all hull, machinery, electrical, and damage control systems for both normal and combat operations.

Customer POC	**Service/Agency POC**	**USD(A&T) POC**
LCDR Chris Cabel, USN	Mr. Jim Gagorik	Dr. Donald Dix
OPNAV N864D2	ONR 334	DDR&E(AT)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602121N		1.1	1.3	1.3	1.3	1.4	1.4
0603508N	R2224	6.0	7.0	7.0	7.0	7.0	7.0
0603792N	R1889	0	4.0	5.5	5.0	0	0
	Total	**7.1**	**12.3**	**13.8**	**13.3**	**8.4**	**8.4**

GV.09.02 Submarine Advanced Machinery Support System

Objectives. (1) Reduce submarine acoustic signature; (2) create integrated modular support systems and mount technology options that significantly reduce the operational acoustic and shock requirements placed upon the supported equipment and machinery; and (3) reduce the life-cycle cost associated with modular support systems, equipment, machinery, and their installation.

Payoffs. The general benefits of this DTO are the reduction of machinery-related acoustic signature, greater use of COTS equipment, improvement of the insertion potential for future electronic equipment and combat system components, and reduction of life-cycle costs. Specific benefits include reduced equipment cost (by 40%) through increased use of COTS equipment, reduced construction costs through modular design and fabrication, increased shock survivability by reduction of equipment accelerations by at least 50%, and significantly improved machinery-related acoustic signature characteristics.

Challenges. Technology challenges include the integration of shock and acoustic requirements into large machinery support structures, extension of Project M mount technology to modular structures, reduction in flanking path and sea-connected system acoustic signatures commensurate with DTO objectives, and development and demonstration of large-scale model systems whose performance can be extended to support full-scale concept development.

Milestones/Metrics.

FY1998: Develop a semiactive shock mount; establish an approach to evaluate performance of shock and acoustic mounts; develop and demonstrate capability to evaluate shock performance of large-scale machinery support structures.

FY1999: Demonstrate performance of semiactive shock mount; demonstrate Project M mount system at ISMS; conduct shock tests on large-scale machinery support structure.

FY2000: Conduct acoustic validation of a shock-capable structure at the Intermediate Scale Measurement System; conduct overboard discharge tests to control noise.

FY2001: Conduct fully destructive testing of the shock-capable structure for concept validation and transition to design community; conduct shock tests of large-scale coated test cylinder; develop control options for vibration in modular support structure.

FY2002: Conduct large-scale tests of hull treatments optimized to control both radiated noise and target strength.

FY2003: Conduct final large-scale integration tests of internal structures, flanking paths, and hull treatments; transition to NAVSEA for engineering development.

Customer POC	**Service/Agency POC**	**USD(A&T) POC**
CAPT James Lyons, USN NAVSEA, 92R	Dr. Richard Vogelsong ONR	Dr. Donald Dix DDR&E(AT)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602121N		1.6	1.4	1.5	1.5	1.6	1.6
0603508N	R2224	2.2	3.3	4.0	4.5	5.0	5.0
0603508N	R2328	5.0	4.9	5.9	0	0	0
	Total	**8.8**	**9.6**	**11.4**	**6.0**	**6.6**	**6.6**

GV.10.01 Submarine Signature Control

Objectives. Develop affordable concepts and technology options to control both acoustic and nonacoustic signatures in order to ensure a stealth advantage for U.S. submarine forces. A balanced and integrated approach to signature vulnerability is required, encompassing acoustic radiated noise, active acoustic target strength, and nonacoustic signatures important in littoral warfare.

Payoffs. The general benefit is maintaining a stealth advantage for U.S. forces as potential threat capability improves and proliferates. Specific benefits include a significant reduction in hull flow and propulsor-related noise; a reduction in design, acquisition, and maintenance cost associated with the propulsor through simplified design; the development of advanced treatments to reduce both acoustic radiated noise and active acoustic target strength; the development of advanced treatments and materials to reduce sonar self-noise; and the reduction of nonacoustic signatures important in littoral warfare.

Challenges. Technology challenges are related to the assessment of critical signature sources. As advancements are made in controlling specific noise sources to reduce the overall signature of submarines, previously unimportant noise sources become critical. An integrated approach must be taken to effectively control submarine acoustic and nonacoustic signatures.

Milestones/Metrics.

FY1998: Complete and document data analysis from the Advanced Vibration Reducer project.

FY2000: Demonstrate acoustic signature control concepts that have reduced weight, volume, and cost impact compared to current acoustic silencing technology and are compatible with shock reduction technology. Demonstrate concepts that control EM signatures to reduce detection and mine vulnerability.

FY2001: Develop pressure hull and nonpressure hull design concepts that provide inherent radiated noise and target strength reduction over conventional design.

FY2002: Develop a hydroacoustic simulation capability to enable reductions in hull flow and propulsor noise and to support reduced design cycle time and testing. Demonstrate a quiet reduced complexity propulsor (NSSN noise goals) at large scale.

FY2003: Develop coating technology to enable design of structural concepts to significantly reduce radiated noise and target strength signatures.

FY2005: Demonstrate multispectral materials for nonacoustic signature reduction. Develop and demonstrate a quarter-scale capability to design pressure hull and nonpressure hull structures for balanced static and shock strength that can provide at least a significant improvement in acoustic signatures over current hull technology.

Customer POC	**Service/Agency POC**	**USD(A&T) POC**
CAPT James Lyons, USN	Dr. Richard Vogelsong	Dr. Donald Dix
NAVSEA, 92R	ONR	DDR&E(AT)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602121N		3.6	3.4	3.6	3.7	3.8	3.9
0603508N	R2224	2.5	0	0	0	0	0
	Total	**6.1**	**3.4**	**3.6**	**3.7**	**3.8**	**3.9**

GV.11.02 Submarine Electric Drive System

Objectives. Develop and demonstrate quieting technologies and acoustic design capabilities for electric main propulsion systems that will enable a significant reduction in radiated noise compared to conventional mechanical drive systems. Application of the capabilities will be demonstrated at an intermediate scale, with emphasis on developing generic technologies to support the investigation of many variants. Enabling technologies that support electric drive, such as power electronic building blocks (PEBBs) and solid-state electrical distribution, will be developed for submarine applications.

Payoffs. The general benefits of submarine electric drive systems over mechanical drive systems are an increased potential to reduce radiated noise, an increased flexibility in machinery space arrangements, a reduction in submarine volume and cost, and an expanded design space for advanced propulsion and maneuvering concepts. The specific payoff from this DTO is the development and demonstration of quieting technology options to enable a significant reduction in propulsor and main propulsion plant signature.

Challenges. Technology challenges in the development of a quiet electric drive system include developing a physics-based understanding of the noise-generation and noise-control mechanisms in electric motors to the degree required to support the acoustic objective; establishing a measurement capability to support acquiring physical understanding of motor noise sources; developing validated electro-acoustic design tools; integrating relevant hydroacoustic, hydrodynamic, and structural acoustic technologies into the design tools; developing motor controllers and bearings that meet acoustic objectives; and developing scaling laws to relate performance demonstrated at intermediate scale with full-scale design concepts.

Milestones/Metrics.

FY1999: Develop design concepts and analysis tools to allow performance evaluations of different quiet electric motor concepts in a cost-effective and timely manner. Develop control techniques for electric motors that incorporate quieting technology.

FY2000: Validate design and analysis tools through small-scale motor experiments. Demonstrate design capability by incorporating quieting technology into small-scale prototype motors.

FY2001: Design and construct multiple intermediate-scale (200–500-hp) motors that incorporate quieting technology developed in this program.

FY2002: In-air demonstration of intermediate-scale electric motors and control systems to validate prediction models. Extend technology developed for main propulsion to other submarine systems, such as secondary propulsion units, main seawater pumps, and external drives or thrusters.

FY2003: In-water demonstration of intermediate-scale electric motors and control systems to validate hydrodynamic and structural acoustic models. Perform final ship impact assessment of electric-drive propulsion system, including motor-quieting techniques developed in this program. Transition design guidance for quiet electric propulsion motors and guidance on integration of electric propulsion motors into submarine main propulsion systems.

Customer POC	Service/Agency POC	USD(A&T) POC
CAPT James Lyons, USN	Dr. Richard Vogelsong	Dr. Donald Dix
NAVSEA, 92R	ONR	DDR&E(AT)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602121N		2.6	2.5	2.6	2.7	2.7	2.8
0603508N	R2224	1.9	3.3	4.0	4.0	6.0	4.0
	Total	**4.5**	**5.8**	**6.6**	**6.7**	**8.7**	**6.8**

GV.12.01 Mission-Reconfigurable Unmanned Undersea Vehicle

Objectives. Develop and demonstrate enabling technologies for a submarine-launched and -recovered, mission-reconfigurable UUV. Specifically, the program will evaluate emerging undersea vehicle technologies by developing a dedicated and reliable UUV technology base in order to generate new ideas and options for a more affordable and capable naval force.

Payoffs. The technical approach includes a thermal propulsion system for long endurance and range, a low-life-cycle-cost rechargeable electric battery, reduced size and weight-integrated motor/propulsor, precision low-speed maneuvering and reduced autopilot life-cycle costs, improved robustness, undersea acoustic communications, covert (passive) precision underwater navigation, and reduced signature.

Challenges. The major technology challenges and barriers for developing an advanced mission-reconfigurable UUV are electrode and cell separator materials for the high-energy density and long-life-cycle electric rechargeable battery; steady-flow, porous-metal combustors with integral heat exchangers for thermal propulsion subsystem reliability; integrated rotor and blade or control surface for motor/propulsor efficiency and noise reduction; adaptation of nonlinear autopilot controller for energetic changing environments; real-time, computationally light algorithms and signal processing for fault tolerance, nontraditional geophysical navigation, and undersea communications; high-data-rate and long-range undersea acoustic communications in a multipath environment; and passive and active signature reduction methodologies.

Milestones/Metrics.

FY1998: Demonstrate the detection and compensation of a UUV fin effector failure by analytical methods.

FY1999: Demonstrate an increase in UUV to host high-frequency underwater communications data rate by a factor of 10X at 2.5 nmi. Perform submarine launch-and-recovery conceptual studies using the two-body unsteady force simulation and visualization model.

FY2000: Demonstrate precision trajectory and stability control of a tactically sized UUV at low speeds (<4 kn).

FY2001: Demonstrate precision covert underwater navigation based on gravity field data; and improved control at low speeds by 2X.

FY2002: Demonstrate an increase in short-range underwater communications data rate by 15X.

FY2003: Increased energy density with an affordable rechargeable battery by 4X and with a thermal wick/Stirling propulsion system by 8X; a 50% decrease in the size and weight of the motor/propulsor; and an increase in mission robustness by 4X.

Customer POC	Service/Agency POC	USD(A&T) POC
CDR Paul Bienhoff, USN	Mr. Daniel Steiger	Dr. Donald Dix
CNO N873	ONR 333	DDR&E(AT)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602633N		7.0	7.0	7.3	7.4	7.7	7.1
	Total	**7.0**	**7.0**	**7.3**	**7.4**	**7.7**	**7.1**

GV.13.00 Integrated Hit/Kill Avoidance Optimization

Objectives. Develop and demonstrate technologies required to enhance the survivability of ground combat vehicles (GCVs) against threats in the 2010+ timeframe. The appropriate mix of these technologies will be balanced for specific applications through tradeoff excursions using applicable survivability optimization models to achieve maximum synergy for a given threat set and scenario. Specific objectives include the development and demonstration of an active protection system (APS) to provide protection against top-attack and tube-launched munitions (KE and CE); demonstration of lightweight armor systems designed to provide vehicles in the 18–40-ton range with protection against the future medium-caliber cannon threat and light- and medium-shaped charge threats, top-attack weapons, and mines; and demonstration of an APS integrated with an appropriate armor configuration for application to the future combat vehicle.

Payoffs. This effort will produce increased GCV crew survivability against current and future battlefield threat munitions, along with increased mobility and transportability through reduced system weight by use of APS and lightweight armor.

Challenges. Technical barriers include integration of individual technologies into a cohesive, supportable, and affordable package for application to GCVs; universal kill mechanism capable of defeating a full spectrum of munitions including KE and CE rounds; precision timing of the proximity fuse used to activate the kill mechanism; development of a cost-effective APS radar; robustness of APS detection/tracking hardware; and space/weight efficiency of potential armor.

Milestones/Metrics.

FY1999: Complete testing of high-density ballistic ceramics.

FY2000: Complete threat versus survivability technology assessment.

FY2001: Demonstrate armor package with 30% reduction in weight against future combat vehicles baselines.

FY2002: Design APS design for ground combat vehicle integration, including sensors, kill mechanism, and delivery technique.

FY2003: Complete design and fabrication of APS kill mechanism for test demonstration.

Customer POC	**Service/Agency POC**	**USD(A&T) POC**
Mr. Alan Winkenhofer	Dr. Richard McClelland	Dr. Donald Dix
Armor Center DFD	TACOM-TARDEC	DDR&E(AT)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602601A	H91	0	0	0.2	0.6	1.2	1.7
0602601A	C05	1.9	2.0	5.5	4.5	0	0
0603005A	221	0	0	0	0	0.5	10.2
	Total	**1.9**	**2.0**	**5.7**	**5.1**	**1.7**	**11.9**

GV.14.00 Reconnaissance, Surveillance, and Targeting Vehicle

Objectives. Develop a vehicle that is V–22 tilt-rotor transportable and incorporates advanced mobility, survivability, RSTA sensors, and C^2 links for sensor-to-shooter capability. The mobility demonstrated will be greater or equal to other vehicles of the Marine Corps ground combat element. The vehicle will be designed and developed with signature-suppressed survivability from the outset, not as an add-on. A fuel-efficient drive train that uses a hybrid-electric drive and power management will be installed for long-range operation and onboard power needs.

Payoffs. V–22 aircraft internal transportability will provide 2X–3X the operational mobility currently attained by vehicle-mounted reconnaissance forces. A hybrid electric drive will provide 1.5X–2X the fuel efficiency and 0.75X the volume needed of current mechanically based propulsion and power systems. Integrated survivability techniques will mitigate electro-optic, visual, and radar cross section signatures for a 50% increase in survivability measured in levels of nondetectability. The hybrid electric propulsion system will significantly reduce acoustic signature (50%) and IR signature (value classified).

Challenges. Technical barriers include integration of all capabilities into a configuration constrained by the requirement to fit and rapidly ingress/egress from the cargo hold of a V–22 (68 inches wide by 66 inches high), development of survivability technology to minimize all signatures in a deployed configuration, maintaining a gross vehicle weight of 8,400 pounds or less, development of a hybrid electric drive and power distribution architecture for management of electric energy without severe weight penalty for energy storage (batteries), and provision of an affordable system design that is acceptable for military adaptation ($105,000–$120,000 average unit rollaway price without sensors and includes baseline passive signature treatment).

Milestones/Metrics.

FY1998: Complete 85% of design; conduct CDR; establish average unit rollaway price for production vehicle (1.2X of HMMWV); verify crew size reduction (25%).

FY1999: Fabricate two demonstration platforms; verify V–22 transportability.

FY2000: Technical testing of completed platforms to verify fuel efficiency (1.5X HMMWV), 10-mile silent movement, visual and IR signature measurements in daylight and one terrain (values classified), line-of-sight communication with EO sensor data (video and data, compared to only data now).

FY2001: Complete technical testing of optimized platforms to verify fuel efficiency (2X HMMWV); 10–15-mile silent movement; visual, radar, and IR signature measurements in two terrains and day/night conditions (values classified); long-range communication with sensor data (over-the-horizon compared to line-of-sight currently). Platform participation in AWE.

FY2002: Robust platforms participate in Marine Corps Capable Warrior AWE and Marine Corps/Navy Extending the Littoral Battlespace ACTD.

Customer POC	Service/Agency POC		USD(A&T) POC
Col Michael Fallon, USMC	Mr. Mike Gallagher	Dr. Art Morrish	Dr. Donald Dix
MCCDC-OSI	MARCORSYSCOM(AWT)	DARPA/TTO	DDR&E(AT)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0603640M	C2223	2.7	2.8	3.0	2.7	2.6	0
0603764E	LNW-01	5.8	9.0	8.0	6.5	3.0	0
	Total	**8.5**	**11.8**	**11.0**	**9.2**	**5.6**	**0**

GV.15.00 Tactical Mobile Robotics

Objectives. Develop advanced mobile robotic technologies, integrate them into systems, and demonstrate them in tactical operations. Perception, autonomy, and locomotion have been identified as the critical technologies. The program objective is to design, develop, and demonstrate a mobile robot with the following capabilities: detection of hazards and targets, estimation of position, creation of topological maps, task-level guidance and control, navigation of complex environments, traversal of rugged terrain, coordinated tactical behavior by a multi-robot team, and locomotion over varying terrain and in advanced forms such as climbing, burrowing, exploiting parasitic attachment, and traveling after an airdrop. To demonstrate the attainment of objectives, two tactical scenarios will be executed: the clearance of a building by dismounted infantry, and special reconnaissance and terminal guidance by special forces.

Payoffs. Achieving these objectives will significantly increase a mission's success-to-risk ratio by reducing personnel involvement in high-mortality-rate tasks, increasing the level of force security, increasing the sensing capability of the warfighter, and enhancing force capabilities. Perception capabilities of the force will be enhanced by the developed technology that will detect hazards and targets regardless of light level, air contaminants, and structural obstacles. Tactical planning capabilities will be increased, and human risk will be significantly decreased, by the development of robot tasking and autonomy technology. Advancements in robotic locomotion will give the tactical mobile robots the capability of performing the varied tasks that will greatly enhance the force's probability of success. Finally, general enhancement of force capabilities include better positioning accuracy both globally and locally, better target tracking capabilities, and better situational awareness leading to heightened force security.

Challenges. Technical barriers include locomotion over rugged urban terrain; locomotion over varying terrain (climbing, burrowing); real-time, on-board multisensor perception and obstacle avoidance; accurate, multisource mapping; accurate indoor navigation over extended periods; task level control; and cooperative multi-robot behavior.

Milestones/Metrics.

FY1998: Demonstrate perception (hazard detection at 10 Hz, 30-m indoor positional accuracy), autonomous navigation (travel 1–10 m per user command), and locomotion (10-cm/s travel, 1-cm rubble, 2-m wall climb) technology breadboards.

FY1999: Demonstrate critical perception (hazard detection at 20 Hz, 10-m indoor positional accuracy), autonomous navigation (travel 10–100 m per user command), and locomotion (50-cm/s travel, 10-cm rubble, 10-m wall climb) technologies. Develop (by a user group) mission requirements for a system demonstration. Establish prioritized set of system demonstrations.

FY2000: Define and test system breadboard/brassboard (average travel at 75 cm/s over hybrid terrain with hazards); integrate technologies into one unit.

FY2001: Demonstrate an integrated tactical mobile robotics system in a user-defined mission (average travel at 1 m/s over hybrid terrain with hazards).

Customer POC	Service/Agency POC	USD(A&T) POC
Maj John Blitch, USAF	Dr. Eric Krotkov	Dr. Donald Dix
SOCOM	DARPA/TTO	DDR&E(AT)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0603764E	LNW-01	12.0	19.6	14.0	7.0	0	0
	Total	**12.0**	**19.6**	**14.0**	**7.0**	**0**	**0**

MATERIALS/PROCESSES

Defense Technology Objectives
for the Defense Technology Area Plan

Materials/Processes

MP.01.01 Laser Eye Protection II-126

MP.02.01 Materials and Processes for Integrated High-Performance Turbine Engine Technology II-128

MP.03.01 Nondestructive Evaluation for System Life II-129

MP.04.01 Materials and Processes for Reentry Vehicle Technology II-131

MP.05.01 Protective Materials for Combatant and Combat Systems Against Conventional Weapons II-132

MP.06.01 Computing and Signal Processing Materials for Use in High- Temperature Shock and Radiation Environments II-133

MP.07.01 Materials and Processes for Corrosion Control and Coatings II-135

MP.07.06 Affordable Sustainment of Aging Aircraft Systems II-137

MP.08.06 Affordable Multimissile Manufacturing ATD II-139

MP.10.06 Interferometric Fiber-Optic Gyroscope Flexible Manufacturing ATD II-140

MP.12.11 Higher Sea State Logistics Support for Expeditionary Forces ATD II-141

MP.13.11 D-Day Fuel Support for Expeditionary Forces ATD II-142

MP.14.11 Wartime Contingencies and Bare Airbase Operations II-143

MP.16.06 Firefighting Capabilities for the Protection of Weapon Systems II-144

MP.17.06 Hazardous and Toxic Waste Treatment/Destruction for DoD Operations II-145

MP.17.11 Airfields and Pavements To Support Force Projection II-147

MP.18.06 Cleanup of Contaminants II-148

MP.18.11 Life-Extension Capabilities for the Navy's Aging Waterfront Infrastructure ATD .. II-150

MP.24.06 Composite Structures for Missile Defense Systems II-152

MP.25.01 Lean Aircraft Production and Sustainment II-153

MP.26.01 Condition-Based Maintenance/Integrity Monitoring II-155

MP.27.01 Materials for Small-Target Detection Capability in High-Clutter Environments II-157

MP.28.01 Enhanced Coastal Trafficability and Sea State Mitigation for Logistics-Over-the-Shore II-158

MP.29.01 Materials and Processes for Integrated High-Payoff Rocket Propulsion Technology II-159

MP.30.01 Sustainable Military Use and Stewardship of the Environment II-160

MP.32.01 Fast, Affordable Product Realization II-161

MP.33.01 Advanced Manufacturing Practices for Affordable Turbine Propulsion II-163

MP.34.01 Composites Affordability Initiative II-165

MP.01.01 Laser Eye Protection

Objectives. Develop materials for laser eye protection from multiple wavelength, multiple power-level laser sources such as rangefinders, illuminators, designators, and dedicated antipersonnel laser weapons.

Payoffs. The technical approach will provide protection for personnel from a larger number of laser threats and will reduce visual performance penalties associated with traditional technologies. The work will use absorbing dyes and dielectric filter technologies for threats in the near-IR region. The work will also extend this protection to visible laser devices without adversely impacting vision. Prior absorbing dye solutions for visible laser protection were not well suited for night operations. Current programs seek to extend the level of protection using alternative materials technologies such as holographic notch filters for visible wavelength rejection. Within the Air Force, two major commands have ranked multiple wavelength laser eye protection in the top 10% of all laboratory efforts in addition to user commands within the Army, Navy and Marines Corps that have endorsed development and demonstration of laser protection as high-priority efforts.

Challenges. The most immediate challenge is to provide protection against traditional laser threats with enough transmission for use in night operations (scotopic luminous transmission >30%). A related challenge is the need to ensure crew station display visibility while selectively eliminating laser radiation operating in spectral proximity (11 nanometers) to the display phosphor emission line. To provide this spectrally selective filtering, it has been necessary to use high-performance reflective filters that if used in conventional ways would not provide adequate protection for exposures greater than approximately 20 degrees off axis. Additionally, it is necessary to develop materials technologies that allow for a timely response to an ever-changing laser threat. Another strongly desired performance characteristic is to keep device haze below 3% to minimize impact on visual performance. Other basic user requirements include environmental durability over an extreme range of conditions, ballistic protection, robust manufacturing capability, optical signature reduction, and reasonable cost.

Milestones/Metrics.

FY1998: Materials technology—demonstrate complete retinal protection, night capability (scotopic luminous transmission, >30%), and display visibility (transmission >25%).

FY1999: Prototypes—night-capable eyewear passes complete MIL-SPEC and ANSI standards. Night-capable eyewear ready for follow-on EMD program.

FY2000: Materials technology—demonstrate rugate and enhanced dielectric filters on lenses capable of supporting ballistics requirements.

FY2002: Prototypes—next-generation laser protective filter technologies available for transition to a variety of tri-service, mission-specific EMD programs.

Customer POC		Service/Agency POC	USD(A&T) POC
CAPT Stuart Ashton, USN NAVAIR PMA202	Maj Robert Wache, USAF HSC/YACP	Dr. George Mueller NRL	Dr. Lewis Sloter DDR&E(AT)
Mr. Robert Sheibley PM ACIS	Ms. Sarah Morgan PM-Soldier	Ms. Pam Schaefer AFRL-MLPJ	
Maj Kenneth Gaskill, USMC MCCDC/Requirements Officer		Mr. Byong Ahn Army NVESD	

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602102F	4348	0.6	0.6	0.6	0	0	0
0602234N		0.4	0.4	0.4	0.4	0.4	0
0603112F	2100	2.3	3.5	4.0	2.4	1.4	0
	Total	**3.3**	**4.5**	**5.0**	**2.8**	**1.8**	**0**

MP.02.01 Materials and Processes for Integrated High-Performance Turbine Engine Technology

Objectives. Develop affordable, low-density, high-strength, high-temperature materials and processing technologies for all classes of future and derivative military gas turbine engines; a critical element in attaining the overall goal of the Integrated High-Performance Turbine Engine Technology (IHPTET) program to double the thrust-to-weight ratio (T/W) of U.S. aircraft turbine engines.

Payoffs. The following capabilities will be achieved: a doubling of range by decreasing fuel consumption in advanced fighters, a doubling of turbine engine thrust-to-weight ratio for increased fighter aircraft maneuverability and payload capacity, and increased fuel efficiency in transport aircraft and cruise missiles. This program will also benefit the technology base for the development of improved propulsion for uninhabited combat air vehicles.

Challenges. Technical barriers include long-life environmental durability at very high temperatures, high-temperature capability with low-density and balanced engineering properties, oxidation resistance at very high temperatures, affordable processing techniques, improved life prediction methodology, and testing capability.

Milestones/Metrics.

FY1999: Provide materials to achieve a 60% increase in T/W of turbine engines with a fuel savings of 30%. Develop and demonstrate orthorhombic Ti matrix composites (TMCs) for 1,400°F applications as bladed rings (blings) with 50% weight savings over Ni-based superalloys. Demonstrate the usefulness of metal matrix composites and gamma TiAl by spin testing a bling containing both materials.

FY2000: Develop materials to support a proof-of-concept demonstrator for the Phase III developments showing an 80% improvement in T/W with a fuel requirement reduction of 35%. Demonstrate advanced (complex architecture) woven preforms and new ceramic matrix composite (CMC) cooling approaches; transition to commercial production of a new fiber. Run a bling-containing orthorhombic TMC and gamma TiAl in a demonstrator engine.

FY2003: Full-up Phase III demo of a 100% improvement in T/W and a 40% fuel savings for turbine engines using new materials that operate at 1,700°F in compressors and at 2,800°F in turbine components. Demonstrate and transition a low-cost, spray-forming process for producing Ni-based superalloy billets for compressor and turbine disks, cases, and rings. Provide the enabling materials for Phase III of IHPTET.

Customer POC		Service/Agency POC	USD(A&T) POC
Mr. David Edmunds F119 Program Office	Col George Monroe, USAF HQ ACC/DRM	Dr. Gil London NAWC	Dr. Lewis Sloter DDR&E(AT)
Mr. Daniel Kunec JSF Program Office	Mr. Olen Sisson APEO (T)	Dr. Daniel Evans AFRL-MLLM	

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602102F	4347	9.6	8.8	7.1	8.2	9.2	0
0602234N		2.5	2.5	2.5	2.5	2.5	2.5
0602712E	MPT-01	1.5	0	0	0	0	0
0603112F	3946	0.1	0	0	0	0	0
	Total	**13.7**	**11.3**	**9.6**	**10.7**	**11.7**	**2.5**

MP.03.01 Nondestructive Evaluation for System Life

Objectives. Develop new and improved nondestructive evaluation/inspection (NDE/NDI) methods and equipment to ensure the safety, reliability, and cost effectiveness of weapon systems.

Payoffs. Development and enhancement of crack and corrosion detection methods are enabling older aircraft systems to continue to operate safely well beyond their original design lifetimes. Development and implementation of current Airframe Structural Integrity Program fleet management tools are entirely dependent on improved NDI methods for crack detection. Higher resolution inspection methods are being developed for enhanced flaw detection. Semiautomated scanning methods with both ultrasonic transducers and multifrequency eddy current probes are enhancing the ability to scan for corrosion damage and for hidden cracks in second layers in transport fuselage structures. This DTO will address the high costs associated with the labor-intensive nature of currently available methods. New digital x-ray technologies are being developed to reduce the hundreds of millions of dollars being expended for x-ray film, processing, and the related hazardous waste stream treatment. The inspection time required for the F/A–18E/F composite horizontal stabilator will be greatly reduced by the development of a new, noncontact thermographic inspection technique. The composite ship mast inspection program will be significantly improved by using noncontact, wide-area microwave inspection methods. Automated inspection is critical to meeting requirements for engine structural integrity and retirement-for-cause programs. Current depot methods cannot meet the demand for future engine designs. Current R&D efforts are addressing multiple issues to bring new technology into these inspection systems. New-technology, single-crack-artifact standards being developed for the inspection systems will reduce the multiple standards ($20,000 each) used at each of the 33 current inspection stations. The new-technology eddy current instruments resulting from lab development efforts will eliminate semiannual calibration costs ($25,000) at each depot and reduce the current replacement spares costs by at least 40%.

Challenges. Technical barriers include the necessity of detecting small cracks and material anomalies in large areas of aging structures with widespread fatigue damage and in rotating components experiencing high-cycle fatigue, the complexity of upgrading older inspection systems, and the difficulty of differentiating corrosion from benign conditions. The onset of widespread fatigue cracking and the very real potential for link-up of the cracks is compromising flight safety in the aging fleet. A new requirement will be for the detection of cracks less than 0.050 inch in second layers and under fastener heads. Quantification of corrosion damage is essential to extend the economic life of the KC–135 and P3C fleets. Fleets groundings due to high-cycle fatigue in rotating turbine engine components have required the development of all new methods for in-service inspection of these components. These methods require the ability to detect volumetric material property changes in components before any measurable cracks are present.

Milestones/Metrics.

FY1998: In-flight demonstration on an F–18 to provide actual systems data for an acoustic emission monitoring system for crack monitoring in a localized area.

FY1999: Measure and compare probability of detection of current- and new-technology crack-artifact standards for enhanced turbine engine disk inspection.

FY2000: High-resolution NDI methods available to differentiate and quantify the types of corrosion. Demonstrate advanced hidden corrosion detection (<10% material thickness loss) methods on transport-type aircraft.

FY2002: Transition to advanced development new detection methodologies for widespread, small (<0.050-in) crack detection.

FY2003: Transition new structural cracking and corrosion detection to Air Force logistics centers and Navy rework facilities.

Customer POC	Service/Agency POC		USD(A&T) POC
Mr. Michael Paulk	Mr. Tobey Cordell	Mr. James Kelly	Dr. Lewis Sloter
MLS-OL/SA-ALC	AFRL-MLLP	ONR	DDR&E(AT)
	Ms. Noreen Cmare-Mascis		
	ARL/VTC		

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602102F	4349	1.3	1.5	1.9	2.9	3.6	0
0602234N		1.0	1.1	1.1	1.2	1.3	1.3
0603112F	3153	2.6	2.8	2.3	1.5	2.0	2.0
	Total	**4.9**	**5.4**	**5.3**	**5.6**	**6.9**	**3.3**

MP.04.01 Materials and Processes for Reentry Vehicle Technology

Objectives. Develop advanced nosetip, heatshield, and antenna window materials and processes for reentry vehicles heat shields since the current material is not available domestically. This program is in support of the Air Force ICBM System Program Office (SPO) Reentry Vehicle Applications Program (RVAP) and Navy SLBM Strategic Systems Program (SSP) Office Reentry Systems Applications Program (RSAP). Both RVAP and RSAP are tasked to maintain their respective service reentry vehicle systems and associated technologies to the year 2020 and beyond. This effort provides advanced nosetip, heatshield, and antenna window materials and processes for RVAP and RSAP evaluation.

Payoffs. The benefit of this effort is (1) the provision of materials and processes technology to support the RVAP and RSAP sustainment of strategic systems at current performance levels, and (2) early materials R&D to enable follow-on systems that are not materials aging limited. The program addresses two issues: the identification of new materials to potentially replace current ICBM and SLBM hardware due to the unavailability of precursor products, and the performance degradation and system-level impacts due to potentially aging materials. The minimum requirement from the ICBM SPO or the SSP Office is to maintain current system performance of the Minuteman III and Trident II systems using replacement materials. System-level impacts would be determined by the ICBM SPO RVAP and SLBM SSP Office RSAP for any aging issues identified and for newly developed materials.

Challenges. The aging mechanism of current materials is not well understood. Current ICBM and SLBM reentry vehicle heatshields cannot be fabricated because the aerospace-grade, continuous-filament-rayon-fiber precursor is no longer domestically produced. Alternative fibers have different ablation characteristics and thermal and mechanical properties that must be investigated and understood in order to properly design the replacement heatshield.

Milestones/Metrics.

FY1998: Moisture-resistant (80% reduction in moisture absorption) replacement antenna windows available for ICBM SPO RVAP evaluation and flight test.

FY2000: Replacement heatshield materials available for ICBM SPO RVAP evaluation and flight test; initial replacement heatshield materials available for SSP Office RSAP evaluation or flight test.

FY2002: Materials aging effects definition and preliminary predictive capability available; follow-on replacement heatshield materials available for SSP Office RSAP evaluation or flight test.

FY2005: Understood and characterized aging and flight phenomenology replacement materials available.

Customer POC	Service/Agency POC	USD(A&T) POC
Dr. Carlos Lopez SPP	Mr. Eric Becker AFRL-MLBC	Dr. Lewis Sloter DDR&E(AT)
Mr. Jim Oldham ICBM SPO	Dr. Mark Opeka NSWCCD	

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602102F	4347	3.7	4.1	3.9	4.1	4.3	0
0602234N		0.9	1.0	1.0	1.0	1.0	1.0
	Total	**4.6**	**5.1**	**4.9**	**5.1**	**5.3**	**1.0**

MP.05.01 Protective Materials for Combatant and Combat Systems Against Conventional Weapons

Objectives. Develop and demonstrate ultralight materials and new armor principles to be incorporated into individual soldier protection gear, face shields, windows, and primary armor for combat systems.

Payoffs. Enhanced protection, mobility and offensive capability will be derived from development of lightweight materials and materials systems for individual combatant protection against the small arms threat. The reduction in individual armor weight represents a 6-pound decrease in a soldier's total load that must be carried into combat and translates into improved mobility and range. Lighter advanced materials and materials systems for armor materials in combat systems will also increase range and performance without sacrificing survivability. Lighter transparent armor for face shields and future armored combat vehicles will provide the same level of protection as current systems. This DTO supports the Military Operations in Urban Terrain JWCO.

Challenges. Primary technical barriers are development of methodologies for producing low-cost, ultralight, and effective armor materials for combatant and combat systems; development of innovative experimental techniques for evaluating and characterizing newly fabricated materials under hostile environments; development of materials model and predictive capability; and optimization of materials fabrication processes for full-scale production.

Milestones/Metrics.

FY1999: Provide materials and material systems for individual combatant protection from small arms threat that are 40% lighter than current systems for body armor and 30% for face shields; establish a new path for body armor with area density of 3-5 psf.

FY2000: Complete feasibility study of fabrication methodologies for four classes of materials: functionally graded materials, nano-crystalline materials, high-modulus and high-strength fibers, and diamond-like ceramics.

FY2001: Complete the development of fabrication processes.

FY2002: Fabricate and characterize selected materials of the four classes of materials including ballistic performance.

Customer POC	Service/Agency POC		USD(A&T) POC
Mr. Phillip Brandler NRDEC	Dr. Steve Wax DARPA/DSO	Mr. Jay Connors ARL	Dr. Lewis Sloter DDR&E(AT)
Dr. James Thompson TARDEC	Dr. S. C. Chou ARL		

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602105A	H84	1.3	1.3	4.0	4.0	4.0	4.0
0602712E	MPT-01	3.1	4.5	5.0	5.0	0	0
	Total	**4.4**	**5.8**	**9.0**	**9.0**	**4.0**	**4.0**

MP.06.01 Computing and Signal Processing Materials for Use in High-Temperature Shock and Radiation Environments

Objectives. Develop materials technologies with sufficient robustness to survive and function in harsh environments at very high operating temperatures or in ionizing radiation with no reduction in performance. This involves the development of (1) silicon carbide (SiC, a wide-bandgap, high-temperature semiconducting material), (2) advanced magnetic memory materials, and (3) thermo-electric thermal management materials. The SiC efforts are being pursued in collaboration with the Sensors, Electronics and Battlefield Environment panel efforts under DTO SE.39.01, Wide-Bandgap Electronic Materials Technology.

Payoffs. The synergistic development of these technologies has high payoff throughout DoD. Critical applications include turbojet engine control systems, missile and torpedo guidance and control, unmanned vehicles, and satellites. SiC will exceed the performance of silicon (which has a maximum operating temperature of 200°C) and can operate up to 600°C. Magnetic film memories offer radiation-hard permanent information storage with no power consumption, and state-of-the-art speed and data density, thereby eliminating mechanical disks or tapes. Thermoelectric materials can provide more than 100°C of active cooling to electronic systems. These technologies will significantly advance the JWCOs of Information Superiority (surveillance, data analysis), Precision Force (guided munitions, surveillance), and Military Operations in Urban Terrain (surveillance, navigation) by providing increased system performance and reliability (projected 5X–10X increase in MTBF), and reduced requirements for maintenance, with a resulting increase in system availability and effectiveness (increased time on station or increased sortie rate or both).

Challenges. The technical challenges include reducing micropipe defects in SiC to less than 5/cm^2, finding a p-type dopant for SiC in device fabrication, developing stable magnetic materials interfaces at elevated temperatures or in the presence of ionizing radiation, controlling oxidation of insulators in spin-tunneling devices, and finding novel ways to insert thin-magnetic-film-based memory into systems.

Milestones/Metrics.

FY1999: Growth of 3-in diameter SiC substrates with micropipe defects less than 50/cm^2. Thermally stable SiC electronics for on-engine controls critical to high-performance turbine engines of the future. Magnetic film memory materials optimized for relative resistance changes of greater than 10%.

FY2000: Thermoelectric figures of merit improved 3X, allowing more than 100°C cooling in three stages or less. Transition 3-in diameter SiC growth technology with centimeter-sized, defect-free areas to production.

FY2001: Complete development of ion-implantation technology for p-type dopant in SiC. Fully functional 4-Mb MRAM (magnetic random access memory) chip.

FY2002: Demonstrate processing techniques for memory cell density improvement of 10X–100X. 3-in diameter SiC substrates with no micropipes; SiC epitaxial layers with a 10X reduction in defects. Demonstrate fully functional 64-Mb MRAM chip.

Customer POC	**Service/Agency POC**	**USD(A&T) POC**
Capt Bruce Anderson, USAF SAF/ST	Dr. Stuart Wolf DARPA/DSO	Dr. Lewis Sloter DDR&E(AT)
Mr. Ron Williams ASC/LPP	Mr. William Woody AFRL-MLP	

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602102F	4348	1.0	1.0	0.8	0	0	0
0602712E	MPT-01	14.7	15.0	21.6	14.0	8.0	0
	Total	**15.7**	**16.0**	**22.4**	**14.0**	**8.0**	**0**

MP.07.01 Materials and Processes for Corrosion Control and Coatings

Objectives. Reduce the substantial maintenance costs associated with corrosion control on DoD equipment while meeting the pollution prevention requirements of Executive Order 12856.

Payoffs. Substantially reduce the $5.5+ billion per year cost to the Navy, Army, and Air Force associated with corrosion control. Payoffs include developing (1) new and environmentally acceptable paints/coatings, metal plating, surface preparation, and cleaning processes that do not rely on hazardous materials to prevent corrosion and fouling of ship and submarine hulls or to prevent corrosion of aircraft, ground vehicles, and weapon systems; (2) environmentally acceptable means to detect, describe, predict, and prevent the many forms of corrosion that degrade materials used on DoD platforms and systems; (3) advanced aircraft extended-life coating capability with a 30–40-year foundation layer and an 8-year topcoat; and (4) extended durability antifouling coatings lasting 5–7 years with only routine cleaning and touchup.

Challenges. Technical barriers include lack of (1) characterization and demonstration of the suitability of current low-volatile organic compound (VOC) paints to meet current military performance criteria; (2) a strong science base describing the interaction of cleaning agents and coatings with new alloys; (3) environmental durability, stain resistance, cleanability, and ultraviolet resistance in gloss/matte coatings with very low organic solvent content; (4) understanding of the mechanisms that corrode ship, submarine, and aircraft alloys and that degrade long-life coatings; (5) an acceptable replacement for hexavalent chromium used as a corrosion inhibitor in coatings and surface treatments and for hard chrome plating operations; and (6) an acceptable replacement for cadmium used as a corrosion-resistant hydrogen barrier coating for landing-gear steels.

Milestones/Metrics.

FY1998: Evaluate the performance of coatings, coating/coating removal processes and surface treatments developed to reduce or eliminate VOCs, hazardous air pollutants, and use of banned substances.

FY1999: Evaluate laser-based cleaning technology and the performance of materials and processes developed as alternatives to hexavalent chrome plating. Evaluate field-extended durability (5–7 years) aircraft coating systems that meet increasing environmental and safety requirements and do not require repainting between depot maintenance intervals. Evaluate fast-drying coating system for ammunition.

FY2003: Demonstrate a long-life (10-year) ship antifouling coating for reduced drag and 35% maintenance cost savings; develop a complete coating system for conventional non-low-observable aircraft as an extended-life system. Demonstrate applique technology for carrier-borne naval aircraft (JSF).

Customer POC	Service/Agency POC		USD(A&T) POC
SMSgt Gregory Stonelake, USA ACC/LGMS	Mr. James Meeker AFRL-MLS	Dr. John Sedriks ONR 332	Dr. Lewis Sloter DDR&E(AT)
Dr. Alex Kaznoff NAVSEA 03M	Mr. Gume Rodriguez AMSRL-WM-MA	Dr. Steven Wax DARPA/DSO	
Mr. Dale Moore NAWCAD 4.3.4			

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602102F	4349	8.4	7.0	6.2	4.5	3.8	0
0602234N		2.0	2.1	2.1	2.2	2.2	2.2
0602712E	MPT-01	4.4	2.4	0.3	0	0	0
0603112F	3153	0.4	0.4	0.6	0.7	0.7	0.9
0603712N	R2206	1.6	1.5	1.0	0.8	0	0
0603716D	P470	0.3	0	0	0	0	0
	Total	**17.1**	**13.4**	**10.2**	**8.2**	**6.7**	**3.1**

MP.07.06 Affordable Sustainment of Aging Aircraft Systems

Objectives. Develop and demonstrate affordable maintenance, repair, overhaul, and remanufacturing technologies and practices to deal with the extraordinary demands imposed by using current aircraft systems far beyond their intended design life.

Payoffs. This DTO will establish industrial base and organic capabilities to support aging aircraft system life extension requirements, reduce life-cycle costs, enhance operational readiness, and advance "lean" concept deployment in repair. Near-term, system-driven needs of the depots and of the private sector repair and overhaul community will be addressed. Technologies nearing completion of laboratory development will be transitioned into user applications. Planned activities will tackle three key ownership cost issues common to each service: inspection and repair of aircraft structure for hidden corrosion and fatigue damage, avionics parts obsolescence, and repairs for aging propulsion systems. Repair cycle time will be attacked in parallel with cost to accelerate returning warfighting assets to service more quickly to offset the negative readiness impact of more frequent repairs required for aging systems. This DTO supports the Joint Readiness and Logistics and Sustainment of Strategic Systems JCWO.

Challenges. Technical barriers to achieving the goal include the lack of (1) quantitative nondestructive inspection (NDI) techniques for detecting and evaluating hidden corrosion and cracks, particularly wide-area damage aspects; (2) affordable, real-time surface inspection capabilities; (3) avionics parts obsolescence management tools and technologies to select and implement the most affordable life-cycle approach; (4) effective techniques for turbine-blade, high-cycle, fatigue-resistance enhancement; and (5) effective techniques for thin-walled blade repair to support propulsion overhaul.

Milestones/Metrics.

FY1998: Transition automated high-pressure waterjet paint-stripping capability to the Oklahoma City ALC, reducing generated hazardous waste by 94% and aircraft structure depaint hours and affiliated flow times by 50%. Expand by 85% current capability to reverse-engineer and produce obsolete avionics microcircuits.

FY1999: Expand reverse-engineering capability to include form, fit, and function emulations for medium- and large-scale integrated circuits. Improve by 25% the probability of detecting aircraft structural damage via low-frequency eddy current inspection.

FY2000: Demonstrate turbine-engine blade overhaul cost reductions with a potential of up to $11 million/yr; establish the capability to repair thin-walled blades. Increase by 25% the availability of selected maintenance systems through condition-based maintenance. Demonstrate the feasibility of reducing overall depot maintenance cycle time by 50% through leveraging best commercial technologies and practices.

FY2001: Demonstrate sharply enhanced NDI techniques for detecting hidden structural corrosion and fatigue damage without having to perform aircraft disassembly.

FY2002: Implement LRIP for digital devices of 100K gate complexity and memories of 256K; increase relative emulation design efficiencies by at least 50% for advanced devices.

FY2003: Implement certifiable high-quality level on advanced emulation microcircuits. Implement LRIP on 300K gate complexity and memories of 512K; increase yield by 20%.

Customer POC		Service/Agency POC	USD(A&T) POC
Mr. Paul Cataldo	Mr. Jerry Yanker	Mr. Steve Linder	Mr. Daniel Cundiff
NAVOP N4	OC-ALC/CD	ONR	DDR&E(LM/TT)

Non-S&T Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0603712S		4.4	5.0	5.5	6.1	6.3	6.5
0708011F		8.0	10.0	12.0	4.0	0	0
0708011N		0.2	0.2	0.2	0	0	0
Total Non-S&T		**12.6**	**15.2**	**17.7**	**10.1**	**6.3**	**6.5**

MP.08.06 Affordable Multimissile Manufacturing ATD

Objectives. Demonstrate advanced missile design and manufacturing enterprise concepts and systems that can reduce the cost of tactical missiles by 25%–50%.

Payoffs. A key concept is the use of flexible multimissile manufacturing as opposed to dedicated production lines for each missile. Benefits for the missile acquisition community include the ability to afford up to twice as many missiles within a fixed budget, faster development cycles to keep up-to-date technology in the field, and a residual base of new competitive capabilities that can respond rapidly to warfighter needs. This DTO supports the Joint Theater Missile Defense JWCO.

Challenges. A key technical barrier is the development of product-line architectures to increase design reuse and parts commonality. Additional challenges are the integration of heterogeneous information systems and processes across missile supply chains and the development and integration of flexible assembly/test systems for multiproduct production.

Milestones/Metrics.

FY1998: Demonstrate multimissile component designs, integrated information systems for missile enterprises (including supply chains), and manufacturing facilities that can meet tri-service needs with a single set of technical and business processes

FY2000: Implement at least two (cost-shared) pilot multimissile factories; demonstrate new production methods; flight test new hardware for at least two missile systems. Results will provide DoD portfolio impact for systems across a full range of complexity from the Advanced Precision Kill Weapon System (APKWS), Joint Standoff Weapon (JSOW), and Brilliant Antitank (BAT) weapon level to systems such as Standard Missile.

FY2001: Transition for implementation across the entire missile portfolio.

Customer POC	**Service/Agency POC**	**USD(A&T) POC**
Mr. Harry Schulte	Mr. Keith Miller	Mr. Daniel Cundiff
AF PEO Tactical Systems	DARPA/DSO	DDR&E(LM/TT)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
S&T Funding							
0603739E	MT-08	24.2	25.2	22.0	0	0	0
Total S&T		**24.2**	**25.2**	**22.0**	**0**	**0**	**0**
Non-S&T Funding							
Industry		25.0	33.0	25.0	0	0	0
Total Non-S&T		**25.0**	**33.0**	**25.0**	**0**	**0**	**0**

MP.10.06 Interferometric Fiber-Optic Gyroscope Flexible Manufacturing ATD

Objectives. Reduce the cost of interferometric fiber-optic gyroscopes (IFOGs) by improving production processes and the design of IFOG and its components.

Payoffs. The emphasis is on design and manufacturing flexibility to make low-volume defense components comparable in cost to high-volume commercial production, with cost goals a factor of 10 lower than current military IFOGs and ring laser gyroscopes. The tactical grade IFOG manufacturing effort, which began in September 1993, will be competed in FY98 and has already demonstrated cost reductions from $6,000/axis to $750/axis. Commercial spinoff has occurred in areas such as thermoelectric coolers, fiber-optic alignment stages, optical couplers, and fiber-optic alignment detector electronics. Tactical-grade IFOGs will be inserted in missiles such as Advanced Medium-Range Air-to-Air Missile (AMRAAM) Lots 8 and 9 for cost and performance improvement. Navigation-grade IFOGs will be inserted in next-generation, low-cost precision navigation programs, such as the GPS Guidance Package Program, to meet warfighter needs for affordable smart weapons that can maintain precision navigation during GPS blackouts. The navigation grade program, which began in 1995, will leave in place a residual base of manufacturing capability to meet the production goal of low-cost ($15,000) precision navigation systems. Progress toward these goals was demonstrated by several brassboard builds that took advantage of significant manufacturing improvements at both the system house and the component supplier level. This DTO supports the Precision Force JWCO.

Challenges. Technical barriers include labor-intensive manufacturing steps such as fiber-winding, optical interconnections, and testing; providing affordable optical sources; lowering fiber production costs and providing low-cost environmentally robust packaging; and integrating manufacturing systems to provide a flexible, multiple-grade integrated process/production line for tactical- and navigation-grade IFOGs.

Milestones/Metrics.

FY1998: Demonstrate from the same production line flexible fabrication of navigation-grade (<0.01 deg/hr) and military tactical-grade (0.1–1.0 deg/hr) IFOGs as lower performing commercial IFOGs. Meet a demonstrable cost goal of <$5,000/triax or <$1,500 per gyro (~75% cost reduction) at the navigation-grade performance level. (This is the last year of a 5-year effort.)

Customer POC		Service/Agency POC	USD(A&T) POC
Mr. Greg Makrakis	Mr. Tim Summers	Lt Col Beth Kaspar, USAF	Mr. Daniel Cundiff
PMA-209	Army PEO-TM	DARPA/DSO	DDR&E(LM/TT)

LTC Craig Naudain, USA
BFVS

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0603739E	MT-08	4.9	0	0	0	0	0
	Total	**4.9**	**0**	**0**	**0**	**0**	**0**

MP.12.11 Higher Sea State Logistics Support for Expeditionary Forces ATD

Objectives. Demonstrate an advanced cargo beaching lighter (ACBL) for ship-to-shore cargo movement in higher sea states. The ACBL will support the combat operations of all military services. Lighters are large, open barges used in loading and unloading larger ships (e.g., container vessels) wherever shallow waters prevent them from coming to the shore. Lighter operations are highly weather, surf, and sea state dependent.

Payoffs. This program will provide advanced connection technologies that will allow safe, quick coupling within the complete sea state 3 range for the basic ACBL modules that make up a lighter. Only two connections have to be made to build the ACBL, whereas the present lighterage asset needs eight connections, all made in the water. Once connected, ACBL modular components will permit elastic configuration options (e.g., larger platforms, ferries) all survivable in sea state 5. The present pontoon and lighterage system's performance rapidly degrades in sea state 2. Without adequate port facilities, power projection requires that Joint Logistics Over the Shore (JLOTS) be able to quickly move large quantities of bulk cargo and fuels from amphibious/sealift ships to the shore in support of landing forces. Doctrine (Joint Pub 4-01.6) requires operational capability in wind and wave conditions through sea state 3. Analysis of sea state patterns in projected conflict scenarios, such as in the Far East, indicates that sea state 3 conditions occur up to 50% of the time. Connecting pontoons to make up various configuration options (e.g., larger platforms, ferries) in anything but sea state 1 is unsafe. This DTO is intended to provide affordable solutions to support combatants and amphibious/sealift ships power projection. Requirements for achieving improved near-term and far-term logistics capability is documented in the Navy's 1997 S&T Requirements Guidance. This DTO supports the Joint Readiness and Logistics and Sustainment of Strategic Systems and the Force Projection/Dominant Maneuver JWCOs.

Challenges. Specific technical barriers include wave-induced motion simulation of modules floating in proximity to one another; rapid, reliable connection systems with relative motion compensation and large force attenuation; load testing and modeling simulations via virtual prototyping; shallow-water environment coupled with anchor soil dynamics; and berthing motions and numeric model predictions with wave overtopping scenarios.

Milestones/Metrics.

FY1999: Demonstrate assembly and connection in open seas of ACBL for the advanced modular causeway lighterage, increasing cargo throughput by 300%. Transition concepts to Joint Modular Lighterage System (JMLS) ACTD (F.20), which is under the program management of a joint Army–Navy IPT.

FY2000: Transition dynamic anchoring development and mooring system hardware installation techniques to JMLS ACTD. This milestone completes the demonstration effort initiated under exploratory development in FY94. Technology goes into a joint buy for the Army and Navy in 2002.

Customer POC	Service/Agency POC	USD(A&T) POC
CDR M. Huntzinger, USN	Mr. Andy Del Collo	Mr. Robert Boyd
CO ACB 1	NAVFAC 15R	DDR&E(ELS)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602121N		0.5	0.4	0.3	0	0	0
0603712N	R1910	1.5	0	0	0	0	0
	Total	**2.0**	**0.4**	**0.3**	**0**	**0**	**0**

MP.13.11 D-Day Fuel Support for Expeditionary Forces ATD

Objectives. Demonstrate the capability to efficiently deliver 100,000 gallons of fuel per day from ship to shore in assault operations (D-day to D+5) from standoff distances of up to 200 nmi. This ATD will validate the use of cost-effective, lightweight, high-strength, collapsible fuel bladders meeting rugged handling and load requirements via landing craft air cushion (LCAC) delivery.

Payoffs. This project will provide an assault echelon fuel transfer capability that is compatible with amphibious (L-class) shipping and LCAC operations. LCAC sorties will be reduced from the present planned 19 roundtrips with hard shell fuel containers to 7 sorties, releasing LCAC assets to move other critical supplies. Present ship-to-shore fuel transfer capabilities such as the Amphibious Assault Bulk Fuel System (AABFS) and the Offshore Petroleum Discharge System (OPDS) will not arrive on site in the first 5 to 20 days. In any case, adequate fuel cannot be provided ashore during the assault echelon due to the retirement of the LST. Further, the AABFS and OPDS cannot be installed in sea state 3 conditions. For future operational tempos, the AABFS and OPDS cannot support the emerging operational-maneuver-from-the-sea operations due to limited standoff distance (4 miles) capability. The urgency of achieving improved near- and far-term logistics capability is expressed in the Marine Corps Warfighter Imperatives identified in the Expeditionary Warfare Roundtable and in the Navy's 1997 S&T Requirements Guidance. The fuel bladder will transition to procurement via the Amphibious Tactical Support Project. This DTO supports Joint Readiness and Logistics and Sustainment of Strategic Systems and Force Projection/Dominant Maneuver JWCOs.

Challenges. Technical barriers include applying combined simultaneous spiral and helical weaving technology to high-strength bladders; thin membrane performance modeling; composite structural analysis; materials properties, shelf life, fatigue testing, and abrasion-resistant-oriented fibers; and surge suppression and explosion effects modeling.

Milestones/Metrics.

FY1998: Demonstrate feasibility of constructing a 50-in diameter seamless 3D woven sleeve with replaceable liner (100-gal-capacity/ft length) with a 50-psi burst strength low-elasticity bladder (5:1 safety factor).

FY1999: Demonstrate a 5X cost-effective, lightweight, high-strength, collapsible, continuous-spiral-woven, fuel-bladder prototype meeting pressure and dynamic load requirements of up to 2.2 g for LCAC delivery from 25 miles offshore within the 30-min load/offload LCAC cycles. This is the last year of a 3-yr ATD effort.

Customer POC	Service/Agency POC	USD(A&T) POC
CDR Kenneth Butryn, USN	Mr. Andy Del Collo	Mr. Robert Boyd
OPNAV N853	NAVFAC 15R	DDR&E (ELS)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0603712N	R1910	1.2	0.8	0	0	0	0
	Total	**1.2**	**0.8**	**0**	**0**	**0**	**0**

MP.14.11 Wartime Contingencies and Bare Airbase Operations

Objectives. Demonstrate technologies for wartime contingencies and modernization of bare base infrastructure, including airmobile shelters and utility systems, to reduce airlift, response time, workforce, and cost for execution of air expeditionary force operations. This DTO supports establishment, operation, and recovery of mission-critical functions on mobile airbases that directly influence DoD global reach capabilities.

Payoffs. A 35% reduction in airlift requirements for a 1,100-man bare base represents a 20:1 dollar return on investment for deployment and an 8:1 dollar return for sustainment. Using innovative geometric designs and lightweight high-performance composites, new airmobile shelter systems that reduce weight, thermal losses, costs, and setup time will be developed. Large high-pressure air beams and advanced air-inflatable shelters will be developed. The program will also develop mobile heat pumps based on acoustic cycle technology to reduce weight and volume and to increase efficiencies. New technologies will advance waste disposal systems. Reduced logistics needs for bare base operations will greatly enhance the mobile warfighting capability and reduce costs for contingency operations. This DTO supports the Joint Readiness and Logistics and Sustainment of Strategic Systems and Force Projection/Dominant Maneuver JWCOs.

Challenges. Technical barriers for shelters include development of large high-pressure air beams, inflatable shelter materials, and self-erecting inflatable concepts. The major technical barrier for the mobile heat pump is the design of heat exchangers for optimizing the acoustic pulse-tube cycle, eliminating the need for conventional evaporators and condensers. Additional barriers include volume/weight reduction of plasma arc waste disposal systems.

Milestones/Metrics.

FY1998: Construct a pulse-cycle mobile heat pump unit that reduces weight and volume by 40% over current units.

FY1999: Design and initiate fabrication of a large advanced air-inflatable shelter that reduces weight and volume by 50% and takes 30% less time to assemble over existing shelters.

FY2000: Complete fabrication and demonstrate advanced air-beam frames for large shelters that reduce weight and volume by 50% and costs by 20%. Demonstrate lightweight heat pump that reduces weight and volume by 40% and increases efficiency by 30%.

FY2001: Demonstrate new plasma arc waste disposal systems that reduce waste volume by 50%.

FY2002: Demonstrate advanced air-inflatable shelters that decrease setup time and thermal losses by 50%.

Customer POC	**Service/Agency POC**	**USD(A&T) POC**
Mr. Joe Fisher	Mr. Jon Porter	Mr. Robert Boyd
HQ ACC/CEXX	AFRL-MLQC	DDR&E(ELS)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602201F	4397	0.3	0.7	1.2	1.0	0.5	1.3
0603205F	4398	0.8	1.2	0.7	0.6	0.5	0.3
	Total	**1.1**	**1.9**	**1.9**	**1.6**	**1.0**	**1.6**

MP.16.06 Firefighting Capabilities for the Protection of Weapon Systems

Objectives. Develop and demonstrate technologies that will provide a mobile, semiautonomous aircraft rescue and firefighting (ARFF) vehicle system with enhanced fire suppression mitigation and improved functional and emergency-response capabilities. Specifically, this DTO will integrate robotic operational features, voice recognition system activation, computer-controlled high-performance suspension, and all-weather response capabilities within a mobile firefighting unit.

Payoffs. This DTO program will significantly reduce fire injuries, fire casualties, and weapon system damage and will reduce labor-intensive aircraft firefighting operations. It will deliver a new generation of high-performance suspension systems for vehicle rollover prevention, unimproved surface traversing capabilities, and computer-controlled fluid leveling. This program will result in the integration of FLIR for all-weather fire scene response, global positioning and accountability of assets for enhanced fire ground management, voice-activated system controls, and an emergency data access heads-up display reducing operator functions by 25%. These technologies will be transitioned to the Air Base Systems Program Office for EMD and acquisition strategy development. This DTO supports all military services' crash rescue operations and the Joint Readiness and Logistics and Sustainment of Strategic Systems and Combating Terrorism JWCOs.

Challenges. Technical barriers include integration and synchronization of robotic, FLIR, and firefighting system activation; maintaining ARFF vehicle footprint and axle weight differentials to prevent rollover; and voice recognition for acquisition.

Milestones/Metrics.

FY1999: Demonstrate high-performance suspension system with 50% capability enhancement.

FY2001: Demonstrate all-weather response capability with 90% accuracy.

FY2002: Refine all weather response capability to 100% accuracy.

FY2003: Demonstrate self-contained semiautonomous ARFF vehicle. Reduce operator functions by 25%.

Customer POC	Service/Agency POC	USD(A&T) POC
Mr. Joe Fisher	Mr. George Hall	Mr. Robert Boyd
HQ ACC/CEXX	WL/FIVC	DDR&E(ELS)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602201F	4397	0.1	0.7	0.8	0.6	0.5	1.2
0603205F	4398	0.4	0.6	0.6	0.6	0.5	0
	Total	**0.5**	**1.3**	**1.4**	**1.2**	**1.0**	**1.2**

MP.17.06 Hazardous and Toxic Waste Treatment/Destruction for DoD Operations

Objectives. Develop, demonstrate, and implement technologies and predictive models to reduce difficult-to-destroy wastes from DoD operations.

Payoffs. Processes to significantly decrease or completely destroy waste propellants, explosives, and pyrotechnics (PEP), nitrous oxides (NOx), volatile organic compounds (VOCs), and metallics will greatly reduce DoD's mission constraints at logistics centers and industrial operations commands due to environmental laws. Operations and maintenance of weapon systems and installations will be more effective and cost less, throughout DoD, ultimately improving training, testing, maintenance, and deployment. Innovative air-quality controls and decision tools, in design, will enable DoD to avoid $250 million annually. Production capabilities will be maintained and compliance costs reduced 20%–30% ($307 million in 1995), using solid- and liquid-waste treatment/destruction technologies. Other improved waste-handling technologies could reduce annual hazardous VOC and heavy-metal disposal costs up to 50% ($75 million in FY95).

Challenges. Technical challenges include handling unstable, highly energetic materials and destroying or converting waste/contaminants without producing unwanted toxic byproducts. Also, DoD must develop lower cost, energy-efficient chemical and physical separators for unique and often complex waste streams; optimize processes to handle variable-concentration waste streams; and destroy unique, recalcitrant wastes derived from military operations.

Milestones/Metrics.

FY1998: Confirm that regenerative sorbents can feasibly and cost effectively reduce NOx/VOC emissions from jet engine test cells, aerospace ground equipment, and stationary sources by 90%; demonstrate that hydrothermal oxidation destroys heavy metals and liquid and solid wastes.

FY1999: Prove that advanced catalysis will cost effectively reduce NOx emissions from jet aircraft by a measurable amount; show that aircraft paint processes, designed to decrease VOC and particulate emissions by 80% (using recirculation, concentration, and biofiltration), are highly cost effective.

FY2000: Develop and refine risk-based atmospheric emission decision tools to improve space launch vehicle availability by 50%; demonstrate that reductive electrochemical treatment and advanced chemical reactors can destroy volatile organics and metals; use predictive models and decision tools to improve DoD material selection, use, and disposal, as driven by emerging environmental regulations.

FY2001: Advance biotechnology to treat wastes from the manufacture and disposal of PEP and complex hazardous wastes.

FY2002: Demonstrate advanced technology to cost effectively remove mercury emissions from flue gases. Characterize VOC emissions from highly volatile aircraft paint products; characterize the components of particulate matter exceeding size limitations of air-quality laws. Refine NOx and carbon monoxide control technology for AF industrial processes in "critical ozone nonattainment areas." Develop control methods to control particulate matter that violates size limitations of air-quality laws.

Customer POC		Service/Agency POC	USD(A&T) POC
Mr. George Carlisle DAIM-ED-C	Dr. Frank Stone CNO N45G	Mr. Gary Schanche CERL	Mr. Robert Boyd DDR&E(ELS)
Mr. Les Keffer USAF/ILEV		Lt Col Allan Weiner, USAF AFRL-MLQE	

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602202F	1900	2.2	2.8	2.9	1.1	1.8	0
0602720A	048	0.8	1.2	1.1	1.1	0	0
0603716D	P470	0.9	0	0	0	0	0
0603780A	852	0	1.1	0.3	0.3	0	0
0603723F	2103	1.1	1.3	2.2	1.4	2.5	0
	Total	**5.0**	**6.4**	**6.5**	**3.9**	**4.3**	**0**

MP.17.11 Airfields and Pavements To Support Force Projection

Objectives. Enhance force strategic deployment from CONUS and operational employment in theater of operation (TO) by providing improved reliable airfields and pavements.

Payoffs. The program will increase reliability of airfields and pavements to support current generation of military and civilian reserve air fleet aircraft and vehicles through the use of local materials, which may be of inferior quality, and pavement binder modifications, resulting in a 10% reduction in construction and maintenance cost. Construction effort will be decreased by 10% for expedient surfaces in TO for military aircraft and vehicles. The project will also provide reliable airfields and pavements to support multiple passes of proposed future-generation aircraft. The results of the research will increase the functional life of airfields and pavements by 10 years, resulting in a 20% reduction in maintenance costs and a 10% reduction in construction costs. The technologies will be transitioned to the user community by incorporating the computer programs into existing design programs through technical reports, recommendations for input into FM15-430-002, "Planning and Design of Roads, Airfields, and Heliports," and construction guide specifications. This DTO supports military contingency site operations and the Joint Readiness and Logistics and Sustainment of Strategic Systems and Force Projection/Dominant Maneuver JWCOs.

Challenges. New technologies are required for material characterization, specifically in nonlinear visco-elastic and visco-plastic behavior and how that behavior affects airfield and pavement performance. Technical barriers include understanding of multiple tire interaction, dynamic loading, and linear and nonlinear material response to those loadings. Specific aircraft that can damage airfields include C–141, C–17, and the proposed million-pound aircraft. Vertical-/short-takeoff and -landing aircraft also pose a significant problem. In general, aircraft loads will continue to increase, but the landing gear for proposed cargo aircraft will remain similar to the Boeing 777 configuration. Larger landing gear is not desirable because it consumes too much of the cargo space. Therefore, the load per tire and tire pressures will continue to increase, resulting in the need for airfields with an increased load-carrying capability.

Milestones/Metrics.

FY1998: Provide reliable airfields and pavements to support current generation of military and civilian reserve air fleet aircraft and vehicles.

FY1999: Provide construction, design, and repair systems to decrease construction effort by 10% for expedient surfaces in TO for military aircraft and vehicles.

FY2002: Provide reliable airfields and pavements to support multiple passes of proposed future-generation aircraft reducing maintenance costs 20% and construction costs 10%.

Customer POC		Service/Agency POC	USD(A&T) POC
Mr. Jim Greene	Mr. Stan Nickell	Dr. Lewis E. Link	Mr. Robert Boyd
AFCESA/ENC	DAIM-FDF-B	CERD-ZA	DDR&E(ELS)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602784A	T40	1.4	1.6	1.2	1.3	1.3	0
0602784A	T42	0.5	0.4	0.4	0.4	0.4	0
0602201F	4397	0.1	0	0	0	0	0
	Total	**2.0**	**2.0**	**1.6**	**1.7**	**1.7**	**0**

MP.18.06 Cleanup of Contaminants

Objectives. Develop a suite of technically effective and affordable technologies to clean up a variety of chemically contaminated DoD sites.

Payoffs. This program reduces the DoD cost of contaminant cleanup by as much as $10 billion over the FYDP. Development focuses on technologies to characterize and treat explosives/energetics, heavy metals, and dense nonaqueous phase liquid (DNAPL)-contaminated soils and groundwater. DoD sites currently number about 21,000, with projected cleanup costs of $30–$35 billion. High-payoff technologies include the DoD framework for environmental risk assessment, onsite risk contaminant fate prediction models, advanced sensors and samplers, and valid guidance on novel remediation processes for chlorinated solvent cleanup, DNAPLs, and surface/subsurface unexploded ordnance. Lastly, advanced extraction and treatment process will cut lead removal costs from $100–$300/ton to $50–$150/ton.

Challenges. Technical barriers include the multitude of differing geographic sites (soil, water, and climate) across DoD land; the large number, varying concentrations, state of mixing, and yet unmapped contaminants encountered at military-unique cleanup sites; the inherent complexity of biological, chemical, and physical phenomena and technologies; and the rapidly changing regulations with which to respond.

Milestones/Metrics.

FY1998: Develop processes to enhance efficacy and decrease cost by 50% include advanced sensors and samplers for onsite, real-time detection and long-term monitoring; ex situ bioremediation for explosives and energetics; and written guidance on cost-effective in situ biological cleanup.

FY1999: Validate protocols for enhanced in situ biotreatment of chlorinated solvents, and rapid detection and in situ treatment of DNAPLs. Metrics are treatment availability. The risk assessment framework reduces cleanup design costs by 20%.

FY2000: Design multisensor, multispectral array for 35% less costly remote detection of surface/subsurface unexploded ordnance.

FY2001: Design, fate, and transport models/simulators that reduce design costs by 30%, integrating earth media, providing rapid contaminant fate predictions, and assessing on-site risks; an in situ extraction/treatment process for lead that gets below existing structures.

FY2002: Increased efficacy and flexibility of advanced groundwater remediation for TNT and other energetics, cutting overall costs to $0.10–$2.00/kgal.

Customer POC	Service/Agency POC	USD(A&T) POC
Mr. George Carlisle DAIM-ED-C	Dr. M. J. Cullinane CEWES	Mr. Robert Boyd DDR&E(ELS)
Mr. Marty Faille AFCEE	Ms. Catherine Vogel AFRL-MLQE	

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602202F	1900	2.1	1.0	0.2	0	0	0
0602720A	835	0	0.9	1.0	1.1	1.1	0
0602720A	F25	0	3.0	3.1	3.2	3.4	0
0603716D	P470	11.7	0	0	0	0	0
0603780A	852	0	10.2	10.0	10.0	0	0
0603723F	2103	1.5	1.4	1.0	0	0	0
	Total	**15.3**	**16.5**	**15.3**	**14.3**	**4.5**	**0**

MP.18.11 Life-Extension Capabilities for the Navy's Aging Waterfront Infrastructure ATD

Objectives. Demonstrate extended useful life and reduced recurring maintenance costs of waterfront structures required for berthing, resupply, maintenance, and overhauling naval combatants.

Payoffs. New upgrade concepts will use composite materials to increase structural vertical and lateral strength, and a corrosion arrestment system will avert continued deterioration of reinforced concrete exposed to harsh marine conditions. Corrosion arrestment mated to the composite upgrades will stabilize further deterioration of reinforced concrete. New repair methodologies will increase pier repair durability for previous rehab spots from 3 to 15 years. Costs have driven maintenance and overhaul of naval vessels from the drydock to the pierside work. With 75% of the Navy's piers more than 40 years old and with increasing deterioration due to age, these piers cannot safely accept large mobile crane loads in conducting pierside maintenance and overhaul. The options are to either build a new structure at an average cost of $30 million or incorporate pier upgrade alternatives costing about $5 million for a typical pier. Requirements for developing system designs and techniques for reducing life-cycle costs are expressed by CNO Affordability Initiatives and documented in Navy's S&T Requirements Guidance. This DTO supports all military tri-services logistics requirements and the Joint Readiness and Logistics JWCO.

Challenges. Technical barriers include modeling of pseudo-ductile load response of composite fiber sheet upgrade components and concrete; modeling polymer matrix/fiber interface behavior and slip; stabilizing concrete substrate deterioration by galvanic cells activated by prior repair work; achieving adhesion and bond strengths between dissimilar surfaces; maintaining corrosion stabilization of steel reinforcement; and determining bio-effects for composite structural members.

Milestones/Metrics.

FY1998: Demonstrate the feasibility of using composite carbon-fiber structural upgrades to uniformly increase pier load capacity by 40% in supporting 100,000-lb-load mobile cranes in Norfolk for piers 10–12 years in age. Demonstrate 5X vertical improvement for 50-year old San Diego piers constructed with under-reinforcing steel typical of older design practices at 20% of the cost of demolishing and replacing with a new structure.

FY1999: Demonstrate sacrificial titanium-sprayed corrosion arrestment techniques to extend the service life of reinforced concrete waterfront facilities by 20–30 years; demonstrate composite upgrade at 50-year old Pearl Harbor wharf.

FY2000: Verify continued structural improvements and upgrade integrity at each of the three sites. This milestone completes a 5-year effort that transitions to the Real Property Maintenance Program.

Customer POC	Service/Agency POC	USD(A&T) POC
CAPT T. Corbette, USN	Mr. Andy Del Collo	Mr. Robert Boyd
CO PWC San Diego	NAVFAC 15R	DDR&E(ELS)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
S&T Funding							
0602121N		0.4	0.4	0.2	0	0	0
0602234N		0.4	0.4	0	0	0	0
0603712N	R1910	0.8	0	0	0	0	0
	Total S&T	**1.6**	**0.8**	**0.2**	**0**	**0**	**0**
Non-S&T Funding							
O&M		0.8	0	0	0	0	0
	Total	**0.8**	**0**	**0**	**0**	**0**	**0**

MP.24.06 Composite Structures for Missile Defense Systems

Objectives. Develop and insert multifunctional composite structural components into missile defense systems. To accomplish this objective, the program must (1) qualify and flight test a resin matrix composite (RMC) sensor gimbal pedestal and bulkhead for the Patriot Anti-Cruise Missile (PACM), (2) develop and demonstrate high-thermal-conductivity RMC trays for ground-based radar systems, (3) develop and test advanced SiC divert system components, and (4) codevelop and flight test advanced composite shrouds for endo-interceptors.

Payoffs. A composite integral radar pedestal mount and bulkhead for the PACM will provide a 40% weight savings compared to a comparable cost baseline aluminum. A composite antenna module for a Theater High-Altitude Air Defense (THAAD) ground-based radar restores thermal margins by more than 18% (currently unattainable with the baseline aluminum) and eliminates the need for special coolant at near-equal cost to the baseline and a factor of 10 savings over a proposed alternative metal components.

Challenges. The primary technical challenges are to demonstrate and evaluate fabrication and performance of interceptor composite components with high-strength, high-stiffness, high-strain-to-failure fibers, and to demonstrate which of several competing fabrication processes, such as resin transfer molding (RTM), will provide repeatable components within the narrow statistical band needed to achieve technology insertion. Process definition and certification efforts will lead to defining costs for low-rate initial production. The specific program challenges are to provide fully acceptable advanced composite components at a cost comparable to baseline aluminum and to develop and demonstrate cost-effective and statistically repeatable manufactured composite missile components.

Milestones/Metrics.

FY1998: Design and test a prototype composite antenna module for THAAD radar systems. Fabricate and test an advanced composite integral bulkhead for PACM. Fabricate and hot-fire test advanced high-temperature components for DACS. Complete fabrication of composite generic missile component by RTM process. Complete critical design of composite shroud.

FY1999: Fabricate and test composite antenna module for THAAD radar system. Flight test advanced composite integral bulkhead for PACM. Complete hot-fire tests of high-temperature composite components for DACS. Complete assessment of RTM process for low-cost manufacture of composite missile components. Fabricate and sled test composite shroud.

FY2000: Insert composite antenna module into THAAD radar system. Flight test composite interceptor shroud in endo-environment.

FY2002: Flight test multifunctional kinetic kill vehicle composite structure.

Customer POC	Service/Agency POC		USD(A&T) POC
Dr. Allen Alexander	Dr. Alok Das	Mr. James Walbert	Dr. Lewis Sloter
PEO Air and Missile Defense	Phillips Lab/VTS	ARL	DDR&E(AT)
Mr. Richard Brown	Dr. John Stubstad		
SFAE-AMD-PA	BMDO/TOS		

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0603173C	1270	1.5	1.7	2.0	2.0	2.0	0
	Total	**1.5**	**1.7**	**2.0**	**2.0**	**2.0**	**0**

MP.25.01 Lean Aircraft Production and Sustainment

Objectives. Accelerate the implementation of lean manufacturing methods in the development, production, and repair of defense weapon systems by demonstrating and documenting dramatic cost and lead-time reductions on current weapon system programs.

Payoffs. This is a joint activity implementing high-risk, high-payoff recommendations and findings from the lean aircraft initiative to reduce acquisition and sustainment costs for aircraft, rotorcraft, and unmanned aeronautical systems. Lean demonstrations will pave the way for greatly broadened implementation of efficient business and manufacturing practices for military systems such as the F–22, C–17, JSF, and RAH–66 as well as unmanned aeronautical systems. Similar implementations in commercial industry have reduced cost by more than 50%, inventory by 90%, and cycle time by 45%. Modular factory pilot projects within this DTO will demonstrate cycle time savings of 45% and cost reductions of up to 50% for selected demonstration articles. Lean concepts will also be transitioned across all services and into other major defense industrial sectors such as shipbuilding and space. This DTO supports the Combat Identification, Joint Theater Missile Defense, Military Operations in Urban Terrain, and Electronic Combat JWCOs.

Challenges. Cultural isolation in defense industries tends to exaggerate the risks and difficulties of implementing efficient approaches to product development and production that have shown dramatic success in other industries. Existing business and management practices deter DoD access to commercial facilities and stifle change within DoD production programs. DoD-unique requirements result in inefficient operations in areas such as inventory control, property management, inspection, purchasing, data rights, supplier relations, and job training. Traditional accounting principles obfuscate true costs and create difficulty in illustrating the benefits of lean practice implementation. Adaptation of successful commercial models is problematic due to extreme differences in business volume and funding stability. Transition of findings from industry assessment and benchmarking hinges on identifying incentives toward their adoption.

Milestones/Metrics.

FY1998: Demonstrate cycle-time and in-process inventory reductions of approximately 80% through the use of lean practices (e.g., reduce process steps by 95%, reduce supplier contracting time by 75%). Complete lean sustainment engine-blade repair and electronics reengineering case studies.

FY1999: Demonstrate reduced cost for aircraft and electronic components by approximately 50% through the use of modular factory concepts (e.g., $18 million savings on C–17 main landing gear pod, microwave power modules from $25,000 to $5,000 per module for thousands of modules for E–2C Hawkeye Cooperative Engagement Capability Program). Identify means of reducing total order fulfillment time (funding leadtime) for F–22 from 32 to 24 months.

FY2001: Demonstrate lean manufacturing or repair of military systems at a cost savings of 30%–50% for a minimum of three major military subsystems. Transition lean manufacturing concepts from the military aircraft sector to at least two other major defense industrial sectors (e.g., shipbuilding, space).

Customer POC	Service/Agency POC		USD(A&T) POC
Lt Gen Kenneth Eickmann, USAF ASC/CC	Mr. Jon Ogg F-22 SPO	Mr. Steve Linder ONR	Mr. Daniel Cundiff DDR&E(LM/TT)
Brig Gen Charles Johnson, USAF ASC/YC (C-17)	LTC Earl Wyatt, USA JSF Program Office		

Non-S&T Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0603800N		0.1	0.1	0	0	0	0
070811F		9.7	10.6	7.0	4.1	0	0
30060 NASA		0.1	0.1	0	0	0	0
64239F C-17		0.1	0.1	0	0	0	0
64239F F-22		0.1	0.1	0	0	0	0
65152N NAVAIR		0.1	0.1	0	0	0	0
Coast Guard		0.1	0.1	0	0	0	0
DLA		0.1	0.1	0	0	0	0
Industry		5.8	1.4	0	0	0	0
TCOM		0.1	0.1	0	0	0	0
Total Non-S&T		**16.3**	**12.8**	**7.0**	**4.1**	**0**	**0**

MP.26.01 Condition-Based Maintenance/Integrity Monitoring

Objectives. Demonstrate and insert condition-based maintenance (CBM)-enabling technologies in fleet weapon systems, and rapidly develop a new generation of mechanical diagnostics technologies that are powerful, affordable, and extremely reliable.

Payoffs. CBM is a tool for equipment asset management that will pay off in three major areas: safety, affordability, and asset visibility. *Safety*—CBM will allow real-time, onboard mechanical diagnostics of critical powertrain, drivetrain, and structural components and act as a "watchdog" as these aging platforms operate. Studies have shown that vibration suppression using smart materials will substantially increase the fatigue lifetime of both helicopters and fixed-wing aircraft. *Affordability*—CBM has the potential to significantly reduce (by 30%) O&S costs, which account for approximately 65% of total life-cycle costs. The insertion of CBM-enabling technologies can save manpower, significantly reduce spare parts usage, reduce depot-level maintenance, and provide accurate data. *Asset visibility/readiness*—inherent in CBM are technologies that allow rapid and accurate assessment of platform health. CBM systems will provide the commander "intelligence" on the status of his equipment, allowing deployment options never before available.

Challenges. There are several challenges facing CBM-enabling technologies: (1) development and integration of self-powered wireless MEMS devices for robust, inexpensive diagnostics; (2) new techniques for oil analysis and monitoring that provide early indications of wear and impending failure; (3) robust methods of detecting corrosion and fatigue in remote locations using intelligent sensors; and (4) advanced signal processing, neural network classifiers, hybrid model development, data fusion, approximate reasoning, and advanced human–computer interface techniques. Furthermore, there are requirements for developing design philosophies for smart materials and structures; continuing development of robust, fast-response sensors and actuators; developing methods for attachment of sensors/actuators; determining number and placement of sensors/actuators; developing hybrid sensors/actuators systems; selecting local or global control; exploring linear vs. nonlinear control theories; selecting the control approach (e.g., neural networks, fuzzy logic); determining the durability, reliability, and maintainability of the sensors, actuators, and information processing network; energy coupling between the actuator and structure; and further reducing size, weight, and power requirements.

Milestones/Metrics.

FY1999: Demonstrate integration of smart sensors and actuators for vibration control in helicopters and fixed-wing aircraft.

FY2000: Demonstrate first generation of self-calibrating, self-organizing, software-reconfigurable wireless MEMS devices on fleet weapon systems. Flight test demonstration of diagnostic system.

FY2001: Demonstrate first generation of remote fatigue-sensing NDE devices on fleet aircraft systems.

FY2002: Demonstrate second-generation, self-powered, distributed MEMS sensor arrays with onboard signal processing, neural network classification, and wireless communications to intermediate sensor nodes for sensor data fusion, systems-level diagnostics, and communications with platform-level condition assessment systems. Eliminate the cost and weight of wires in naval installations. Reduce the cost per sensor node from (present) $2,000 to <$50.

Customer POC		Service/Agency POC	USD(A&T) POC
Mr. Bill Deaton CVX	Dr. Bill Scheuren JSF	Dr. Robert Crowe DARPA/DSO	Dr. Lewis Sloter DDR&E(AT)
Mr. Jim Lee AAAV	Mr. Phillip Schneider PMS 377	Dr. R. Pohanka ONR	
LCDR R. Muldoon, USN H-53	LCDR David Spracklin NAVAIR 41.1.2	Mr. Tobey Cordell AFRL-MLLP	
Mr. Tom Ready DD-21		Mr. James Meeker AFRL-MLS	

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602122N		0.3	0.3	0.3	0.3	0.3	0
0602712E	MPT-01	2.0	2.0	0	0	0	0
0602233N		1.1	0.9	0.3	0.3	0.3	0
0602234N		1.9	2.8	1.1	1.1	1.1	0
0603707N	R1773	0.9	1.4	1.9	1.9	1.9	0
0603712N	R1910	0.6	1.1	2.4	2.4	2.4	0
	Total	**6.8**	**8.5**	**6.0**	**6.0**	**6.0**	**0**

MP.27.01 Materials for Small-Target Detection Capability in High-Clutter Environments

Objectives. Develop and demonstrate electronic materials that will enable development of high-temperature electronic components that significantly enhance capabilities in detecting small targets or signals in a high-clutter environment.

Payoffs. The payoffs from these technologies will be (1) a revolutionary capability in cruise missile defense in littoral (close-to-shore, wide range of sea state environments) operations and related low-angle airborne or spaceborne radar detection scenarios, (2) factors of two to three range enhancement for wireless intercepts and communications, and (3) the ability to detect unintended electromagnetic emissions from ground sites at larger standoff distances. The technologies to achieve these payoffs are (1) cryogenic components consisting of very low phase noise resonators, very high performance filters, Josephson junction-based A/D and other radio frequency components, and (2) frequency-agile ferroelectric and ferrite materials to provide wideband tuneability and large phase shifts at very low loss and at low cost for filters and phased-array antennas.

Challenges. Very low loss ferroelectric and ferrite materials need to be fabricated for significant utilization in frequency and phase agile components. A robust high-temperature superconducting (HTS) single and multiple layer technology, including Josephson junctions, needs to be established for the fabrication of advanced A/D and other digital and analog high-performance components. The main challenges for the cryogenic technologies are in refrigeration and cryo-packaging.

Milestones/Metrics.

FY1998: Demonstrate functional superconducting stable local oscillator integrated into SPK–9B radar with >10X improvement in sensitivity for cruise missile detection in high clutter. Demonstrate 24-element ferroelectric lens phased-array antenna. Demonstrate A/D circuits performance above 16 effective bits at 20-Msamples/s data rate and 5 effective bits at 10-Gsamples/s data rate.

FY1999: Demonstrate multifuctional A/D circuits integrated on cryocooler. Demonstrate low-phase-noise 100-GHz clock and arbitrary function (D/A) generator.

FY2000: Demonstrate voltage controlled oscillator tuned over 2X for secure communications.

FY2001: Demonstrate prototype high-Q (3000) filter with octave tuneability for SINCGARS base station. Demonstrate high-performance, very low noise receiver for detection of unintended radiation from critical sites and platforms.

FY2002: Demonstrate 200-element phased-array antenna with 20-deg steering.

Customer POC	Service/Agency POC		USD(A&T) POC
Mr. Bob Anderson NAVSEA	Dr. Frank Patten DARPA/DSO	Dr. Deborah Van Vechten ONR	Dr. Lewis Sloter DDR&E(AT)
	Dr. Somnath Sengupta ARL	Dr. Stuart Wolf DARPA/DSO	

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602102F	4348	2.0	0	0	0	0	0
0602234N		2.6	2.6	2.6	2.6	2.6	0
0602712E	MPT-01	5.0	7.2	5.0	0	0	0
	Total	**9.6**	**9.8**	**7.6**	**2.6**	**2.6**	**0**

MP.28.01 Enhanced Coastal Trafficability and Sea State Mitigation for Logistics-Over-the-Shore

Objectives. Develop and demonstrate technologies that will permit cargo-vessel discharge to lighterage in highly adverse sea conditions and trafficability, both on beaches and between beaches and the inland transportation network. The products from this effort will support combat operations of all military services.

Payoffs. This DTO will greatly enhance DoD logistics-over-the-shore (LOTS) capability, including (1) a fully functional prototype Rapidly Installed Breakwater System (RIBS) to attenuate wave energy and, through a reduction of adverse sea conditions, the ability for cargo vessel-to-lighterage discharge to continue through sea state 3; and (2) lightweight materials and construction techniques to rapidly increase trafficability in coastal areas to the level required to support logistics throughput requirements. Products complement DTO MP.12.11, Higher Sea State Logistics Support for Expeditionary Forces. Design, deployment, employment, and training guidance will be transitioned to the Army through the U.S. Army Engineer Waterways Experiment Station to the U.S. Army 7th Transportation Group in accordance with the *Joint Vision 2010* JLOTS Master Plan requirements. This DTO supports the Joint Readiness and Logistics and Sustainment of Strategic Systems and Force Projection/Dominant Maneuver JWCOs.

Challenges. Specific technical barriers to this effort include the development of optimal RIBS designs, fabrication of RIBS using lightweight high-strength materials, development of a deployment mechanism, and development and selection of moorings for RIBS. Criteria, materials specifications, and construction practices will need to be developed that address affordable soils stabilization and surfacings that can withstand 10,000 passes of military-unique loadings such as the 10 x 10 Palletized Loading System with wheel loadings up to 9,000 lb.

Milestones/Metrics.

FY2000: Complete engineering design for full-scale breakwater(s) based on detailed engineering analyses, laboratory tests, and one-fourth-scale field tests; provide the capability to rapidly stabilize beach sands with minimum logistics burdens and reduced engineer equipment.

FY2002: Demonstrate rapidly installed breakwaters for reduction of wave conditions in sea states up to lower end of sea state 4 by 50%; demonstrate improved techniques to rapidly stabilize soft soils for roads and material storage areas associated with LOTS operations.

Customer POC		Service/Agency POC	USD(A&T) POC
Mr. W. Adams	LTC Steve Loomis, USA	Dr. Lewis E. Link	Mr. Robert Boyd
ATSE-CD	AFZF-ENL	CERD-ZA	DDR&E(ELS)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0603734A	T08	0	0.3	3.6	4.9	4.4	0
	Total	**0**	**0.3**	**3.6**	**4.9**	**4.4**	**0**

MP.29.01 Materials and Processes for Integrated High-Payoff Rocket Propulsion Technology

Objectives. Develop the technology for advanced spacelift vehicles with an overall objective of low-cost, high-performance access to space for military and nonmilitary space launch systems and improved performance in tactical and spacecraft propulsion systems. This DTO supports the Integrated High-Payoff Rocket Propulsion Technology (IHPRPT) DoD initiative, which continues through 2010.

Payoffs. Lower cost, high-performance access to space for military and nonmilitary space launch systems and improved performance in future tactical and spacecraft propulsion systems. The key components of liquid fuel engines that advanced materials can significantly impact include lightweight ducts, turbo pumps, injectors, and nozzles. The key material advancements in the solid systems will provide lightweight and performance enhancements in the nozzle/throat, insulation, and cases.

Challenges. Technical barriers include the development of affordable materials and processes sustained by maintaining an adequate industrial base. Liquid-fuel engine systems require material systems to improve fuel compatibility, reduce component weight and volume, increase rotodynamic speeds (to decrease turbo pump assembly size), increase turbine-blade and disk capability of withstanding thermal shocks and high stresses (at high temperatures), reducing composite processing costs, utilizing advanced bearing concepts, and identifying advanced bearing concept limitations. Material and processes technology challenges include carbon-carbon densification and cost reduction; oxidation-resistant coatings; higher temperature and higher strength-to-weight metallics, intermetallics, metal matrix composites, and ceramic matrix composites; and higher strength-to-weight and durable organic matrix composites and polymers. Solid-engine systems technical challenges include adapting polymeric materials for use in manufacturing reduced weight components, eliminating bondlines, and identifying high-strength case materials for decreased component mass/volume.

Milestones/Metrics.

FY2000: Materials and processing technologies must be able to support Phase I technology goals. The technology goals will result in system payoffs defined as 17%/50% (expendable/reusable launch vehicles (ELV/RLV)) increase in payload capability and 20%/30% (ELV/RLV) reduction in launch costs. Continued materials analysis in parallel with component technology demonstrations is needed in order to assess materials solutions. These assessments will be key to determining specific materials solutions for IHPRPT Phases II and III.

FY2005: Materials and processes to achieve liquid cryogenic propulsion system demonstrations (Phase II) that will attain 34%/100% (ELV/RLV) payload increases with cost reductions of 40%/60% (ELV/RLV) and hydrocarbon demonstrations that will attain payload increases of 50% with cost reductions of 28%. Materials for solid and hybrid propulsion systems must be assessed and developed to meet payload increases of 13% with cost reductions of 20%.

Customer POC	Service/Agency POC	USD(A&T) POC
Maj Randy Korrell, USAF	Mr. Michael Stropki	Dr. Lewis Sloter
AFSPC/XPX	WL/MLI	DDR&E(AT)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602601F	1011	1.6	1.4	1.4	2.1	2.9	2.8
0602102F	4347	1.1	1.6	1.6	0.9	0.8	1.3
	Total	**2.7**	**3.0**	**3.0**	**3.0**	**3.7**	**4.1**

MP.30.01 Sustainable Military Use and Stewardship of the Environment

Objectives. Achieve maximum range use while complying with federal environmental regulations by developing effective, well-populated models to predict, prevent, control, or remediate environmental damage to military training and test ranges.

Payoffs. Tri-service warfighters would have less restricted use of airspace and ranges, improving DoD readiness and saving dollars now spent on corrective practices that deny range access. Services currently lack the wherewithal to respond to civilian concerns that training schedules, patterns, loads, and noise will not damage ranges and their inhabitants. Manual downloading of data that is labor- and time-intensive and costly would be automated, enabling real-time access to accurate and reliable data. Advanced, knowledge-based computing and accurate, automated monitoring, coupled with accurate modeling of noise propagation, will reduce military avoidance areas by 60%.

Challenges. Two big challenges are (1) developing ability to predict maximum allowable stress on ecosystems without causing irreversible damage, and (2) developing signature recognition algorithms for blast noise, impulse noise, sonic booms, and short-duration subsonic bursts. Military stressors are often intense, many species and complex natural processes are involved, and cost/complexity of collection techniques must decrease. Integrating new sensors into a common model and event-recognition software and comprehensively packaging processors, sensors, software, and transmitters are added challenges. Also, data need to be inserted into range management models, and the true impacts of military activities on resources need to be calculated.

Milestones/Metrics.

FY1999: Characterize up to 80% of intense, land-based training/testing that may be stressing environmental resources. Show remote event data sensors/collectors can be 60% cheaper to own and operate.

FY2000: Assemble database and guidance on activities impacting protected species; develop and select process-based models; link guidance and models up to 50% of key species.

FY2001: Simulate mission impacts on key populations and habitats with biological or spatial models; model effects of management actions that reduce ecological conflicts with training and testing areas by 50%.

FY2002: Identify and test process and model interactions of training/testing on ecosystem; increase model accuracy of environmental process predictions by 50% to 75%; ensure models perform systematically as impact and assessment decision tools.

Customer POC		Service/Agency POC	USD(A&T) POC
Mr. Jesse Borthwick AFDTC/EMX	Lt Col Tom Lillie, USAF HQ USAF/XOOA	Mr. Robert Lee AFRL-MES	Mr. Robert Boyd DDR&E(ELS)
Mr. Al Chavis ACC/DRSL	Mr. William Russell MCHB-DC-EEN	Mr. Milon Essoglou NAVFAC 15R	
Mr. Vic Diersing OEDP		Mr. William Goran CERL	

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602202F	7757	0.2	0.2	0.3	0.2	0	0
0602720A	896	2.0	2.5	2.0	1.5	0.9	0
	Total	**2.2**	**2.7**	**2.3**	**1.7**	**0.9**	**0**

MP.32.01 Fast, Affordable Product Realization

Objectives. Develop and demonstrate key advanced information technologies, such as simulation and modeling techniques and international product data standards, needed to enable shorter, lower cost transition from design to production and repair.

Payoffs. The goal is to contribute to meeting DoD requirements for sharp reductions in production and repair cost and time through more effective industrial and manufacturing engineering processes that plan, schedule, and control factory operations. These processes are directly responsible for more than one-third of weapon system costs and strongly influence the efficiency of another third. The JSF Program Office has determined that improvements to these above-the-floor functions could reduce production costs by 25%. A secondary goal is to contribute tools needed by the acquisition reform thrust to address cost as an independent variable. Technologies developed, extended, or applied in this DTO are needed by, and applicable to, virtually all weapon systems and other defense products in development, production, and operation as well as replacement-part acquisition and the production of uniforms for new recruits. Initial customers include F–22, JSF, AWACS, Warner-Robins ALC; and USMC, USN, and USAF recruit induction centers. These technologies are required to integrate and improve the many disparate information systems used by individual organizations and their supply chains to analyze designs for manufacturability and to plan, schedule, and control manufacturing and repair facilities. This program also will provide technologies that emphasize affordability analyses to facilitate design for low-cost manufacturing and rapid transition from design to production. This DTO supports the Force Projection/Dominant Maneuver and Electronic Combat JWCOs.

Challenges. Technical barriers include inability to capture and communicate design intent; inability to simulate the downstream manufacturing cost effects of design decisions; inability to interoperate manufacturing, product, and cost information systems within and among companies; lack of effective tools and of accurate, timely information for scheduling individual factories and supply chains for significant reductions in span time and inventories; lack of manufacturing planning methods capable of automatically and correctly selecting and sequencing lowest cost processes; and inability to adequately plan for unpredictable manufacturing environments.

Milestones/Metrics.

FY1998: Reduce development time for mixed signal circuit cards by 25% through simulatable specifications; demonstrate the feasibility of extending the technology and its benefits to the electronic subsystems level; demonstrate a potential 1% life-cycle cost reduction on JSF by integrating advanced process planning and factory cell simulation tools.

FY1999: A 3:1 reduction in cost to develop electronics test program sets; these costs are now typically about $675 million per aircraft program. Transition a distributed design environment for IPPD in missiles and similarly complex electro-mechanical systems.

FY2000: Demonstrate the ability to explore 10X more design alternatives in conceptual design in half the time. Validate STEP (Standard for Exchange of Product) testing suites for shipbuilding applications.

FY2001: Reduce lead time by at least 50% (from 122-day baseline) with commensurate reductions in inventory for items acquired by all USMC, USN, and USAF recruit induction centers by integrating DoD systems for product data, procurement, and ordering with industry systems for factory planning, scheduling, order release, and shop floor tracking.

Customer POC		Service/Agency POC	USD(A&T) POC
Mr. Hank Duhamel AWACS Program Office	Mr. David Medley Parris Island USMC Trng Ctr	Mr. Steve Linder ONR	Mr. Daniel Cundiff DDR&E(LM/TT)
Mr. John Eck F-22 SPO	LTC Earl Wyatt, USA JSF Program Office		

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
S&T Funding							
0602301E	ST-11	5.0	2.7	0	0	0	0
Total S&T		**5.0**	**2.7**	**0**	**0**	**0**	**0**
Non-S&T Funding							
0708011F		6.2	4.9	3.2	2.1	0	0
0708011N		1.0	1.0	1.0	0	0	0
0708011S		2.8	2.9	2.6	2.6	0	0
Total Non-S&T		**10.0**	**8.8**	**6.8**	**4.7**	**0**	**0**

MP.33.01 Advanced Manufacturing Practices for Affordable Turbine Propulsion

Objectives. Significantly reduce the cost and lead time to acquire turbine engine critical components needed by most military aircraft as well as key land combat vehicles and naval subsystems.

Payoffs. High-performance, highly reliable turbine engines are crucial to the nation's air, land, and sea combat superiority. They power all combat aircraft in all services, all cargo and C^2 aircraft, all manned reconnaissance aircraft, and the Abrams tank. These engines are also used in numerous power-generation subsystems throughout all services. Current and future turbine engine capabilities are fundamentally based on the performance, quality, and service life of critical rotating components—disks and blades—made from forgings and castings, and achieved at currently high cost with long development and production lead times. This DTO will mount an integrated attack on the major sources of these costs and times: poor flow of information and material; wasteful process steps; excessive inventories; extensively qualified, rigidly controlled processes; redundant inspections at all processing stages; and numerous nonvalue-adding certifications, audits, reviews, reporting, record-keeping, and other administrative actions. Goals will be met through implementing advanced product development and supply chain management practices emerging from the lean aircraft initiative (DTO MP.25.01) by exploiting the flexibility permitted by recent acquisition reform advances. Goals will be further met by implementing advances in metals processing and machining technologies, process and equipment control methods, quality assurance methods and inspection technologies throughout the key propulsion sector elements of engine companies, forging and casting suppliers, and material producers. Direct benefits to the scores of systems to be impacted have not been calculated, but cost avoidance on just the F–22, F/A–18E/F, and JSF could exceed $1.5 billion.

Challenges. Key technical barriers include lack of effective, validated collaboration practices between engine primes and suppliers in efforts to improve quality, reduce cost, and improve lead time; ineffective process control approaches; poor understanding of the impact of process variables on product quality for advanced processes; and lack of validated tools and techniques to support integrated product/process development between engine prime contractors and key lower tier suppliers of forgings and castings.

Milestones/Metrics.

FY1998: Demonstrate key process variable controls for single crystal airfoils.

FY1999: Demonstrate 25% reduction in cost for investment cast airfoils through advanced process control, saving a potential $70 million per year. Validate new processes for producing Ti alloys for critical rotating components of the F414 and F404 engines, saving over $60 million in initial application—F/A–18 aircraft.

FY2000: Demonstrate enhanced powder metallurgy processing of superalloys for turbine engine applications that provide $15 million in life-cycle cost savings for V–22 and RAH–66 engines.

FY2001: Demonstrate $50 million per year cost avoidance in quality assurance costs for high-value engine forgings. Demonstrate 40% reduction in forging product development time through collaborative IPPD of finished part, forging, and die design involving engine companies and forging and die suppliers.

FY2002: Demonstrate 50% reduction in lead time (14 months to 7 months) and 25% reduction in acquisition cost for high-value critical forged components ($50,000 to $37,000) through implementation of lean practices to reduce and eliminate nonvalue-adding administrative and management costs.

Customer POC	**Service/Agency POC**	**USD(A&T) POC**
Mr. Rafael Villalba	Mr. Steve Linder	Mr. Daniel Cundiff
ASC/LPZ	ONR	DDR&E(LM/TT)

Non-S&T DTO Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0708011F		6.6	6.7	8.4	4.0	2.4	0
0708011N		6.8	3.2	0.3	0	0	0
Total Non-S&T		**13.4**	**9.9**	**8.7**	**4.0**	**2.4**	**0**

MP.34.01 Composites Affordability Initiative

Objectives. Develop and integrate the tools, methodologies, and technologies necessary to design and manufacture a composite airframe using revolutionary design and manufacturing practices.

Payoffs. This DTO will create a paradigm shift in the design and manufacture of composites, which will result in an order-of-magnitude reduction in aircraft structure acquisition cost. As a secondary payoff, this DTO will increase the use of composites in DoD systems to maximize weapon system effectiveness. The application of affordable, low-risk composite structures can increase the performance of the system by reducing the weight and signature of structures allowing for increased range, payload, maneuverability, survivability, and speed while achieving reduced corrosion and fatigue problems. A change in the corporate culture (paradigm shift) for designing, manufacturing, and assembling composite structures will be instituted among the aerospace primes. The initial focus of the composites affordability initiative (CAI) will be on fighter structures with the first opportunity for insertion being the JSF. As such, CAI has been structured into three components focused on addressing JSF requirements. To validate the paradigm shift, CAI will flight demonstrate an affordable "all-composite" fighter structure in 27 months. Affordable composites methodologies and technologies will be transitioned to JSF EMD at an acceptable level of risk and will lead to increased applications of composites for JSF. Pervasive technologies will be validated for initial demonstration on fighter structures but with applicability to other DoD weapon systems. Additional demonstrations will follow the fighter demonstration. This effort will be planned, managed, and executed through IPTs representing the Air Force, Navy, JSF, and U.S. composites industry. This DTO supports the Combat ID and Force Projection/Dominant Maneuver JWCOs.

Challenges. Technical barriers include the limited availability of effective design, cost, and analysis tools; restrictive business practices for composites; lack of integrated databases to support design and development; insufficient understanding of process capability shortfalls and cost drivers; and risk involved in the early implementation of advanced technology into an EMD vehicle.

Milestones/Metrics.

FY1998: Establish a conceptual design of an affordable, all-composite aircraft that meets JSF requirements at a cost significantly lower than JSF baseline costs; complete the conceptual design review.

FY1999: Complete the first flight of the all-composite aircraft.

FY2000: Transition affordable technologies at an acceptable level of risk into JSF EMD; demonstrate affordability and performance through a major structural demonstration of an advanced fighter structure.

FY2002: Demonstrate affordability and performance through a major structural demonstration of the next demonstrator system.

Customer POC	Service/Agency POC	USD(A&T) POC
LTC Earl Wyatt, USA	Mr. Steve Linder	Mr. Daniel Cundiff
JSF Program Office	ONR	DDR&E(LM/TT)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
S&T Funding*							
0603211F	486U	1.3	0.5	0.8	0	0	0
0602201F	2402	0	0.8	1.1	0	0	0
Total S&T		**1.3**	**1.3**	**1.9**	**0**	**0**	**0**
Non-S&T Funding							
0708011F		8.3	6.2	6.1	7.0	4.1	0
0708011N		6.0	6.0	6.0	0	0	0
Industry		15.0	15.5	16.0	10.0	10.0	0
Total Non-S&T		**29.3**	**27.7**	**28.1**	**17.0**	**14.1**	**0**

*PE 0602234N (core program and congressional plus-ups) and PE 0602122N (DTO AP.02.00, Fixed-Wing Vehicle Structure Technology) support pervasive composite technology development that will benefit the CAI program.

BIOMEDICAL

Defense Technology Objectives
for the Defense Technology Area Plan

Biomedical

MD.01.J00 Sustained Operations Enhancement Ensemble II-168

MD.02.J00 Vaccines for Prevention of Malaria II-170

MD.03.J00 Far-Forward Assessment and Treatment for Blood Loss; Development of Blood Products and Resuscitation Fluids II-171

MD.04.J00 Medical Countermeasures for Botulinum Toxin II-172

MD.05.J00 Chemical Agent Prophylaxes II-173

MD.06.J00 Prevention of Diarrheal Diseases II-174

MD.07.J00 Medical Countermeasures for Vesicant Agents II-175

MD.08.J00 Laser Bioeffects Countermeasures II-176

MD.09.J00 Advanced Medical Technology—Advanced Field Medical Support in Forward Combat Areas II-178

MD.10.J00 Deployment Toxicology Technologies II-179

MD.11.J00 Far-Forward Assessment, Treatment, and Management of Combat Trauma and Severe Hemorrhage and Sequelae II-181

MD.12.J00 Antiparasitic Drug Program II-182

MD.13.J00 Medical Countermeasures for Staphylococcal Enterotoxin B II-183

MD.14.J00 Medical Countermeasures for *Yersinia pestis* II-184

MD.15.J00 Medical Countermeasures for Encephalitis Viruses II-185

MD.16.J00 Multiagent Vaccines for Biological Threat Agents II-186

MD.17.J00 Common Diagnostic Systems for Biological Threats and Endemic Infectious Diseases II-187

MD.18.J00 Medical Countermeasures Against Ionizing Radiation II-189

MD.19.J00 Optimization of Physical Health and Readiness II-190

MD.20.J00 Diagnostic Biodosimetry Technologies II-192

MD.21.J00 Medical Treatment Strategies for Depleted Uranium Hazards II-193

MD.01.J00 Sustained Operations Enhancement Ensemble

Objectives. Develop and adapt countermeasures for behavioral and physiological degradation caused by demands of sustained operations. Efforts will ensure that personnel perform optimally in all environments and operational extremes. Specifically, advances in pharmaceutical technology will be exploited to improve drug countermeasure specificity, warfighter monitoring technologies will be used to provide self-monitoring and control to individuals (e.g., improved sleep watch that will account for physical fatigue and desynchronization), and new sensor technologies will be exploited to extend the coverage of sustained operations physiological monitoring to improve readiness and sustainability.

Payoffs. These countermeasures will extend the capacity of deployed forces so that they can better keep up with technological advances in equipment that qualitatively extend capabilities and increase the duration of maintenance-free nonstop operation. "Owning the night" requires also staffing the night, even as reduced manning is anticipated; thus, interventions to optimize efficiency and prevent catastrophic failures caused by fatigue lapses are critical. Fatigue during extended contingency operations limits unit operational effectiveness and jeopardizes safety. Stress and fatigue are the primary or secondary cause of a large number of casualties. These factors can become the primary agents of mission failure. For example, 26% of major nonejection accidents in combat aircraft are attributable to failures of attention, and 15% are attributable to fatigue and circadian phenomena. Implementation will reduce accidents involving loss of duty days in active duty personnel involved in continuous operations by 15%. This technology helps to guard against the possibility of critical decision errors or attention lapses that may be decisive in warfighting.

Challenges. Technological barriers include unknown interactions between pharmacological aids and other fielded drugs, an incomplete understanding of sleep physiology and the purpose of restorative sleep, and the development of dry electrode technology for noninvasive brain activity monitoring.

Milestones/Metrics.

FY1998: Develop recommendations for an operational doctrine for pharmacological intervention to counter fatigue and sleep loss in military operations, improving the performance of personnel experiencing 72 hours without sleep by 35%.

FY1999: Provide joint guidance for commanders, integrating knowledge of sleep loss, melatonin, shift work schedules, and performance decrements for conducting rapid deployments and sustained operations to reduce performance decrements by 25%.

FY2002: Field a ruggedized, noninvasive alertness monitoring system for air defense and other warfighters involved in critical vigilance activities.

Customer POC		Service/Agency POC	USD(A&T) POC
COL Richard Beauchemin, USA ASD(HA)HSO&R	Mr. Chris Kearns USA DBBL	LTC Karl Friedl, USA USAMRMC	Dr. Anna Johnson-Winegar DDR&E(E&LS)
COL Larry Godfrey, USA HQ, USSOCOM	Col Harmon, USAF HSC/YA		

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602202F	7184	0.5	0.5	0	0	0	0
0602787A	878	1.5	1.8	0	0	0	0
0602233N		1.3	1.4	1.5	1.6	1.2	0
0602787A	879	0.7	0.7	0	0	0	0
0603706N	R0096	0.8	0.9	1.0	1.0	1.4	0
	Total	**4.8**	**5.3**	**2.5**	**2.6**	**2.6**	**0**

MD.02.J00 Vaccines for Prevention of Malaria

Objectives. Develop vaccines to prevent the most common causes of malaria in deployed forces.

Payoffs. Malaria is a medical threat to U.S. forces deployed to the tropical regions of Africa, Asia, South and Central America, and the Pacific. In Vietnam, infection rates reached 600 per 1,000 soldiers per year. In 1996, malaria reemerged in U.S. forces deployed to South Korea. The most common causes of malaria among humans are *Plasmodium falciparum* and *Plasmodium vivax*. Current prevention of malaria depends on the proper use of prophylactic drugs. An effective vaccine will sustain readiness and reduce manpower loss due to disease caused by malaria and drug side effects, circumvent parasite drug-resistance, and reduce the medical logistics burden as prophylactic drugs will no longer be required on the battlefield.

Challenges. Technical barriers include determining the protective mechanisms of immunity against malaria, determining the malaria antigens involved in protective immunity, developing in vitro assays that are predictive of protective immunity, and identifying safe and effective methods of delivering malaria antigens to elicit a protective immune response.

Milestones/Metrics.

FY1998: Demonstrate the feasibility of a DNA *P. falciparum* vaccine in preclinical studies.

FY2000: Complete all preclinical trials required to begin testing in human volunteers of a multiantigen, multistage malaria vaccination process to prevent *P. falciparum* infection in 80% of immunized troops.

FY2002: Complete all preclinical trials required to begin testing in human volunteers of a multiantigen, multistage malaria vaccination process to prevent *P. vivax* infection in 80% of immunized troops.

FY2003: Assess feasibility of a combined polyvalent malaria vaccination process to prevent both *P. falciparum* and *P. vivax* malaria infection in 80% of immunized troops.

Customer POC		Service/Agency POC	USD(A&T) POC
COL Richard Beauchemin, USA ASD(HA)HSO&R	COL Helen Tiernan, USA USAMEDD C & S	COL Charles Hoke, Jr., USA USAMRMC	Dr. Anna Johnson-Winegar DDR&E(E&LS)

COL Myung Kim, USA
J-4, Pentagon

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602787A	870	2.3	2.7	2.6	2.8	3.1	3.1
0603002A	810	1.5	1.5	1.5	1.5	1.7	1.7
	Total	**3.8**	**4.2**	**4.1**	**4.3**	**4.8**	**4.8**

MD.03.J00 Far-Forward Assessment and Treatment for Blood Loss; Development of Blood Products and Resuscitation Fluids

Objectives. Develop products that will allow field medics to save lives by stopping hemorrhage from becoming life-threatening and by quickly, efficiently, and effectively resuscitating victims following massive blood loss. In the pre-hospital setting of modern battlefields, 50% of combat deaths are due to hemorrhage.

Payoffs. This program will demonstrate safety and efficacy sufficient to justify transition to advanced development of a field-portable, infusion-fluid warming device. The goal of this effort is to double the storage life of liquid whole blood and blood products and to define optimum resuscitation perfusion pressures, volumes, and temperatures for early versus delayed field resuscitation of hemorrhage, improving survival by 10%. Candidate products for local hemostasis will be evaluated and demonstrated to keep 20% of hemorrhages from becoming life-threatening.

Challenges. Technology barriers addressed include instability of red blood cells during prolonged storage, an inadequate understanding of the effects of fluid resuscitation on physiological status and outcome, and simple, reliable materials and methods to stop arterial bleeding.

Milestones/Metrics.

FY1998: Demonstrate safety and efficacy sufficient to justify transition to development of a field-portable, infusion-fluid warming device.

FY1999: Double the storage life of liquid whole blood products; define optimum resuscitation perfusion pressures, volumes, and temperatures for early versus delayed field resuscitation of hemorrhage, improving survival by 10%.

FY2001: Complete an evaluation of candidate products; demonstrate hemostasis to keep 20% of hemorrhages from becoming life-threatening.

Customer POC		Service/Agency POC	USD(A&T) POC
COL Richard Beauchemin, USA ASD(HA)HSO&R	COL Myung Kim, USA J-4 Staff, Pentagon	CDR Doug Forcino ONR	Dr. Anna Johnson-Winegar DDR&E(E&LS)
COL Robert Deaderick, USA AMEDD C&S			

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602233N		0.9	0.9	1.0	1.0	0	0
0602787A	874	1.5	1.6	1.6	0	0	0
0603002A	840	0.7	0.7	0.7	0	0	0
0603706N	R0095	5.1	5.2	5.4	5.6	0	0
	Total	**8.2**	**8.4**	**8.7**	**6.6**	**0**	**0**

MD.04.J00 Medical Countermeasures for Botulinum Toxin

Objectives. Develop medical countermeasures against the biological warfare (BW) threat of botulinum toxin. Specifically, recombinant vaccine technology will be exploited to provide a second-generation vaccine candidate that is effective against serotypes A, B, E, and F and may be less reactogenic and more affordable to manufacture.

Payoffs. Botulinum toxin is a validated BW threat of high priority. It is a potent toxin that is lethal by aerosol exposure. There are seven distinct serotypes of the toxin. The present toxoid vaccine, which includes five serotypes (A, B, C, D, and E), is in short supply, and there are no drugs available for treatment of botulism poisoning. This effort, which began in 1994, will lead to the development of a new-generation, recombinant-derived vaccine that is effective against serotypes A, B, E, and F of *Clostridium botulinum*. These countermeasures will reduce the BW threat and enhance the operational flexibility of U.S. forces.

Challenges. Major technical challenges include development of appropriate model systems for investigational purposes and determining expression vectors for recombinant products.

Milestones/Metrics.

FY1998: Transition to advanced development (program definition and risk reduction phase) a vaccine candidate that will provide a minimum of 80% protection against an aerosol challenge in immunized personnel, with protection against serotypes A, B, E, and F, and that will induce minimum reactogenicity.

Customer POC	**Service/Agency POC**	**USD(A&T) POC**
COL Robert Deaderick, USA	COL Gerald Parker, USA	Dr. Anna Johnson-Winegar
AMEDD C&S	ACC/HQ, USAMRMC	DDR&E(E&LS)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0603384BP	TB3	1.8	0	0	0	0	0
	Total	**1.8**	**0**	**0**	**0**	**0**	**0**

MD.05.J00 Chemical Agent Prophylaxes

Objectives. Demonstrate an improved medical protection capability against the threat of nerve agents. The specific technology being developed through this effort is a genetically engineered human cholinesterase for use as a pretreatment for nerve agent exposure. Cholinesterases are enzymes that tightly bond to and are the toxicological target for nerve agents. Introduction of exogenous cholinesterase into the bloodstream can intercept and scavenge nerve agents before they can exert their toxic effect within the nervous system. Genetic engineering of the cholinesterase enzyme is required to improve its effectiveness and enable cost-effective mass production.

Payoffs. Nerve agents are a validated threat to U.S. forces. In comparison to currently fielded nerve agent countermeasures, achievement of this technology objective will provide a capability for extended protection against a wide spectrum of nerve agents without causing side effects, behavioral effects, or the need for extensive post-exposure therapy. Improved prophylaxis for chemical warfare agents deters their use by the enemy and increases the capability of U.S. forces and allies to sustain operational tempo and provide full-dimension protection.

Challenges. Major technical challenges include developing effective pretreatments completely devoid of side effects, developing suitable animal models, developing high-yield molecular expression systems, reducing clearance of cholinesterases from the blood to extend duration of action, and extrapolating efficacy test results from animals to man.

Milestones/Metrics.

FY1999: Identify protein-based bioscavengers that protect against 5 LD50 of nerve agent in animal models without additional therapy and without operationally significant physiological or psychological side effects; transition to advanced technology development (concept exploration phase).

Customer POC	**Service/Agency POC**	**USD(A&T) POC**
COL Robert Deaderick, USA	COL Gerald Parker, USA	Dr. Anna Johnson-Winegar
AMEDD C&S	ACC/HQ, USAMRMC	DDR&E(E&LS)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602384BP	TC2	1.1	0.9	0	0	0	0
0603384BP	TC3	1.2	1.3	0	0	0	0
	Total	**2.3**	**2.2**	**0**	**0**	**0**	**0**

MD.06.J00 Prevention of Diarrheal Diseases

Objectives. Develop combined vaccines to prevent the most common causes of acute diarrhea in deployed forces.

Payoffs. Traveler's diarrhea is a threat to U.S. forces deployed worldwide and affects 20%–30% of military personnel deployed OCONUS. During Operation Desert Shield/Storm, more than 50% of soldiers reported diarrhea within the first 90 days. In recent years, rates of diarrhea were reported to be around 30% among U.S. military personnel participating in Operations Cobra Gold (Thailand) and Bright Star (Egypt) training exercises. Traveler's diarrhea is also a problem aboard Navy ships. More than 1,000 labor-hours were lost due to diarrheal infections after the USS *Eisenhower* made a 3-day port call in Alexandria, Egypt. The most common causes of traveler's diarrhea are *Shigella sonnei*, *Shigella flexneri*, Enterotoxigenic *Escherichia coli* (ETEC), and *Campylobacter*. Effective combined vaccines will sustain readiness by reducing manpower loss due to traveler's diarrhea.

Challenges. Technical barriers include determining the protective mechanisms of immunity against enteric bacteria, determining the antigens of enteric bacteria that are involved in protective immunity, developing in vitro assays that are predictive of protective immunity, and identifying safe and effective methods of delivering bacterial antigens to elicit a protective immune response.

Milestones/Metrics.

FY1998: Develop a *Shigella flexneri* vaccine.

FY1999: Develop a *Shigella sonnei* vaccine and a modified live *Campylobacter* vaccine.

FY2001: Develop a *Shigella dysenteriae* and an ETEC vaccine.

FY2003: Assess the feasibility of a combined vaccine to prevent several key enteric pathogens from causing diarrhea.

Customer POC		Service/Agency POC	USD(A&T) POC
COL Richard Beauchemin, USA ASD(HA)HSO&R	COL Helen Tiernan, USA USAMEDD C&S	COL Charles Hoke, Jr., USA USAMRMC	Dr. Anna Johnson-Winegar DDR&E(E&LS)

COL Myung Kim, USA
J-4 Staff, Pentagon

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602787A	870	1.5	1.7	1.5	1.6	1.0	1.2
0603002A	810	1.1	1.2	1.2	1.2	0.8	0.8
	Total	**2.6**	**2.9**	**2.7**	**2.8**	**1.8**	**2.0**

MD.07.J00 Medical Countermeasures for Vesicant Agents

Objectives. Demonstrate a safe and effective pharmacological countermeasure to prevent or decrease the severity of injuries caused by vesicant chemical agents, focusing principally on sulfur mustard. Several pharmacologically distinct classes of compounds have been identified and assessed, each of which interferes at a different point in the multistep chain of biological events that is triggered by sulfur mustard. These classes, which have been shown to have efficacy in one or more cellular or animal models, include intracellular calcium modulators, protease inhibitors, and various anti-inflammatory drugs. The various technological alternatives will ultimately be competed against one another with respect to safety and efficacy to determine an optimal approach (or combination of approaches) for transition to advanced development.

Payoffs. Vesicant chemical agents, such as sulfur mustard, are a significant threat to U.S. forces. There are no specific medical counteragents for blister agents. Medical management of the injuries these agents inflict presently depends on immediate decontamination followed by conventional treatment of the resulting blisters or burns, rather than on specifically designated pretreatment/treatment. This work will yield a vesicant agent countermeasure that will substantially reduce the number of casualties or degree of injury among exposed soldiers, with consequent reductions in the medical logistic burden. Effective countermeasures to vesicant chemical agents would deter their use and enhance capabilities of U.S. forces to sustain operational tempo.

Challenges. Major technical challenges include developing effective pretreatments completely devoid of side effects, developing suitable animal models, and extrapolating efficacy test results from animals to man.

Milestones/Metrics.

FY2000: Identify candidate medical countermeasures that reduce both morbidity and healing time by 50% following vesicant exposure; demonstrate safety and efficacy of this countermeasure sufficient to transition to advanced technology development (concept exploration phase).

Customer POC	Service/Agency POC	USD(A&T) POC
COL Robert Deaderick, USA	COL Gerald Parker, USA	Dr. Anna Johnson-Winegar
AMEDD C&S	ACC/HQ, USAMRMC	DDR&E(E&LS)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602384BP	TC2	3.8	3.6	3.4	0	0	0
0603384BP	TC3	5.1	5.2	5.5	0	0	0
	Total	**8.9**	**8.8**	**8.9**	**0**	**0**	**0**

MD.08.J00 Laser Bioeffects Countermeasures

Objectives. Mitigate the impact of low-level, laser-induced glare and laser eye injuries on visually mediated human performance. Specifically, this program will determine the medical implications of battlefield lasers, develop and validate computer models of vision and performance decrements induced by battlefield lasers based on the bioeffects research, and determine battlefield triage and treatment strategies. These data and models will provide the basis for a directed-energy warfare threat analysis and mission planning system, a simulation network for training, personnel protection requirements validation for advanced materials, increasing efficiency of protective systems by a factor of 10, and medical treatment of laser-induced eye injuries.

Payoffs. The ability of even low-power lasers to damage the eye or temporarily alter vision and performance poses an especially pervasive threat to military operations. Aviators and ground soldiers at relatively close-engagement distances are acutely vulnerable to laser-induced effects as a consequence of the time-critical nature of many visually guided tasks or visually intense operational requirements. The loss of visual sensitivity for a few seconds during a critical phase in a maneuver can lead to catastrophic failure and compromise mission accomplishment.

Challenges. Technological barriers are development of materials or strategies to achieve eye protection against frequency-agile lasers, knowledge engineering status (e.g., threat models, simulation evaluation technologies), and laser interactions with ocular tissues, secondary effects, repair mechnanisms, and pharmacological intervention understanding.

Milestones/Metrics.

FY1998: Validate glare models of laser-induced contrast reduction that include effects of transparencies; define laser-induced scotoma model based on laser bioeffects research and scotoma simulation to predict performance degradation; identify mature triage and medical intervention concepts to treat battlefield eye injuries.

FY1999: Merge scotoma model with glare model to develop a bioeffects threat analysis system and mission planning system to achieve full integration of recommendations regarding laser exposure limits and risks to military personnel; transition pharmacological interventions for treatment of primary and secondary effects of laser eye injury to clinical trials.

FY2001: Develop a directed-energy warfare server for laser bioeffects for use on a DoD-distributed interactive simulation network for training; provide a knowledge-based tool for assessment and treatment of laser injury.

FY2003: Complete field evaluation of nonlinear optical materials for frequency-agile laser eye protection; provide data to validate personnel protection requirements for advanced materials.

Customer POC		Service/Agency POC	USD(A&T) POC
COL Richard Beauchemin, USA ASD(HA)HSO&R	Col James Massaro, USAF AFIWC	LTC Karl Friedl, USA USAMRMC	Dr. Anna Johnson-Winegar DDR&E(E&LS)
CAPT Stuart Ashton, USN PMA 202	CPT John Olson, USA USAIC	Mr. James Brinkley AFRL-CF	
Col Harmon, USAF HSC/YA			

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602202F	7757	0.9	0.9	0.9	1.0	1.0	1.0
0602233N		0.8	0.9	0.9	1.0	1.1	1.1
0602787A	878	0.8	0.8	0.9	0.9	0.9	0
0603231F	3257	0.7	0.7	0.7	0.7	0.6	0.6
0603706N	R0096	0.6	0.6	0.7	0.7	1.0	1.0
	Total	**3.8**	**3.9**	**4.1**	**4.3**	**4.6**	**3.7**

MD.09.J00 Advanced Medical Technology—Advanced Field Medical Support in Forward Combat Areas

Objectives. Execute a combat casualty care effort, started in FY97, to develop and test physiological status monitor technology (biophysical and biochemical smart sensors and information fusion). This will provide the basis for near-real-time casualty detection, provide physiologic status of combat casualties, and support rapid, far-forward casualty care. Casualty detection is obtained via direct or computer-aided assessment of state changes in monitored physiological variables. Far-forward casualty care will be enhanced by developing and testing computer-assisted monitoring, diagnoses, and medical assist support software and hardware technologies now part of Warrior Medic.

Payoffs. The goals of this program are a reduction in total casualties by effecting a reduction in killed-in-action (KIA) casualties and a reduction in the personnel evacuation burden due to nondisease battle injuries. This technology will decrease medic casualties. (One-third of medics who die in combat are killed trying to retrieve KIA casualties.)

Challenges. Technical barriers include modeling clinical judgment and the development of advanced noninvasive biosensor technologies for physiological measurement. Additional challenges include sensor fusion and clinical database integration to provide straightforward decision assistance to the medic.

Milestones/Metrics.

FY1998: Enhance Land Warrior message system to integrate Warrior Medic into the Land Warrior team and to improve casualty location and retrieval. Conduct concept experimentation program at the Dismounted Battlespace Battle Lab.

FY2000: Complete first generation of sensor fusion with decision-assist algorithm; field test in conjunction with intensive care platforms.

FY2001: Integration with medical situational awareness and control; integrate maturing, nonevasive sensors into initial warrior medic platform.

FY2003: Technology demonstration in field; technology insertion into Land Warrior.

Customer POC		Service/Agency POC	USD(A&T) POC
COL Richard Beauchemin, USA ASD(HA)HSO&R	COL Helen Tiernan, USA USAMEDD C&S	CDR Doug Forcino ONR	Dr. Anna Johnson-Winegar DDR&E(E&LS)
CDR Michael Sashin, USN J4(MRD)	Mr. Chris Kearns USA DBBL	Col John Silva, USAF DARPA/DSO	

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602712E	MPT-07	7.0	0	0	0	0	0
0602787A	874	0.6	0.7	0.7	0	0	0
0602787A	869	0	0.1	0.2	0.5	0.5	1.0
0603002A	840	0.2	0.2	0.3	0.3	0.3	0.3
0603706N	R0095	0.6	0.8	1.0	1.2	1.2	1.3
	Total	**8.4**	**1.8**	**2.2**	**2.0**	**2.0**	**2.6**

MD.10.J00 Deployment Toxicology Technologies

Objectives. Perform research leading to development of technologies that protect U.S. forces from toxic and hazardous chemicals and complex chemical mixtures before and during deployment. Current capabilities for exposure, hazard, and risk assessment are inadequate and inaccurate and are not integrated for rapid deployment and ease of use. New, rapid, and less expensive medical toxicology materiel, as well as decision-assist algorithms and training paradigms, will be developed to protect the warfighter from the thousands of hazardous substance mixtures to which he/she may be exposed during deployments and training. Specifically, rapid, biologically based assays and models will be developed rather than relying on knowledge of toxicity and interactions of individual chemicals to reveal a hazard to human health and performance.

Payoffs. DoD Directive 6490aa states that the military departments will conduct joint comprehensive medical surveillance. This policy includes monitoring environmental, occupational, and epidemiological threats and stressors. Personnel in operational environments may be exposed to harmful chemicals as a result of inadequate environmental protection in the area of operations, industrial accidents, sabotage, or the intentional or unintentional actions of enemy or friendly forces. Currently, there is only limited intelligence information on specific environmental threats for many regions of the world where deployment could be anticipated. Furthermore, real-time situations could involve ever-changing mixtures of chemicals and stressors with threats to human health and performance, requiring retrospective research programs like the current Persian Gulf War illness effort after every future deployment. A proactive and integrated toxicological assessment system that provides field commanders with needed information requires development of new technologies and models. This research and development will improve the health risk assessment process for operational risk management, addressing the needs identified by the Deployment Toxicology Users Work Group and reducing the uncertainty of toxicological exposures and risks that followed Operation Desert Shield/Storm.

Challenges. Real-time detection equipment must incorporate the latest sensing and detection technologies, microfabrication technologies, and new and improved polymers and resins and biotechnologies into smaller, lighter, easier to operate, and logistically supported materiel for operational users. A toxicity test battery must be developed that incorporates advances in data fusion to evaluate exposure and hazard data and be integrated with adverse health and performance models. The materiel must also exploit data fusion technologies and ensure compatible data input into medical surveillance systems. Current funding limits the investment to only a few of the research needs.

Milestones/Metrics.

FY1998: Demonstrate a toxicity test battery for neurological and performance consequences of toxic exposures to allow battlefield commanders for the first time to realistically assess the mission performance degradation of such exposures.

FY1999: Provide early warning of acute health and performance degradation from toxicological threats during deployment by developing a new family of precise function-related detection methods for a wide range of chemical stressors, including intrinsic cellular toxicity testing batteries for water-soluble and volatile chemicals, and near-real-time bioassays biosentinels for detection of neurotoxic and oxidative stress hazards.

FY2000: Accurately model toxicological exposures, including an integrated target organ dose estimation tool employing human, biologically based kinetic models in conjunction with chemical fate and transport models, to determine target organ doses of operationally relevant toxic hazards for personnel in the field; this will improve preventive medicine officer field hazard assessment capabilities.

FY2001: Develop an area dosimeter for lipophilic toxic hazards; demonstrate feasibility of a personal dosimeter based on the same technology. These will prevent uncertainty about chemical exposures and make chemical and toxic hazards identification possible during and after future deployments.

FY2002: Demonstrate feasibility of a bioelectronic sensor ("electronic canary") based on molecular mechanisms of toxicity from next-generation toxicity testing methodology research; this provides a real-time personal or area warning device that will be integrated with warfighter personal status monitoring systems.

Customer POC		**Service/Agency POC**	**USD(A&T) POC**
COL Richard Beauchemin, USA ASD(HA)HSO&R	CAPT David Macys, USN NEHC	LTC Karl Friedl, USA USAMRMC	Dr. Anna Johnson-Winegar DDR&E(E&LS)
LTC Robert Landry, USA AMEDD C&S	LTC Kotu Phull, USA USACHPPM		
Dr. David Erwin HSC/OE			

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602202F	7757	2.2	2.2	2.2	2.3	2.3	2.3
0602233N		0.6	0.6	0.7	0.7	0.8	0
0602787A	878	0.6	1.0	1.2	1.3	1.5	0
0603706N	R0096	0.8	0.8	0.8	0.9	0.9	0
	Total	**4.2**	**4.6**	**4.9**	**5.2**	**5.5**	**2.3**

MD.11.J00 Far-Forward Assessment, Treatment, and Management of Combat Trauma and Severe Hemorrhage and Sequelae

Objectives. Develop products directed at preventing delayed cellular and metabolic derangements following massive hemorrage or trauma through more effective initial treatments, drugs, devices, etc. Often, these cellular or metabolic events that begin as cascades are manifested days later as severe complications (secondary brain injury, multiple organ failure, etc.) or death. The DTO effort will result in products that will save lives now lost to combat trauma and severe hemorrhage. This effort will identify, evaluate, and transition initial trauma treatments or products to more effectively abolish or attenuate complications arising from combat trauma.

Payoffs. Initiatives will demonstrate safety and efficacy sufficient to accelerate product development of a pharmacologic intervention to preclude or reduce ischemia/reperfusion injury by 20% or more. Demonstrated safety and efficacy will be sufficient to accelerate development of pharmacologic or device interventions to lower tissue oxygen requirements by 20%. Products will be capable of reducing or preventing development of secondary injuries from combat trauma and massive hemorrhage, particularly brain and spinal cord injury, by 20%.

Challenges. Technology barriers addressed include inadequate understanding of the efficacy and safety of pharmacologic interventions for ischemia-reperfusion injury, inadequate understanding of the mechanisms of brain and spinal cord injury that occur secondarily to mechanical trauma, and the difficulty of rapidly altering core body temperature in austere environments.

Milestones/Metrics.

FY2000: Demonstrate safety and efficacy sufficient to accelerate product development of a pharmacologic intervention to preclude or reduce ischemia/reperfusion injury by 20% or greater.

FY2003: Demonstrate safety and efficacy sufficient to accelerate development of pharmacologic or device interventions to lower tissue oxygen requirements by 20%.

Customer POC		Service/Agency POC	USD(A&T) POC
COL Richard Beauchemin, USA ASD(HA)HSO&R	COL Myung Kim, USA J-4 Staff, Pentagon	CDR Doug Forcino ONR	Dr. Anna Johnson-Winegar DDR&E(E&LS)

COL Robert Deaderick, USA
AMEDD C&S

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602233N		0.9	0.9	0.9	1.0	1.0	1.1
0602787A	874	4.0	3.9	4.0	4.2	4.4	4.6
0603002A	840	0.7	0.6	0.6	0.6	0.8	0.8
0603706N	R0095	2.0	2.1	2.2	2.2	2.3	2.4
	Total	**7.6**	**7.5**	**7.7**	**8.0**	**8.5**	**8.9**

MD.12.J00 Antiparasitic Drug Program

Objectives. Continue to identify and develop drugs for the prevention and treatment of multidrug-resistant malaria and other parasitic diseases until effective vaccines are developed.

Payoffs. Malaria is a medical threat to U.S. forces deployed to the tropical regions of Africa, Asia, South and Central America, and the Pacific. In Vietnam, infection rates reached 600 per 1,000 soldiers per year. In addition, cutaneous and visceral leishmaniasis were the most common chronic infections in Operation Desert Shield/Storm veterans. Current prevention of malaria depends on the proper use of prophylactic drugs; however, the continuing emergence of multidrug-resistant malaria is rendering current prophylactic drugs ineffective. This program will identify new drugs that are effective at preventing or treating multidrug-resistant malaria and other parasitic diseases. The payoff will be sustained readiness by reducing loss of manpower due to illness caused by malaria and other parasitic diseases.

Challenges. Technical barriers include a long-term continuing effort to keep up with multidrug-resistant malaria, determining mechanisms of emerging drug-resistance, and developing in vitro and animal models for predicting effectiveness of preventive and treatment drugs against malaria.

Milestones/Metrics.

FY1998: Complete all studies necessary for submission of an investigational new drug (IND) to the FDA to permit advanced development of a drug to prevent malaria (Halofantrine or Atoguone-Proguanil).

FY2000: Complete all studies necessary for submission of an IND to the FDA to permit advanced development of a drug to treat (radical cure) malaria (biguanide analog).

FY2001: Complete all studies necessary for submission of an IND to the FDA to permit advanced development of a drug to prevent malaria (acridine analog).

Customer POC		Service/Agency POC	USD(A&T) POC
COL Richard Beauchemin, USA ASD(HA)HSO&R	COL Helen Tiernan, USA USAMEDD C&S	COL Charles Hoke, Jr., USA USAMRMC	Dr. Anna Johnson-Winegar DDR&E(E&LS)

COL Myung Kim, USA
J-4 Staff, Pentagon

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602787A	870	0.7	0.8	0.8	1.1	1.1	1.1
0603002A	810	2.9	3.0	2.9	2.9	3.4	3.5
	Total	**3.6**	**3.8**	**3.7**	**4.0**	**4.5**	**4.6**

MD.13.J00 Medical Countermeasures for Staphylococcal Enterotoxin B

Objectives. Develop medical countermeasures against the biological warfare (BW) threat of staphylococcal enterotoxin B (SEB) toxin. Recombinant vaccine technology will be exploited to provide an effective candidate that may be safer and more affordable to manufacture than traditional toxoid vaccines.

Payoffs. SEB is a validated BW threat of high priority. It is an incapacitating and potentially lethal biological toxin that can be delivered by either aerosol or oral routes to a target population. This easily produced bacterial toxin can be a serious problem on the battlefield, causing sepsis (blood poisoning) and shock. Deliberate exposure of troops to SEB delivered as a BW agent would significantly reduce mission effectiveness. The development of a vaccine against SEB reduces this threat for the warfighter, deters its use as a BW agent, and enhances strategic mobility.

Challenges. Major technical challenges include developing appropriate model systems for investigational purposes, determining expression vectors for recombinant products, and retaining antigenicity without superantigen properties in a vaccine candidate.

Milestones/Metrics.

FY2000: Transition to advanced development (program definition and risk reduction) a second-generation (recombinant) SEB vaccine that protects 80% of immunized personnel against both a lethal and an incapacitating aerosol challenge of SEB.

Customer POC	**Service/Agency POC**	**USD(A&T) POC**
COL Robert Deaderick, USA	COL Gerald Parker, USA	Dr. Anna Johnson-Winegar
AMEDD C&S	ACC/HQ, USAMRMC	DDR&E(E&LS)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602384BP	TB2	1.6	1.4	0	0	0	0
0603384BP	TB3	2.3	2.7	1.9	0	0	0
	Total	**3.9**	**4.1**	**1.9**	**0**	**0**	**0**

MD.14.J00 Medical Countermeasures for *Yersinia pestis*

Objectives. Develop medical countermeasures against the biological warfare (BW) threat of *Yersinia pestis*, the causative agent of plague. Technology efforts address both vaccines for protection and the identification of antibiotics for therapy. Recombinant vaccine technology will be exploited to provide an effective vaccine candidate.

Payoffs. Plague caused by *Y. pestis* is a validated BW threat of high priority. Bubonic and pneumonic plague caused by *Y. pestis* are serious BW threats to the warfighter. Plague is a disease of rapid onset and high death rates. The effects of aerosol exposure could be further exacerbated by secondary human-to-human spread from infected personnel. The current plague vaccine is too reactogenic, induces immunity that is short-lived, requires multiple immunizations, and is of unproven efficacy against an aerosol exposure. This effort, which began in 1994, will transition to advanced development a new vaccine candidate that should protect against parenteral and aerosol exposure, have long-lasting immunity, and protect against the three different forms of the disease. The combination of prophylactic (vaccine) and therapeutic (antibiotic) treatments will afford the warfighter the greatest degree of protection against infection with plague, deter its use as a BW agent, and increase the strategic mobility of U.S. forces.

Challenges. Major technical challenges include developing appropriate model systems for investigational purposes, determining expression vectors for recombinant products, and determining the appropriate antigens for a multivalent plague vaccine candidate.

Milestones/Metrics.

FY1998: Transition to advanced development (program definition and risk reduction phase) a second-generation (recombinant) vaccine candidate that will protect 80% of immunized personnel against an aerosol challenge of *Yersinia pestis*, with minimum reactogenicity. Complete evaluations of new-generation antibiotics for effectiveness against both bubonic and pneumonic plague.

Customer POC	Service/Agency POC	USD(A&T) POC
COL Robert Deaderick, USA	COL Gerald Parker, USA	Dr. Anna Johnson-Winegar
AMEDD C&S	ACC/HQ, USAMRMC	DDR&E(E&LS)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602384BP	TB2	0.8	0	0	0	0	0
0603384BP	TB3	1.1	0	0	0	0	0
	Total	**1.9**	**0**	**0**	**0**	**0**	**0**

MD.15.J00 Medical Countermeasures for Encephalitis Viruses

Objectives. Develop medical countermeasures against the biological warfare (BW) threat of the equine encephalitis viruses. Recombinant vaccine technology will be exploited to provide effective vaccine candidates.

Payoffs. Equine encephalitis viruses are a group of viruses that cause disorientation, convulsions, paralysis, and death. They are important BW threats because of aerosol infectivity and relative stability. Clinical illness associated with Venezuelan, Eastern, and Western equine encephalitides (VEE, EEE, and WEE, respectively) includes headache, fever, chills, nausea, vomiting, mental confusion, sleepiness, and sometimes seizures and other neurological signs and symptoms. Mosquito vectors normally transmit these alphaviruses to birds, horses, and humans; however, alphaviruses are very stable when freeze dried and have the potential to be used as a biological weapon. Safe and effective vaccines are needed to protect warfighters. Current vaccines for alphaviruses causing encephalitis are inadequate. Improved vaccines would decrease the threat of BW and enhance strategic mobility.

Challenges. Major technical challenges include development of appropriate model systems for investigational purposes and determining expression vectors for recombinant products.

Milestones/Metrics.

FY1998: Transition to advanced development (program definition and risk reduction phase) an improved vaccine capable of protecting a minimum of 80% of immunized population against an aerosol challenge of VEE strains 1 A/B and C, with minimum reactogenicity.

FY1999: Construct analogous (to a VEE vaccine) vaccine candidates for EEE and WEE.

FY2000: Transition to advanced development a vaccine candidate effective against all pathogenic strains of VEE virus (i.e., a multivalent vaccine for strains 1 A/B/C, 1E, and III).

Customer POC	**Service/Agency POC**	**USD(A&T) POC**
COL Robert Deaderick, USA	COL Gerald Parker, USA	Dr. Anna Johnson-Winegar
AMEDD C&S	ACC/HQ, USAMRMC	DDR&E(E&LS)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602384BP	TB2	0.4	0	0	0	0	0
0603384BP	TB3	0.8	0.8	0.7	0	0	0
	Total	**1.2**	**0.8**	**0.7**	**0**	**0**	**0**

MD.16.J00 Multiagent Vaccines for Biological Threat Agents

Objectives. Produce a vaccine, or vaccine delivery approach, that could be used to concurrently immunize an individual against a range of biological warfare (BW) threats. Bioengineered and recombinant vaccine technologies (naked DNA vaccines or replicon vaccines) will be exploited to achieve multivalent vaccines that are directed against multiple agents, yet use the same basic construct for all of the agents.

Payoffs. Vaccines currently being developed for biological threat agents are univalent with respect to the threat itself (e.g., separate vaccines against agents such as anthrax, plague, botulinum toxins, variola virus). Multiagent vaccines to be demonstrated through this DTO would be analogous to such commercial vaccines as combined diphtheria-pertussis-tetanus vaccine and measles-mumps-rubella vaccine. The possibility of achieving protective immunity against multiple BW threat agents with a much reduced requirement for the number of vaccines or immunization schedules means greater flexibility and fewer time constraints in fielding a force protected against the threats. Other potential benefits include decreased cost of production, greater range of potential vaccine production facilities, and possible faster time for licensure of vaccines. Due to the nature of the some of the threat agents and lack of commercial viability for such a combined product, there is no other commercial or foreign source through which to procure such products.

Challenges. Major technical challenges include development of appropriate model systems for investigational purposes and evaluating immunogenicity, efficacy, and possible interference effects of a multiagent vaccine candidate.

Milestones/Metrics.

FY1998: Select promising systems for testing; acquire desired genetic materials for incorporation.

FY1999: Develop appropriate animal models for evaluating single and potential combined agent vaccines.

FY2000: Select most promising approach and identify final agents to be incorporated into the combined product; begin evaluation of immunogenicity for combined products and examine for possible interference effects.

FY2001: Test efficacy of combined products individually and in combined products.

FY2002: Complete preclinical data package for FDA; submit package for transition to advanced development (program definition and risk reduction phase).

Customer POC	Service/Agency POC		USD(A&T) POC
COL Robert Deaderick, USA	CDR Shaun Jones, USN	COL Gerald Parker, USA	Dr. Anna Johnson-Winegar
AMEDD C&S	DARPA/DSO	ACC/HQ, USAMRMC	DDR&E(E&LS)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602383E	BW-01	1.0	1.0	1.0	1.0	1.0	0
0602384BP	TB2	0.4	0.6	1.0	0.5	0.3	0
0603384BP	TB3	0	0.5	0.9	1.5	1.7	0
	Total	**1.4**	**2.1**	**2.9**	**3.0**	**3.0**	**0**

MD.17.J00 Common Diagnostic Systems for Biological Threats and Endemic Infectious Diseases

Objectives. Develop state-of-the-art technologies (platforms/devices) capable of diagnosing infectious disease and biological warfare (BW) agents in clinical specimens. The devices will be used by preventive medicine personnel for disease surveillance and monitoring and by medical laboratory personnel for the diagnosis of disease due to natural and BW threat agents. Efforts will focus on an immunologically based membrane device to rapidly detect host immune responses to etiologic agents or the antigens or products of the agents themselves, and on miniaturized polymerase chain reaction technology for detection and identification of nucleic acids of natural infectious disease and BW agents.

Payoffs. The ability to quickly identify exposure to specific BW and infectious disease agents and rapidly treat warfighters is critical to maintaining the strength of the force as well as giving commanders the ability to provide specific protective measures to yet unexposed warfighters. The technologies to be provided will benefit all elements of health care from forward-based to CONUS-based fixed medical facilities, and will allow medical diagnosis of biological threat agents and endemic infectious diseases much farther forward on the battlefield than is currently possible. Many BW-agent-induced illnesses have early symptoms that are flu-like and indistinguishable from each other and other less harmful pathogens. The ability to detect infection immediately after exposure would be extremely helpful in determining whether a BW attack has occurred and how many warfighters were exposed and thus in need of treatment. Early diagnosis is key to providing effective therapy. An effective broad diagnostic capability is important in locating the correct therapeutics and getting them moved in-theater in a timely manner. Collaborations with industrial/biotechnology, government, and academic centers of excellence will be developed to leverage continuing advances in biotechnology and industry.

Challenges. Requisite technologies require adaptation for clinical use and for detection of specific infectious disease or BW agents. Challenges include development of appropriate antibodies, elimination of interference from substances contained in clinical samples, and selection of appropriate nucleic acid probes. There are a large number of actual and potential biological threat agents. The diagnostic system must be able to distinguish these diverse pathogens both from each other and from those common natural infections that may begin with similar signs and symptoms. Current diagnostic systems also require manual sample collection and preparation, which is labor intensive and time consuming especially when large numbers of clinical samples must be collected in the field.

Milestones/Metrics.

FY1999: Transition to advanced development (program definition and risk reduction phase) an immunologically based membrane platform requiring no special instrumentation that is capable of the rapid detection of specific host immune responses to a broad range of etiologic agents or for detecting the antigens or products of these agents in clinical specimens, with 100% specificity and 97% sensitivity for each agent.

FY2002: Transition to advanced development a handheld device capable of detecting and identifying nucleic acids of a broad range of natural infectious disease and BW agents in clinical specimens, with 100% specificity and 97% sensitivity for each agent.

Customer POC
COL Robert Deaderick, USA
AMEDD C&S

Service/Agency POC
COL Charles Hoke, Jr., USA
USAMRMC

COL Gerald Parker, USA
ACC/HQ, USAMRMC

Dr. Steven Morse
DARPA/DSO

USD(A&T) POC
Dr. Anna Johnson-Winegar
DDR&E(E&LS)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602383E	BW-01	1.0	2.0	2.0	2.0	1.0	0
0602384BP	TB2	0.5	0.5	0.6	0.6	0.6	0
0603384BP	TB3	0.5	0.6	1.0	1.0	1.0	0
	Total	**2.0**	**3.1**	**3.6**	**3.6**	**2.6**	**0**

MD.18.J00 Medical Countermeasures Against Ionizing Radiation

Objectives. Develop fieldable advanced medical strategies for the prevention and treatment of radiation injuries. Pharmacologic interventions will be designed and tested and recommendations made to maximize protection of personnel against early radiation syndromes (e.g., performance decrement and lethality) as well as late-arising health effects (e.g., cancer, mutations).

Payoffs. Effective mitigation of health consequences and performance-degrading effects will (1) reduce casualty load at medical treatment facilities, (2) sustain a more effective operational force after a radiation exposure event, (3) allow commanders to conduct operations in radiation field environments without undue health risks (both near-term and long-term health risks) to personnel, and (4) reduce the negative psychological impact on personnel tasked to operate in contaminated environments. Very significant reductions (40%) in acute casualty rates are expected based on recent animal studies. Even greater reductions (60%) are expected for late-arising consequences such as cancers, mutations, and other radiation-induced illnesses.

Challenges. This effort must determine the efficacy of protective treatments under multiple exposure conditions and of slow-release drugs delivered during protracted external radiation exposures, and sustain optimum therapeutic drug levels in the blood without undue toxicity and safety test in volunteers prior to fielding.

Milestones/Metrics.

FY1998: Establish assays to measure blood levels of radioprotectants; develop therapeutic indexes to achieve optimum radioprotection for both acute and protracted radiation exposures.

FY1999: Recommend prophylactic and therapeutic drug combinations to achieve maximum survival protection against acute (early) radiation injury; deliver a fieldable protocol for cytokine treatment of acute radiation injury.

FY2000: Demonstrate feasibility of using a slow-release drug delivery system for the extended preventive treatments of acute radiation injury.

FY2001: Optimize prophylactic and therapeutic drug combinations to achieve maximum protection against late-arising diseases of major concern (e.g., cancer, mutation-mediated illnesses).

FY2002: Demonstrate effectiveness of prophylactic and therapeutic drug combinations using a simple, self-administered, slow-release delivery system.

FY2003: Complete safety testing of the medical countermeasure system in human volunteers.

Customer POC		Service/Agency POC	USD(A&T) POC
Dr. Salvatore Cirone ASD(HA)CS	COL Larry Godfrey, USA HQ, USSOCOM	LTC(P) Robert Eng, USA AFRRI	Dr. Anna Johnson-Winegar DDR&E(E&LS)

RADM Michael Cowan, USN
JS/J4

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602787D	P505	2.4	2.5	1.8	2.0	0.6	0.7
0603002D	P506	0.9	1.0	0.9	0.7	0.9	1.0
	Total	**3.3**	**3.5**	**2.7**	**2.7**	**1.5**	**1.7**

MD.19.J00 Optimization of Physical Health and Readiness

Objectives. Use state-of-the-art biomechanical, physiological, and biochemical methods to overcome technological barriers to noninvasive tests and measures. This research will develop physical selection, training programs, and operational fitness to reduce the incidence of musculoskeletal injuries, enhance recovery from injury, and maximize individual readiness during military training and operations.

Payoffs. A high level of fitness and training and optimal nutritional status can substantially attenuate the multistressor impacts of the combat environment and thereby enhance military performance and readiness. DoD Directive 1308.1 on physical fitness and weight control is intended to optimize physical readiness of military members; however, standards and methods used to train, promote, and test for physical fitness originated from limited physiological data. Inappropriate physical training programs commonly produce acute or overuse injuries and may result in injury due to inadequate physical conditioning for job-specific physical requirements. Overly stringent body fat standards impair readiness by promoting disordered eating behaviors. A recent review by the Armed Forces Epidemiology Board concluded that injuries—the "hidden epidemic" in the military—have greater impact on the health and readiness of U.S. armed forces than any other category of medical complaint during peacetime and combat, with disability compensation in excess of $750 million per year. The review concluded that training injuries may have the biggest impact on readiness. Substantial savings through medical cost avoidance and enhanced military readiness through reduction of lost duty days can be achieved through scientifically defined improvements in training and screening procedures. For example, a recent Navy study demonstrated that modification of a training program for USMC recruits at one center significantly reduced stress fractures, regaining 14,880 otherwise lost training days among 22,000 recruits for an annual savings of $4.5 million and without compromising the rigorous physical standards.

Challenges. Large-scale prospective field studies are difficult and expensive to organize and conduct, particularly in units with high rates of attrition. The absence of an integrated tri-service medical injuries and illnesses database for both outpatient and inpatient has been a major handicap to preventive medicine researchers. Noninvasive technologies (such as stable isotope-labeled biochemical tracers to define energy expenditure and muscle protein turnover rates, and footstrike monitors and body-mounted triaxial accelerometers to acquire data on locomotory patterns and impact forces) must be further developed and procedures standardized for comparison across studies. Methods for multicompartment and regional assessments of body composition must be further developed for field applications. New technologies to measure the internal and external forces and torques acting on the body during the performance of various physical tasks and in the design of personal equipment need further development for both laboratory and field use. Physical performance tests need to be validated as predictors of military job performance.

Milestones/Metrics.

FY1998: Recommend a single set of scientifically based body fat techniques traceable to multicompartment body composition standards and population-validated general fitness assessment techniques; develop criteria for appropriate standards for all military services.

FY1999: Develop improved physical training programs from biomechanical and bone/collagen biomarker studies that will optimize military performance and reduce training injuries by 50% during initial entry training and by 50% for occupational injury.

FY2000: Provide guidelines for physical performance standards; develop criteria from biomechanical and biomarker research for materiel interventions to optimize efficiency and ensure safety of individual equipment (e.g., boots and load carriage equipment), reducing stress-related lower extremity injuries in ground forces by 20%.

FY2001: Define and validate job-related physical training standards based on modeling strength and endurance dimensions of performance.

FY2002: Develop special physical training and performance nutrition programs using stable isotope tracer techniques for specific physical performance of elite units, special occupational requirements (e.g., load carriage, occupational exposure to high-g-force/shock environments), and optimized performance of all service members in jobs with high physical demands and those exposed to extreme environments.

FY2003: Optimize military performance and injury prevention on the basis of research on musculoskeletal damage and metabolic recovery responses following intensive activity.

Customer POC		Service/Agency POC	USD(A&T) POC
LTC Beth Foley, USA DCSPER	COL Thomas Padgett, USA ASD (FMP) (PSFE)	LTC Karl Friedl, USA USAMRMC	Dr. Anna Johnson-Winegar DDR&E(E&LS)
LCDR Rene Hernandez, USN BUPERS	Maj Michael Snedecor, USAF HSC/PSP		

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602233N		0.2	0.7	0.7	0.6	0.5	0.3
0602787A	879	0.7	0.7	0.8	0.8	0.8	0
	Total	**0.9**	**1.4**	**1.5**	**1.4**	**1.3**	**0.3**

MD.20.J00 Diagnostic Biodosimetry Technologies

Objectives. Develop a biodosimetry assay system based on chromosomal aberrations that permits a rapid, high-throughput capability to assess radiation exposure for large numbers of casualties as far forward as possible.

Payoffs. Use of symptomatology or physical dosimeters, even when available, does not provide adequate diagnostic information to treat life-threatening radiation injuries. This system will provide physicians with the ability to definitively triage radiation victims, make appropriate treatment decisions, reduce the uncertainties associated with the variability of individual response to radiation exposure, and identify patients with partial-body exposures.

Challenges. Difficulties include reducing labor-intensive requirements for sample preparation, automating scoring of the chromosomal aberration assay, validating assay for human use, and incorporating assay into a rapid field-based delivery platform.

Milestones/Metrics.

FY1999: Complete development of simplified sample preparation protocol; complete in vitro radiation calibration curves.

FY2001: Complete in vivo studies validating chromosome aberration assay over a broad dose range and partial-body exposure situations.

FY2002: Complete developments to automate scoring of the chromosome aberration assay.

FY2003: Demonstrate a fieldable and high-throughput biodosimetry system for transition to advanced development.

Customer POC		Service/Agency POC	USD(A&T) POC
Dr. Salvatore M. Cirone ASD(HA)CS	RADM Joan Engel, USN BUMED, Code 02	LTC(P) Robert Eng, USA AFRRI	Dr. Anna Johnson-Winegar DDR&E(E&LS)
LTC Carl Curling, USA HQDA (DASG-HCO)	COL Larry Godfrey, USA HQ, USSOCOM		

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602787D	P505	1.2	1.3	1.1	1.0	0.7	0.4
0603002D	P506	0.7	0.7	0.9	1.1	1.0	0.9
	Total	**1.9**	**2.0**	**2.0**	**2.1**	**1.7**	**1.3**

MD.21.J00 Medical Treatment Strategies for Depleted Uranium Hazards

Objectives. Determine the long-term health effects of exposure to depleted uranium (DU) fragments, and develop short- and long-term treatment strategies.

Payoffs. The Persian Gulf War produced a small number of friendly-fire incidents in which U.S. soldiers were injured with DU fragments. The demonstrated success of this new class of munitions guarantees that DU will be deployed by future adversaries on a large scale, greatly increasing the number of casualties with DU fragment injuries. Because of the unique and poorly understood radiological and toxicological properties of DU, knowledge of the immediate and long-term health risks is very limited. Current treatment strategies are in the most primitive stages of development, and conventional diagnostic capabilities make it difficult to ascertain that personnel are wounded with DU rather than fragments from other metals. Little is known about the long-term health effects to personnel wounded with DU. This research will define the most important pathologies associated with DU fragments embedded in tissues, develop rapid assessment tools that can be used to identify personnel wounded with DU, and develop safe and effective treatment strategies to minimize the long-term risks of DU shrapnel.

Challenges. The effort must develop the reagents needed to improve the sensitivity of tests to detect DU in urine and reduce the toxicity of pharmaceutical agents designed to decrease DU load in wounded individuals.

Milestones/Metrics.

FY1999: Complete animal studies to assess the basic toxicological consequences of exposure to DU fragments; complete human model for DU organ distribution from embedded fragments.

FY2000: Provide fieldable, rapid assessment tool for detection of DU in urine and treatment recommendations.

FY2001: Complete in vitro studies to define mutagenic and carcinogenic potential of exposure to DU fragments.

Customer POC		Service/Agency POC	USD(A&T) POC
Dr. Salvatore M. Cirone ASD(HA)CS	Dr. Michael Kilpatrick OSA(GWI)	LTC(P) Robert Eng, USA AFRRI	Dr. Anna Johnson-Winegar DDR&E(E&LS)

Ms. Donna Doganiero
MCHB-DC-O

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602787D	P505	0.8	0.7	0.8	0.8	0.9	0.9
0603002D	P506	0.4	0.3	0.3	0.3	0.3	0.3
	Total	**1.2**	**1.0**	**1.1**	**1.1**	**1.2**	**1.2**

SENSORS, ELECTRONICS, AND BATTLESPACE ENVIRONMENT

Defense Technology Objectives for the Defense Technology Area Plan

Sensors, Electronics and Battlespace Environment

SE.01.02	Low-Cost Electronically Scanned Antennas	II-197
SE.02.01	Foliage Penetration Detection Algorithm Demonstration	II-198
SE.03.01	Advanced Radar Processing From Airborne Platforms	II-199
SE.04.02	High-Frequency Surface Wave Radar Shipboard Demonstration	II-200
SE.05.01	Automatic Radar Periscope Detection and Discrimination	II-201
SE.06.01	Multifunction Electro-Optical Sensors and Signal Processing	II-202
SE.07.02	Advanced Pilotage	II-203
SE.08.01	Advanced Infrared Search and Track Systems	II-204
SE.09.02	Multiwavelength, Multifunction Laser	II-205
SE.13.02	Lightweight, Broadband, Variable-Depth Sonar	II-206
SE.14.02	Multistatic Active Antisubmarine Warfare	II-207
SE.15.01	Affordable High-Performance Towed Arrays	II-208
SE.19.03	Affordable ATR via Rapid Design, Evaluation, and Simulation	II-209
SE.20.01	Automatic Target Recognition for Reconnaissance and Surveillance	II-211
SE.24.02	Advanced Common Electronic Modules	II-212
SE.26.01	Millimeter-Wave Power Modules	II-213
SE.27.01	Microwave SiC High-Power Amplifiers	II-214
SE.28.01	Low-Power Radio Frequency Electronics	II-215
SE.29.01	Design Technology for Radio Frequency Front Ends	II-216
SE.33.01	Advanced Focal Plane Array Technology	II-217
SE.35.01	Optical Processing and Memory	II-218
SE.36.01	Photonics for Control and Processing of Radio Frequency Signals	II-219
SE.37.01	High-Density, Radiation-Resistant Microelectronics	II-220
SE.38.01	Microelectromechanical Systems	II-222
SE.39.01	Wide-Bandgap Electronic Materials Technology	II-223
SE.43.01	Energy Conversion/Power Generation	II-224
SE.44.01	Power Control and Distribution	II-225
SE.45.01	Forecast of Littoral Currents and Waves	II-226
SE.47.01	Autonomous Ocean Sampling Network: Mapping of Ocean Fields	II-227
SE.52.01	Weather/Atmospheric Impacts on Sensor Systems	II-228
SE.53.01	On-Scene Weather Sensing and Prediction Capability	II-230
SE.55.01	Space Radiation Mitigation for Satellite Operations	II-231
SE.56.01	Satellite Infrared Surveillance Systems Backgrounds	II-232

SE.57.01 Analog-to-Digital Converter II-233
SE.58.01 Lookdown Bistatic Technology II-234
SE.59.01 Low-Light-Level Imaging Sensors II-235
SE.60.01 Underwater Acoustic Communications II-236
SE.61.01 Multiphenomenology Sensor Fusion for ATR and Tracking II-237
SE.62.02 LADAR ATR for Conventional Weapons II-239
SE.63.02 Digital Beamforming Antenna Technology II-241
SE.64.02 Millimeter-Wave Gyro-Amplifiers II-242
SE.65.02 Long- and Dual-Wavelength, Large-Area, Staring Focal Plane Arrays II-243
SE.66.02 Packaging and Interconnect for Multiple Technologies II-245
SE.67.02 Hyperspectral Terrain and Target Classification Technology II-246
SE.68.01 Rapid Mapping Technology II-248
SE.69.01 Autonomous Distributed Sensors II-249

SE.01.02 Low-Cost Electronically Scanned Antennas

Objectives. Develop low-cost electronically scanned antennas (ESAs) for multiple platforms and applications that allow warfighters to benefit from the acquisition of a significantly larger number of more capable and less costly systems. The current antenna integration includes three parts: the Rotman lens, an Endfire "Vivaldi" notches aperture array, and a switch control matrix.

Payoffs. The payoffs are to achieve mission-acceptable performance (platform dependent) at a procurement cost of less than 70% of current high-performance active element array costs.

Challenges. The technical challenges are to develop a horizontally polarized antenna with an operating frequency range from 6 to 18 GHz, an azimuth field of view ±45 deg, an antenna gain of 30 dB, and beamwidths of 2-deg azimuth and 6-deg elevation at an affordable cost.

Milestones/Metrics.

FY1998: Build and test a ferroelectric lens with a 3-GHz bandwidth and insertion loss of less than 1.5 dB for a single lens; finalize, assemble, and test Rottman lens design; realize acceptable performance of an ESA at less than 50% of the current cost; reduce radar systems cost by 40%; improve system reliability by 40%. Test a diode lens as a radar with slotted array: 1-GHz bandwidth, less than 1-dB insertion loss, and less than 2-dB sidelobe degradation.

Customer POC	Service/Agency POC	USD(A&T) POC
Mr. E. Newman	Mr. William Miceli	Dr. Jasper Lupo
PEO	ONR	DDR&E(SEBE)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602232N		1.7	0	0	0	0	0
	Total	**1.7**	**0**	**0**	**0**	**0**	**0**

SE.02.01 Foliage Penetration Detection Algorithm Demonstration

Objectives. Provide radar sensor, signal processor, and signal detection and discrimination algorithm developments tailored to concealed target detection.

Payoffs. Adversary forces have utilized the tactic of hiding under tree canopies since the Vietnam era. Current fielded radar systems, operating at X-band (8–12 GHz), have little or no capability to detect and discriminate targets concealed in foliage. Removal of the safe haven of tree cover for threat forces is a significant improvement in warfighting capability. This effort, which started in May 1995, collected a unique data set (2.5 km^2 of clutter data and 100 target realizations) over an extended frequency range from 25 to 1200 MHz with the BoomSAR at Aberdeen Proving Ground in FY97. In FY98, this DTO ground demonstrated real-time target detection algorithms having high detection probability and low false-alarm rate of broadside targets and some capability against nonbroadside targets; algorithms have been transitioned and delivered to the Counter–Camouflage Concealment and Deception ATD (DTO A.11).

Challenges. This DTO conducts experiments using low-frequency synthetic aperture radar (SAR) sensors to develop foliage penetration radar system technology, requisite target detection and discrimination algorithms, and a radar signal processing algorithm that provides a 90% detection probability with less than 0.1 false alarm per square kilometer against time-critical targets concealed under foliage.

Milestones/Metrics.

FY1998: Ground demonstrate real-time target detection algorithms having a 90% detection probability with less than 0.1 false alarm per square kilometer of targets concealed under foliage.

Customer POC	Service/Agency POC	USD(A&T) POC
Mr. Charles Christianson	Mr. Dennis Mukai	Dr. Jasper Lupo
PEO-IEW	AFRL	DDR&E(SEBE)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0603203F	665A	0.6	0	0	0	0	0
	Total	**0.6**	**0**	**0**	**0**	**0**	**0**

SE.03.01 Advanced Radar Processing From Airborne Platforms

Objectives. (1) Address identified needs for performance upgrades to both Air Force and Navy airborne early warning (AEW) radar sensors and the development of a lightweight synthetic aperture radar/moving target indicator (SAR/MTI) radar for tactical Army UAV platforms. (2) Develop and incorporate advanced space-time adaptive processing (STAP) algorithms into existing lookdown airborne sensors providing clutter suppression 30 dB beyond that achievable currently. (3) Develop lightweight SAR/MTI payloads for tactical UAVs emphasizing Longbow algorithms, wavelets, and COTS.

Payoffs. This DTO will provide the warfighter with information superiority of the battlespace in a multiplicity of environments.

Challenges. STAP techniques that are amenable to existing airborne platforms such as the E–2C need to be developed. Investigation of low-cost modifications are required to be coupled with algorithms that deliver the required performance. For UAVs, the challenges include the ubiquitous issues of cost, weight, volume, modest antennas size, and processing low-velocity platform data.

Milestones/Metrics.

FY1998: Extend height finding of targets by a factor of 2 for E–2C.

FY1999: STAP augmentation showing 15-dB improvement in J-hook clutter suppression on the airborne STAP testbed; achieve radar hardware weight of 80 lb or less.

FY2000: Demonstrate low-cost, lightweight SAR/MTI with 70% probability of detection and false alarm rate of two per minute at ranges greater than 12 km for MTI and 5 km for SAR.

Customer POC	**Service/Agency POC**	**USD(A&T) POC**
Mr. Charles Christianson	Mr. Jeff Sichina	Dr. Jasper Lupo
PEO-IEW	ARL	DDR&E(SEBE)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602120A	H16	1.7	0.3	0	0	0	0
0602232N		0.6	0.6	0	0	0	0
0602702F	4506	1.2	1.0	0.7	0	0	0
0603238N	R2145	1.0	1.0	0	0	0	0
0603762E	SGT-02	4.1	12.0	0	0	0	0
0603772A	243	3.3	3.7	3.6	0	0	0
0603789F	4072	1.2	0	0	0	0	0
	Total	**13.1**	**18.6**	**4.3**	**0**	**0**	**0**

SE.04.02 High-Frequency Surface Wave Radar Shipboard Demonstration

Objectives. Demonstrate over-the-horizon detection of low-flying antiship missiles by a shipboard radar operating in the high-frequency band near 20 MHz. Detection and tracking of the targets will exploit sea-surface hugging features of surface-wave propagation. The High-Frequency Surface-Wave Radar (HFSWR) shipboard demonstration will provide critical early warning (30 seconds for a Mach 2 target) of missile attack and cueing of weapon engagement radars. Target transitions include both forward-fit (CVN–76 and SC–21) and back-fit (LSD–41 class and other ships slated for the self-defense system). The HFSWR is currently under development for testing on the Self-Defense Test Ship (SDTS) and LSD–41 class ship. At-sea testing will continue in FY98.

Payoffs. Performance goals include detection of a supersonic sea-skimming missile at 2.5 times the range currently achievable with a microwave radar, with better than a 1-degree azimuth tracking accuracy. Applications of the HFSWR to theater ballistic missile defense are also being pursued against target-of-opportunity missile launches during the at-sea testing period. Supporting work on the feasibility of a bistatic or multistatic configuration of the HFSWR is being conducted by ONR. The HFSWR program, which was initiated in October 1995, has accomplished shipboard HF noise measurements taken on LSD–45 and developed HF antenna pattern modeling of LSD–41. These efforts have led to specification development for the HFSWR ATD system.

Challenges. Critical issues to be addressed by the demonstration include compatibility of the radar with other shipboard HF systems and the effects of the complex shipboard scattering environment on target detection and tracking.

Milestones/Metrics.

FY1998: Detection and tracking of BQM–74 drone at 20 nmi by a system installed on LSD–41.

Customer POC	Service/Agency POC	USD(A&T) POC
Mr. E. Newman	Dr. R. Dinger	Dr. Jasper Lupo
PEO	SPAWARSYSCEN	DDR&E(SEBE)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602232N		0.4	0	0	0	0	0
0603792N	R1889	5.5	0	0	0	0	0
	Total	**5.9**	**0**	**0**	**0**	**0**	**0**

SE.05.01 Automatic Radar Periscope Detection and Discrimination

Objectives. Demonstrate advanced radar technology for surface and airborne radars to automatically detect exposed periscopes in the presence of sea clutter and small targets and debris found in the littoral environment. The Navy's current periscope detection airborne radar, the AN/APS–137, is the basis for this development and will be enhanced by developing and integrating automated detection and discrimination technology, along with automatic target classifier/recognition processing, to enable rapid distinction of periscopes in the complex clutter (sea clutter, floating objects) typical of littoral operating environments.

Payoffs. With the end of the cold war, Navy mission needs have shifted from blue (open ocean) to brown (littoral) waters. Regional conflict involvement requires protection of fleet units from submarine torpedo attack in shallow water, where acoustic sensors perform poorly. The Third World diesel-electric submarine threat provides significant periscope detection opportunities.

Challenges. The primary technical challenge is the radar signal processing and implementation to achieve adequate probability of detection rapidly in conditions of high-clutter backgrounds associated with low-grazing angles and littoral environments. Due to the complex nature of the littoral environment, radar processing technology development beyond this DTO may be needed to ensure detection and classification over a 24-hour operational period.

Milestones/Metrics.

FY1998: Conduct shipboard technical assessments of radar processing techniques and architectures that will provide >50% probability of detection with less than 5 s of exposure time.

Customer POC	Service/Agency POC	USD(A&T) POC
Mr. Gary Snider	Dr. Dave Johnson	Dr. Jasper Lupo
NAVAIR	ONR	DDR&E(SEBE)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0603747N	R2142	9.0	0	0	0	0	0
	Total	**9.0**	**0**	**0**	**0**	**0**	**0**

SE.06.01 Multifunction Electro-Optical Sensors and Signal Processing

Objectives. Demonstrate a tri-service operational requirement for improved algorithm performance and efficiency in passive infrared search and track (IRST) sensors that can support target classification through extraction of temporal, spectral, and polarimetric data.

Payoffs. This DTO will provide the ability to autonomously acquire and track threat targets that are increasingly stealthy in a wide (360-degree) panoramic field of regard. Theater ballistic missiles will be over-the-horizon detected and precision tracked at ranges out to 500 km, and cruise missiles will be horizon detected (13-nmi) for ship self-defense.

Challenges. Technical challenges include the development of highly stabilized IRST sensing capabilities for precision tracking of threat aircraft from ground combat vehicles and air-to-air target acquisition. Recent developments in the state of technology in large-area, highly uniform, infrared focal plane arrays and stabilized optics have made possible high-sensitivity, multifunction, and multicolor sensors. Another challenge is to develop multidimensional processing algorithms to fully exploit the spatial, spectral, and temporal characteristics of a dynamic target relative to natural background clutter.

Milestones/Metrics.

FY1998: Initial transition of algorithms and high-data-rate, COTS real-time processor (750 Mpixels 12 bits/pixel) to PEO (TAD) for integration with the shipboard two-color IRST; operational evaluation at sea.

FY1999: Continue at-sea IRST operational evaluation for transmission to PEO (TAD).

FY2000: Complete at-sea IRST operational evaluation, which demonstrates 360-deg field of regard with the ability to detect LO cruise missiles at ranges to the horizon.

Customer POC	**Service/Agency POC**	**USD(A&T) POC**
Mr. Walter Bahr	Mr. Jim Buss	Dr. Jasper Lupo
PMA-231	ONR	DDR&E(SEBE)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602232N		0.7	2.0	0.8	0	0	0
0602702E	TT-06	4.5	3.1	6.6	0	0	0
0603203F	665A	0	0.2	2.0	3.0	3.5	2.0
	Total	**5.2**	**5.3**	**9.4**	**3.0**	**3.5**	**2.0**

SE.07.02 Advanced Pilotage

Objectives. Develop and demonstrate advanced sensor technology for night and adverse-weather pilotage/navigation.

Payoffs. This DTO will provide advanced low-light-level-visible and infrared-fused sensor technology for night and adverse-weather pilotage/navigation requirements including an all-aspect view via fixed spherical coverage using large staring focal plane arrays and multispectral image fusion. This program, which began in FY93, has successfully demonstrated an integrated wide-field-of-view pilotage/navigation sensor and display suite with image fusion. The system transitioned to the PM-Rotary Pilotage Associate ADT.

Challenges. Technical barriers include combining the most salient features from the complementary forward looking infrared (FLIR) and low-light-level-visible sensor imagery to show a single, composite picture, including high-resolution foveal vision, of the operating area on a helmet-mounted display. Additional challenges are the developments that provide a 50% increase in obstacle recognition range in the poorest weather and in the darkest nights and a 50% increase in the instantaneous field of vision.

Milestones/Metrics.

FY1998: Demonstrate an integrated, wide-field-of-view pilotage/navigation sensor and display suite with image fusion. Image fusion combines the most salient features from the complementary FLIR and image intensified sensor imagery to show a single, complete picture of the operating area on a helmet-mounted display. Demonstrate a 25% decrease in target detection time using fused imagery.

Customer POC	Service/Agency POC	USD(A&T) POC
Mr. Mel Jackson	Mr. Fred Petito	Dr. Jasper Lupo
PM Comanche	NVESD	DDR&E(SEBE)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
S&T Funding							
0603710A	K86	2.5	0	0	0	0	0
Total S&T		**2.5**	**0**	**0**	**0**	**0**	**0**
Non-S&T Funding							
0603800N	D2209	4.9	0	0	0	0	0
Total Non-S&T		**4.9**	**0**	**0**	**0**	**0**	**0**

SE.08.01 Advanced Infrared Search and Track Systems

Objectives. Develop and demonstrate (1) the sensing capabilities of highly stabilized passive infrared search and track systems (IRSTs) for over-the-horizon detection and precision tracking of TBMs and cruise missiles for ship self-defense, and (2) sensors for detection and precision tracking of threat aircraft from ground combat vehicles.

Payoffs. This DTO will provide significant increases in operational capabilities in that the warfighter will be equipped with a covert long-range surveillance, precision track, and cueing sensor that had not been feasible before technology advances. As a result, the battlespace will be significantly expanded, making over-land engagements, air-defense engagements, detecting and tracking TBMs to 300 nmi, and detecting and tracking cruise missiles out to 110 nmi. This program, which began in FY96, has experienced delay in hardware/software signal processing and serious delay in developing 640 x 480 medium-wavelength and long-wavelength FPAs. The system is scheduled to be delivered in May 1998. The analysis of the data and final report is scheduled for completion in December 1998.

Challenges. Significant sensor and system improvements are required to develop an affordable passive targeting capability that achieves these requirements. Such improvements include seamless integration of joint airborne and surface assets, use of airborne fire control to support surface and fighter missile engagements, ability to engage low-altitude/RCS and dim (subsonic) threats in littoral regions, and backscan step-stare (electronic stabilization) and SPRINT (shift, pan, register, and integrate) processing to include electronic de-roll (~100 optical distortion maps required for 4 or 5 degrees of roll).

Milestones/Metrics.

FY1998: Operational utility evaluation of airborne step-stare IRST in a carrier-based E–2C AEW aircraft out to 250 nmi. Transition the step-stare surveillance IRST to Naval Air Systems Command for engineering development. Demonstrate 640 x 480 staring panoramic multifunction and multiplatform IRST.

Customer POC	**Service/Agency POC**	**USD(A&T) POC**
CAPT Shepard, USN	Mr. Jim Buss	Dr. Jasper Lupo
PMA-231	ONR	DDR&E(SEBE)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602232N		2.8	0	0	0	0	0
	Total	**2.8**	**0**	**0**	**0**	**0**	**0**

SE.09.02 Multiwavelength, Multifunction Laser

Objectives. Develop and demonstrate high-efficiency, compact, laser-diode-pumped LADAR systems in the 0.26–12-μm spectral region. The multifunctionality of single-wavelength, solid-state sources will also be investigated as a means of maximizing their utility.

Payoffs. This DTO will develop a tunable (0.25–12-mm) multifunction laser capable of precision range (<1 m at 20-km target range) and velocity (<1 mm/s) measurements with sufficient repetition rate (200–1000 Hz) to support a target vibration analysis and target profiling. The resulting laser source technology will provide the warfighter the ability to accomplish multiple goals such as LADAR, rangefinding, target degradation, combat identification, wind shear determination, obstacle avoidance, and secure communications using a single laser system.

Challenges. A diode-pumped ND:YAG laser will need to be developed that has a wide range of energy and pulse repetition frequency (PRF) outputs; new, high-duty laser diode arrays will be used for high-repetition rates and optical parametric oscillators for wavelength conversions. Novel cavity designs are required to allow for switchable outputs.

Milestones/Metrics.

FY1998: Develop modules with multiple wavelength outputs that meet technical requirements (<1-m range resolution and <1-mm/s velocity resolution).

FY1999: Complete development of multiapplication systems (200–1000-Hz repetition rate, 720-km range); investigate horizontal technology interpation approach to multifunction and multiapplication.

FY2000: Demonstrate tunable laser capability at ranges of up to 20 km with <1-m resolution.

FY2001: Demonstrate repetition rates of 200–1000 Hz to support target vibration analysis and profiling.

Customer POC	Service/Agency POC	USD(A&T) POC
Mr. Walter Bahr	Mr. Edward Watson	Dr. Jasper Lupo
PMA-231	AFRL	DDR&E(SEBE)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602204F	2001	0.8	0.5	0	0	0	0
0602709A	H95	1.4	1.6	0	0	0	0
0603203F	665A	2.5	1.7	1.2	1.4	0	0
	Total	**4.7**	**3.8**	**1.2**	**1.4**	**0**	**0**

SE.13.02 Lightweight, Broadband, Variable-Depth Sonar

Objectives. Develop and demonstrate a surface-ship-towed active sonar system employing new broadband signal generation and processing, energy-dense transducer material, and sparse receiver line array technologies to reliably detect and classify small, very quiet, low-Doppler, below-the-layer threat submarines in the shallow-water littoral warfare.

Payoffs. Controlling an area of the ocean will permit the surface combatant to confidently sail into any waters to accomplish its primary missions. The detection ranges capable with the Lightweight, Broadband, Variable-Depth Sonar (LBVDS) will reduce the visual targeting capability of threat submarines, diminishing the submarine torpedo threat. Broadband waveforms will mitigate environmental effects.

Challenges. A broadband sonar with large time-bandwidth products (~10,000) and good spatial (~0.3-m) and Doppler (~0.3-m/s) resolution is required to suppress reverberation and channel fading effects that dominate shallow-water active acoustic returns. A variable depth sonar is required to match the signal to the sound channel occupied by the target while reducing surface reverberation (greater than 10 dB). A lightweight tow body is required to minimize ship impact issues. Signal processing algorithms for maximum broadband detection/classification performance are needed.

Milestones/Metrics.

FY1999: Conduct sea trial to evaluate system issues and collect broad-bandwidth data.

FY2000: Design, fabricate, and test the control, transmit, receive, and handling subsystems; demonstrate time-bandwidth product signals of 10,000.

FY2002: Complete system integration; conduct at-sea demonstration of performance against a low-Doppler, below-the-layer threat in shallow water; demonstrate 90% P_d at a 7–10-nmi range and a one-per-day false alarm rate.

Customer POC	Service/Agency POC	USD(A&T) POC
CAPT John Barry, USN	Mr. Ken Dial	Dr. Jasper Lupo
N863E	ONR	DDR&E(SEBE)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602314N		1.1	0.9	0	0	0	0
0603747N	R2142	14.1	16.2	14.6	9.1	3.0	0
	Total	**15.2**	**17.1**	**14.6**	**9.1**	**3.0**	**0**

SE.14.02 Multistatic Active Antisubmarine Warfare

Objectives. Develop and demonstrate a multistatic ASW capability incorporating an off-board, high-power, long-endurance, low-frequency acoustic source; an open-architecture, COTS-based, onboard signal processor; performance models; and CONOPs. This capability has application to existing surface-ship, submarine, air, and deployed distributed sensor field receivers.

Payoffs. As threat submarines become quieter, passive sonars alone may not be capable of providing adequate detection margins; use of active sonars may be required to detect and localize such threats. Off-board sources (OBSs) provide a multistatic option that also avoids the beacon effects of organic sources.

Challenges. The employment of an acoustic OBS requires efficient combination of a liquid metal combustor, a Stirling thermal-to-electric conversion engine, a torque-free flywheel, compact transducers, communications technologies, and electronic command and control in a package compatible with diverse platforms. Mechanical deployment approaches must be developed and demonstrated. Models and simulations must be employed to design the OBS, predict its performance, and develop concepts of operation for each employing platform operating in the dynamic littoral environment. Existing receivers must be integrated with processors incorporating target detection, classification, and clutter reduction algorithms to demonstrate an effective multistatic ASW system capability.

Milestones/Metrics.

FY1998: Initiate sea trials for algorithm development.

FY1999: Complete sea trials and initiate final OBS design.

FY2000: Complete OBS final design that will lead to a 15–20-dB improvement over existing passive systems; increase detection ranges by 3X–5X; increase area coverage by 10X.

Customer POC	**Service/Agency POC**	**USD(A&T) POC**
CAPT John Morgan, USN	Dr. Steven Ramberg	Dr. Jasper Lupo
N84	ONR	DDR&E(SEBE)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0603763E	MRN-02	0.3	0	0	0	0	0
0602314N		5.0	7.2	6.4	0	0	0
	Total	**5.3**	**7.2**	**6.4**	**0**	**0**	**0**

SE.15.01 Affordable High-Performance Towed Arrays

Objectives. Develop technology for improved towed arrays for tactical submarine and surface-ship use. Towed arrays are the most effective sensor available for passive sonar detection of threat submarines at long ranges, with emphasis on detection of low-frequency radiated noise. Analysis of current and projected threat submarine signatures indicates a need for a 10-dB increase in directivity index over current towed arrays. Both multiline volumetric towed array and all-optical array technologies are being pursued

Payoffs. This DTO will improve the acoustic performance and lower the cost of towed arrays through advances such as multiline volumetric towed arrays that provide significant aperture in all three dimensions and by all-optical array technology that eliminates discrete hydrophones, complex telemetry, and much of the hand-labor cost of manufacturing current-generation towed arrays. Per-element wet-end costs will be reduced by 80%–90%.

Challenges. Designs are needed for (1) multiline towed arrays that can be used with existing handling systems and (2) hydrodynamic technologies to allow fully reconfigurable apertures. Bragg-grating-based multiplexing will be used to reduce array production cost. Flow-induced self-noise for the thin-optical towed array (TOTA) design will be mitigated. Fiber-optic technologies and associated interrogation schemes that do not require Bragg gratings need to be designed.

Milestones/Metrics.

FY1998: Demonstrate acoustic performance and cost-reduction goals for TOTA; transition high-gain multiline technology.

FY1999: Demonstrate fully reconfigurable multiline towed array apertures.

FY2000: Demonstrate a new approach for constructing all-optical arrays with potential for greater than 90% reduction in per-channel cost and inherent versatility for use over a very wide acoustic bandwidth.

Customer POC	Service/Agency POC	USD(A&T) POC
Mr. Jim Thompson	Mr. Scott Littlefield	Dr. Jasper Lupo
PEO-USW ASTO	ONR	DDR&E(SEBE)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602314N		4.1	2.4	1.2	0	0	0
0603792N	R1889	3.9	5.4	5.4	0	0	0
	Total	**8.0**	**7.8**	**6.6**	**0**	**0**	**0**

SE.19.03 Affordable ATR via Rapid Design, Evaluation, and Simulation

Objectives. Reduce the cost and development time for automatic target recognition (ATR) systems by facilitating the use of algorithm development tools for integrated performance evaluation, software reuse, and seamless algorithm transfer to high-power computer architectures and embedded hardware.

Payoffs. Sound research and development of viable ATR systems carries special infrastructure needs. Completion of this objective will provide a virtual distributed laboratory (VDL) that links service resources, developers, and evaluators, greatly enhancing access to ATR development tools. Benefits will include (1) "honest broker," rigorous evaluation of ATR algorithms, (2) improved algorithms through the promotion of modular design and common interfaces, (3) robust algorithms developed in conjunction with controlled evaluations using simulations of realistic environments and operating conditions based on access to well ground-truthed data sets, and (4) extensible algorithms that are able to recognize novel targets included by means of rapid target insertion based on high-fidelity signature modeling. The VDL will support system-level virtual prototyping for rapid and affordable ATR development.

Challenges. The major technology barrier is the development of validated synthetic signatures and scene simulation with sufficient fidelity to support ATR development.

Milestones/Metrics.

FY1998: Establish the best methods, procedures, and standard benchmarks for ATR performance evaluation; establish a common performance database for ATR; establish capability to disseminate results via the VDL; incorporate ATR underpinnings results from the research community; using real and SAR imagery, establish the human-to-human ATR performance baseline for wide area search.

FY1999: Demonstrate IR scene generation at 1–5-Hz synthetic with high fidelity to support ATR ID evaluation.

FY2000: Demonstrate real-time synthetic multisensor image generation to support distributed interoperable simulations in accordance with the high-level architecture.

FY2001: Conduct a near-real-time multisensor ATR and fusion algorithm demonstration and evaluation in the VDL environment against realistic operational scenario conditions with both known and novel targets.

FY2003: Demonstrate a reconnaissance-to-shooter platform rapid target acquisition and strike simulation using the VDL and the DoD battlelab simulation environments, emphasizing prototype ATR and fusion software and hardware.

Customer POC	**Service/Agency POC**	**USD(A&T) POC**
Col Gentrup, USAF	Mr. L. Goodwon	Dr. Jasper Lupo
ACC/DRA	AFRL	DDR&E(SEBE)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602204F	2003	3.6	2.4	3.2	3.9	1.8	0
0602204F	6095	3.6	3.9	0	0	0	0
0602709A	H95	7.6	7.9	4.3	4.6	0	0
0603203F	69DF	3.6	3.0	2.5	0	0	0
0603232D	P232	6.5	4.6	4.4	4.7	4.8	4.9
	Total	**24.9**	**21.8**	**14.4**	**13.2**	**6.6**	**4.9**

SE.20.01 Automatic Target Recognition for Reconnaissance and Surveillance

Objectives. Demonstrate ATR algorithms for tactically meaningful reconnaissance and surveillance scenarios, finding and recognizing exposed targets in relatively benign backgrounds. The ATR capability will provide automated target screening and exploitation aids for the image analyst in reconnaissance or surveillance platforms or in ground stations. The effort focuses primarily on ATR for radar sensors operating in synthetic aperture radar (SAR), inverse SAR (ISAR), or high-range resolution (HRR) modes. Vehicles of interest for target recognition demonstrations are mobile battlefield targets that are both moving and stationary. Template-matching and model-based ATR techniques will be demonstrated to expand the envelope of applicability of this technology to larger target sets and extended operating conditions in a variety of tactically significant environments and backgrounds.

Payoffs. The battlefield commander will be provided with enhanced situational awareness by fully exploiting the capability of reconnaissance and surveillance platforms. Currently, on the order of 70% of imagery collected is not screened by reconnaissance and surveillance image analysts due to the throughput of today's sensors and the limited number of analysts available to exploit the imagery.

Challenges. The robustness of ATR performance must be demonstrated in the face of real-world target and background variability.

Milestones/Metrics.

FY1998: Demonstrate 0.9 probability of identification (P_{id}) against stationary multiple rocket launcher and probability of false alarm (P_{fa}) of 0.01 FA/km^2 using Predator SAR; demonstrate detection and track maintenance using JSTARS of 0.9 probability against high-value moving ground targets.

FY1999: Demonstrate for U–2 and HAE UAV detection, track maintenance, and 0.9 probability against high-value moving ground targets; demonstrate in P–3 and S–3 aircraft, using ISAR imagery, 0.85 P_{id} against moving ground vehicles and small ships.

Customer POC	Service/Agency POC	USD(A&T) POC
COL Debusk, USA	Dr. R. Hummel	Dr. Jasper Lupo
ACC/DRR	DARPA	DDR&E(SEBE)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602204F	6095	0.3	0.3	0	0	0	0
0602232N		2.4	2.7	0	0	0	0
0602702E	TT-06	1.1	0	0	0	0	0
0603203F	69DF	0.7	1.4	1.9	2.6	0	0
0603760E	CCC-02	3.0	3.0	0	0	0	0
0603762E	SGT-04	32.2	27.5	0	0	0	0
	Total	**39.7**	**34.9**	**1.9**	**2.6**	**0**	**0**

SE.24.02 Advanced Common Electronic Modules

Objectives. Extend the state-of-the-art in digital electronics having as its goal an all-digital sensor suite. This program, funded under the Affordability Program, will provide an integrated rather than a federated sensor suite. Specifically, the program will develop electronic modules for two processing families: common sensor interfaces acquiring data directly from the sensors of the electronic suite in a platform, and digital processing computing nodes sustaining increased performance in processing, communication input-output bandwidth, and latency. The program builds on the $100 million DARPA investment in computing, signal processing, electronic packaging, and interconnect technologies.

Payoffs. The technical approach includes the performance of tradeoff studies to define critical design parameters affecting requirements for system applications across the naval airborne, shipborne, undersea, and overhead platforms involving RF sensor, interfacing, and data processing assets. This will be followed by the development of a system design document describing recommended architecture(s) and function performance parameters. The key common modules will then be developed, and demonstration tests will be initially performed in the laboratory and then in an SH–60R helicopter for flight testing. This program will provide a 10:1 reduction in weight and power, 8:1 reduction in life-cycle cost (LCC) for electronic modules, and a 5:1 reduction in wiring.

Challenges. Technical barriers include the integration of advanced electronic components such as analog-to-digital, digital-to-analog, and RF up-and-down converters in a high-density, low-power, multifunction common module and the development of a multifunction parallel processor.

Milestones/Metrics.

FY1998: Module design and prototyping; validate LCC module.

FY1999: Module assembly, fabrication, integration, and laboratory tests resulting in 10:1 reduction in weight.

FY2000: Install on SH–60 and conduct flight demonstrations that validate a 5:1 reduction in wiring and 8:1 reduction in LCC.

Customer POC	Service/Agency POC	USD(A&T) POC
CAPT R. Kollmorgem, USN	Mr. William King	Dr. Jasper Lupo
PMA-299	ONR	DDR&E(SEBE)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602122N		2.3	0	0	0	0	0
0603217N	R0446	0.9	3.4	3.5	0	0	0
	Total	**3.2**	**3.4**	**3.5**	**0**	**0**	**0**

SE.26.01 Millimeter-Wave Power Modules

Objectives. Develop compact, lightweight, highly efficient transmit/receive modules operating in the 18–40-GHz frequency range. The module technology supports ongoing and planned communications and electronic warfare systems and is compatible with application in multifunctional electronically steered, active arrays.

Payoffs. Initial evaluation of the millimeter-wave power module (MMPM) technology for electronic warfare is planned for FY98 with the implementation of a 1 x 8 active, electronically steerable array (NATO TRIAL MACE test) and an ALE–50-based MMPM towed decoy. Specific metrics for the MMPM effort are a wideband efficiency of greater than 30% and output powers greater than 45 W. This DTO supports JWCO Information Superiority (A.10, High-Altitude Endurance Unmanned Aerial Vehicle ACTD, and A.13, Satellite C^3I/Navigation Signals Propagation Technology); Combat Identification, Electronic Combat, and Joint Theater Missile Defense JWCOs are also supported. This effort, which started in 1995, demonstrated a millimeter wave power module that achieved 40-W peak power over the 18–40-GHz frequency range in a 35 in^3 volume.

Challenges. The primary technical challenges encountered in this development are driven by the need to obtain efficient power production in a small package and to obtain a proper balance between performance and affordability. As with the microwave power module, the approach is to distribute the RF gain between the solid-state driver and the vacuum power booster to reduce the size, increase the efficiency, and reduce the noise performance of the module. The MMIC driver, vacuum amplification stage, and electronic power conditioning are optimized for functionality and efficiency. The need to respond to specific applications at an affordable cost determines the module configuration.

Milestones/Metrics.

FY1998: Plan initial evaluation of the MMPM technology for electronic warfare with implementation of a 1 x 8 active, electronically steerable array (NATO TRIAL MACE test) and an ALE–50-based MMPM towed decoy.

Customer POC	Service/Agency POC	USD(A&T) POC
Mr. Scott Sharp	Dr. Ingham Mack	Dr. Susan Turnbach
AFSPC	ONR	DDR&E(SEBE)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602234N		0.6	0	0	0	0	0
0603203F	69CK	0.2	0	0	0	0	0
	Total	**0.8**	**0**	**0**	**0**	**0**	**0**

SE.27.01 Microwave SiC High-Power Amplifiers

Objectives. Develop compact, lightweight, highly efficient L- through X-band microwave solid-state transmitter building blocks for potential use in high-performance radar, communications, and electronic warfare systems. This DTO will develop advanced silicon carbide (SiC)-based field-effect transistors (FETs) and static-induction transistors (SITs) that meet output power, power density, efficiency, linearity, operating voltage, and temperature. These transistors provide size, reliability, and life-cycle cost advantages over competing Si and GaAs-based solid-state amplifiers and tube-based RF transmitter systems.

Payoffs. This DTO directly supports the Air Force's AN/TPS–75 ground-based radar transmitter upgrade; impacts Army Patriot, GBR, and THAAD systems; and affects ground-based, shipborne, and airborne surveillance, fire control radars, and EW jammer equipment. In FY97, the program will complete development of (1) 75-W S-band power SIT and (2) high-temperature interconnects as needed for SiC MMICs. The FY98 goal is development of 150-W S-band SIT and 10-W X-band metal semiconductor FET (MESFET). The program will demonstrate, by FY99, the applicability of a wide bandgap material, SiC, to prove high-power microwave amplifiers by demonstrating a 300-W S-band SIT and 100-W, 10-GHz hybrid amplifier.

Challenges. The challenges lie in material quality and uniformity, scaling to large active areas, affordability and manufacturability, and thermal management.

Milestones/Metrics.

FY1998: Develop 150-W S-band SIT and 25-W X-band MESFET.

FY1999: Assess the applicability of SiC to high-power microwave amplifiers by demonstrating a 300-W S-band SIT and 100-W, 10-GHz hybrid amplifier.

Customer POC	Service/Agency POC	USD(A&T) POC
Col Patrick Madden, USAF	Mr. Tim Kemerley	Dr. Susan Turnbach
$ASC^2A/C2CG$	AFRL-WL	DDR&E(SEBE)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602204F	2002	0.9	0.8	0	0	0	0
0602234N		0.3	0	0	0	0	0
0603739E	MT-06	2.0	2.0	0	0	0	0
	Total	**3.2**	**2.8**	**0**	**0**	**0**	**0**

SE.28.01 Low-Power Radio Frequency Electronics

Objectives. Develop new, lower power RF devices and components that are needed to improve sensitivity, selectivity, and dynamic range while minimizing power consumption in planned and ongoing communications and sensor-based systems. Present microwave and RF electronics for antenna arrays used on airborne and space-based platforms are inadequate in terms of size, weight, and power consumption. In addition, the demands for low-observable detection and high-speed communication in a severe jamming environment are challenging available technology. This DTO supports DTO SE.63.02, Digital Beamforming Antenna Technology.

Payoffs. This DTO encompasses design, fabrication, and simulation of device structures, circuits, and materials for miniaturized low-loss filters and microresonators, miniature digital receivers, and direct digital synthesizers. State-of-the-art high-resolution A/D and D/A converters will be integrated with monolithic microwave circuits using advanced mixed mode microwave/digital packaging technologies. Miniature filters will be embedded in the module package. The resulting miniature digital receiver and synthesizer modules will achieve a 10:1 size reduction over present technology. In the near term, this technology will benefit advanced system concepts, especially UAV and spaceborne platforms where size and weight reductions are critical. In the longer term, this technology will enable fully digital beamsteering arrays.

Challenges. The challenges in this program are achieving low-power consumption together with low noise and high-dynamic range demanded by a military jamming environment, and developing design tools suitable for mixed RF/frequency-domain and digital/time-domain simultaneous simulations.

Milestones/Metrics.

FY1998: Demonstrate miniature X-band (8–12-GHz) filters for advanced receiver applications.

FY1999: Fabricate and evaluate miniature digital receivers and direct digital synthesizers to reduce the weight and volume of portable and airborne systems enabling digital array radar, communication, and electronic warfare.

Customer POC	Service/Agency POC	USD(A&T) POC
Mr. Viktor Jonkoff	Mr. Tim Kemerley	Dr. Susan Turnbach
JSF	AFRL-WL	DDR&E(SEBE)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602204F	2002	0.9	0.7	0	0	0	0
0603203F	69CK	0.6	0.5	0	0	0	0
	Total	**1.5**	**1.2**	**0**	**0**	**0**	**0**

SE.29.01 Design Technology for Radio Frequency Front Ends

Objectives. Develop tools and processes for the rapid and efficient design of monolithic microwave integrated circuits (MMICs), multichip assemblies, and mixed signal electronic subsystems for use in high-performance, military-essential electronic warfare, radar, and communication systems. Work focuses on providing enhancements by leading computer-aided engineering (CAE) tool suppliers with tight coupling to the microwave and millimeter-wave industry and establishing processes to ensure that end-user requirements are addressed. The resulting capabilities will become part of the commercial product lines of the leading CAE suppliers and will, therefore, be sustained after the (microwave and analog front-end technology (MAFET)) program ends.

Payoffs. The overall payoff is to drive down system front-end costs, increase system front-end capabilities, enhance system portability, upgrade reliability, and reduce life-cycle costs. The MAFET design environment will help accomplish the above cost objectives by reducing RF multichip assembly module development from the present 20 person-years of effort to 6 and the cycle times from over 3 years to 1 by FY99. The MAFET design system will enable the synthesis and simulation of military-unique components for a broad range of sensor system applications.

Challenges. The challenges involve reducing the number of design cycles by providing more accurate models and developing a behavioral modeling capability to support virtual prototyping. Another challenge is to reduce the time per design cycle by developing faster simulation tools and better integration of design tools to allow more portability of designs and models among tools.

Milestones/Metrics.

FY1998: Release the Beta version of design environment to all benchmark sites; demonstrate mixed-signal coupling and contamination analysis software.

FY1999: Evaluate the final version of design environment for mixed-signal RF front-end designs.

Customer POC	Service/Agency POC	USD(A&T) POC
Mr. Viktor Jonkoff	Ms. Elisa Sobelewski	Dr. Susan Turnbach
JSF	DARPA/ETO	DDR&E(SEBE)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602204F	6096	1.5	1.9	0	0	0	0
0603739E	MT-06	9.1	0	0	0	0	0
	Total	**10.6**	**1.9**	**0**	**0**	**0**	**0**

SE.33.01 Advanced Focal Plane Array Technology

Objectives. Using cooled and uncooled arrays, increase range and target acquisition by improving the noise-equivalent delta temperature (NEDT) of uncooled sensors and by fusing two or more bands of cooled detectors, resulting in a higher target discrimination.

Payoffs. Uncooled focal plane arrays (FPAs) are low in cost, weight, and power consumption. Consequently, applications in the low-to-medium performance military market will proliferate if the sensitivity and resolution can be improved. Fusing two or more bands of cooled high-performance FPAs will result in a sensor with improved detection range and an order of magnitude reduction in false alarm rates. Using sophisticated growth and fabrication techniques will increase the functionality of FPAs and make them more affordable.

Challenges. The major challenges for the uncooled sensor are the reduction in thermal isolation and the increase in responsivity of uncooled detector material. The major challenges for the high-performance cooled arrays are to grow the substrates monolithically on silicon and develop on-chip readouts to pre-process and fuse the large data rates.

Milestones/Metrics.

FY1998: Demonstrate monolithic 1024 x 1024 mid-wavelength infrared (MWIR) FPA.

FY1999: Demonstrate NEDT of 0.01K for uncooled FPA with 30-μm pixels; demonstrate a 10X reduction in false alarm rate with dual-band FPA sensing, resulting in a 2X increase in effective detection range.

FY2000: Complete flexible manufacturing technology for HgCdTe for burst-mode operation.

Customer POC		Service/Agency POC	USD(A&T) POC
Mr. R. Habayeb	Mr. C. Thorton	Dr. Stuart Horn	Dr. Susan Turnbach
NAVAIR 4.OT	USA DBBL	NVESD	DDR&E(SEBE)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602234N		0.8	0.8	0	0	0	0
0602702F	4600	0.8	0.7	0	0	0	0
0602705A	H94	0.9	1.0	0	0	0	0
0602709A	H95	4.6	4.1	0.3	0	0	0
0603739E	MT-03	8.7	11.0	3.0	0	0	0
	Total	**15.8**	**17.6**	**3.3**	**0**	**0**	**0**

SE.35.01 Optical Processing and Memory

Objectives. Develop radically new optical concepts to achieve data storage of terabit to petabit (10^{12}–10^{15}) per cubic centimeter with nanosecond access times and optical interconnect technologies that provide terabit-per-second throughput between chips, boards, and processors. The goal is to achieve tera-operations-per-second processing in a massively parallel optoelectronic processor that is small in size and low in power consumption.

Payoffs. High-speed signal processing and information storage needs are driven by the operational realities of increasing jammer densities against C^4I assets, low-observable target surveillance, and the requirement to manage large intelligence databases. Performance limits of conventional electronic approaches to air and ground surveillance are stressed by low-observable threats, sophisticated electronic countermeasures, increased target densities, and complexity of the modern battlefield, all of which make high-processing speeds essential. Hybrid or all-optical techniques provide solutions to the processing bottleneck at reasonable levels of cost, power consumption, and volume.

Challenges. Major challenges are developing large (1,000/cm^2) "smart" pixel and detector arrays and new materials for high-density holographic data storage and erasable optical discs. Also, memory access times need to be lowered, typically in the millisecond range and higher for disc and magnetic memories to the 1-100-ns range. Optoelectronic integration to reduce size and cost is a major challenge in the implementation of parallel interconnects and processors.

Milestones/Metrics.

FY1999: Demonstrate a 2.5-Gbps parallel optical interconnect; demonstrate a 3D write once–read many (WORM) optical memory system.

FY2000: Demonstrate a 1-Gbps free-space optical interconnect; demonstrate a 3D read–write–erase optical memory.

Customer POC		Service/Agency POC	USD(A&T) POC
Mr. L. Fenstermacher	Mr. M. Tinney	Dr. Don Hanson	Dr. Susan Turnbach
ACC	USAF/AIA	AFRL-RL	DDR&E(SEBE)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602702F	4600	3.0	2.0	1.5	0	0	0
0603726F	2863	0	0.8	0.9	0	0	0
0603726F	2810	0.7	1.8	1.6	0	0	0
0603739E	MT-04	9.6	10.0	0	0	0	0
	Total	**13.3**	**14.6**	**4.0**	**0**	**0**	**0**

SE.36.01 Photonics for Control and Processing of Radio Frequency Signals

Objectives. Develop photonics technology to route, control, and process RF and microwave signals in military applications including photonic components and systems for control of phased array antennas and distribution of RF signals.

Payoffs. Conventional phased arrays are limited to 10% bandwidth because the phase shifters are frequency dependent, resulting in beam "squint" for broadband signals. Fiber optics provide true time delay, which eliminates this problem. The antenna beam control technology will result in >1,000X improvement in bandwidth capability for ISR sensors and substantial cost savings due to lighter, smaller (by a factor of 100), and less complex assemblies. Beam control provides antijam, wideband, multimode phased array antennas for such applications as GPS and UAVs. Fiber optics also enables the remoting of antennas and emitters over kilometer distances, whereas coaxial links are limited to a few hundred feet by inadequate frequency response and dispersion.

Challenges. Optical fiber and planar waveguides provide a broadband, low-loss transmission medium for long, distortionless communications links for emitter remote operation and true time delay for optical beamforming. Most applications have stringent dynamic range requirements; consequently, the principal challenge lies in developing the components including low-relative intensity noise (<150 dB/Hz) laser diode sources, fast power-tolerant (100 mW) detectors, linearized modulators, and low-insertion-loss (<1 dB) switches to meet the requirements.

Milestones/Metrics.

FY1999: Demonstrate 1–100-GHz optical radio frequency synthesizer with -90-dBc phase noise. Develop modulators and detectors for 30–300 GHz with <3 dB insertion loss.

FY2000: Demonstrate an optically controlled phased array for SATCOM and ECM. Develop a 2–18-GHz optical interconnect for airborne signal distribution.

Customer POC		Service/Agency POC	USD(A&T) POC
Mr. John Montgomery	Mr. M. Tinney	Dr. Don Hanson	Dr. Susan Turnbach
NRL	USAF/AIA	AFRL-RL	DDR&E(SEBE)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602234N		3.4	3.1	0.4	0	0	0
0602702F	4600	3.7	4.0	3.5	0	0	0
0603726F	2863	1.1	0.2	0	0	0	0
	Total	**8.2**	**7.3**	**3.9**	**0**	**0**	**0**

SE.37.01 High-Density, Radiation-Resistant Microelectronics

Objectives. Focus on high-performance, extremely dense, radiation-resistant microelectronics that are key to continued U.S. domination of battlefield surveillance, intelligence, and communications as well as joint theater missile defense. Space applications, which presently dominate requirements for radiation-resistant microelectronics, need to operate reliably after exposure to natural and nuclear radiation (e.g., total dose 300 krad, dose rate upset thresholds 10^8 rad/s, SEU thresholds 40 MeV-cm^2/mg).

Payoffs. Strategic missiles (Minuteman and Trident), BMDO interceptor systems, and satellites such as MILSTAR, UHF Follow-On, GPS–IIF, DSP, SBIRS–High, SBIRS–Low, and Advanced EHF require radiation-resistant microelectronics. This DTO provides these space and strategic systems with timely access to key microelectronic technologies. The technologies developed also provide significant reductions in weight, size, and power while simultaneously increasing performance.

Challenges. Challenges include (1) developing affordable process, design, and layout of microelectronics to enable them to survive in the unique radiation environments required by DoD systems; (2) applying electronic design automation tools in conjunction with high-volume commercial processes to close the gap between radiation-resistant and commercial devices; and (3) reducing piece-part costs to DoD customers by increasing commercial purchases.

Milestones/Metrics.

FY1998: Develop submicron, radiation-resistant microelectronics fabrication process to enable development of a 4-Mb SRAM and 32-bit data processor.

FY1999: Demonstrate 256-kb nonvolatile memory; develop mixed-signal sensor processor that incorporates next-generation packaging concepts; develop an ultra low power, 12-bit A/D converter; demonstrate how commercial automated electronic design tools can be adapted to meet radiation-hardened electronics requirements.

FY2000: Demonstrate a radiation-hard 4-Mb SRAM with 16X density improvement and <2X the speed; space qualify high-speed device manufacturing technology.

FY2001: Qualify submicron 4-Mb memories, single-chip 32-bit data processor, and 3,000-k gate array; demonstrate a high-gate-count (~400,000) rad-hard field-programmable gate array; develop a scaleable, open-system space computer architecture.

FY2002: Demonstrate space qualifiable data processor node for scaleable space computer.

Customer POC	Service/Agency POC	USD(A&T) POC
Ms. Karen Basany SMC	Dr. B. Singaraju AFRL	Dr. Susan Turnbach DDR&E(SEBE)
Mr. Erwin Myrick BMDO/TRS	Mr. R. C. Webb DSWA/ESE	

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602601F	8809	3.5	3.3	4.1	4.4	4.8	0
0602715H	AF	5.8	0	0	0	0	0
0602715BR	AF	0	6.7	5.8	7.3	7.5	7.7
0603401F	2181	9.0	8.6	9.2	8.4	9.2	0
	Total	**18.3**	**18.6**	**19.1**	**20.1**	**21.5**	**7.7**

SE.38.01 Microelectromechanical Systems

Objectives. Develop MEMS components that are expected to improve the size, weight, cost, and assembly complexity of existing applications areas such as positioning systems and inertial guidance systems by an order of magnitude. MEMS sensor and actuator arrays are expected to increase performance, capability, and lifetime of major systems such as communications and military platforms.

Payoffs. This DTO will merge sensing, computation, and actuating to realize new systems and strategies for both perceiving and controlling weapon systems, processes, and battlespace environments. MEMS promises to allow new programs started in the near term to deploy accelerometer and inertial guidance functions an order of magnitude lower in size, weight, cost, and assembly complexity than alternative technologies.

Challenges. Key near-term challenges are to develop the basic materials, devices, and processes to integrate mechanical components with sensing, computing, and actuating components at a density of 1,000 mechanical components/cm^2 with on-chip microelectronics of at least 10,000 transistors. A basic support for this technology area will be the development of an infrastructure that not only can build single prototype components at increasing densities and complexities, but also lays the foundation for establishing a reliable, assured industrial base to supply emerging defense applications.

Milestones/Metrics.

FY1998: Demonstrate integration densities of 500 components/cm^2.

FY1999: Demonstrate high-density data storage of 40X greater capacity; demonstrate integration densities of 1,000 components/cm^2; demonstrate microactuators for airfoils.

FY2000: Demonstrate MEMS devices for RF applications, filters, and switches.

Customer POC	Service/Agency POC	USD(A&T) POC
Mr. Viktor Jonkoff	Dr. A. P. Pisano	Dr. Susan Turnbach
JSF	DARPA/ETO	DDR&E(SEBE)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0603739E	MT-12	52.0	55.5	29.3	0	0	0
	Total	**52.0**	**55.5**	**29.3**	**0**	**0**	**0**

SE.39.01 Wide-Bandgap Electronic Materials Technology

Objectives. Develop high-performance, wide-bandgap semiconductor materials for compact transmitters used in military-essential RF radars, communications and electronic warfare sensors, and laser sources and detectors. Goals include development of lattice-matched substrates for SiC and GaN devices and methods to produce uniform semi-insulating and doped films.

Payoffs. Attainment of SiC goals will enable production of high-power switches operating at 1,000 V and at current densities exceeding 1,000 A/cm^2. The resultant power density exceeds that of silicon by a factor of five, achieving considerable size and weight reduction of power supplies. Attainment of the III–N goals will allow high-power RF performance and development of long-life lasers.

Challenges. SiC RF power device production requires 3-inch substrate diameter. Semi-insulating, lattice-matched substrates are required for planar RF device technology. Defect levels must be reduced to avoid compensation and to improve dielectric strength. Viable lattice-matched substrates are needed for GaN. Defect densities in GaN are still orders of magnitude too high for long-lived, high-frequency (30-GHz) RF devices. No shallow p-type dopant exists for SiC or GaN.

Milestones/Metrics.

FY1998: Demonstrate 2-in diameter wafers of 4H SiC with doping concentration variation <10% and micropipe density <5/cm^2; demonstrate high-resistivity SiC substrates.

FY1999: Demonstrate a commercially viable SiC epitaxy process; demonstrate a means to synthesize 1-in diameter substrates lattice matched to GaN.

FY2000: Demonstrate materials/processing quality commensurate with power device structures with <10% performance variation across wafer.

FY2001: Transfer to manufacturing 3-in diameter wafers of 4H SiC with doping concentration variation <10% and micropipe density <5/cm^2.

Customer POC	Service/Agency POC		USD(A&T) POC
Mr. Viktor Jonkoff	Dr. Ben Shanabrook	CDR Robert Childs, USN	Dr. Susan Turnbach
JSF	NRL	BMDO/TOS	DDR&E(SEBE)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602173C	1651	1.6	1.6	1.6	1.6	0	0
0602173C	1660	0.5	0.5	0.5	0.5	0	0
0602204F	2002	0.1	0.1	0.1	0	0	0
0602234N		0.3	0.3	0.3	0.3	0	0
0602702F	4600	0.2	0.2	0.1	0	0	0
0602712E	MPT-02	1.9	2.0	0	0	0	0
	Total	**4.6**	**4.7**	**2.6**	**2.4**	**0**	**0**

SE.43.01 Energy Conversion/Power Generation

Objectives. Demonstrate safe, small, lightweight, low-cost, environmentally compatible power sources with higher power and energy densities and improved flexible charging systems.

Payoffs. Payoffs include lower costs; lighter burden for the warrior; longer periods of autonomous operation; more user friendly systems; smaller, lighter systems with higher efficiencies; and reduced thermal signature.

Challenges. Several barriers need to be overcome: increasing energy density while maximizing safety, providing logistically acceptable charging systems; attaining good low-temperature performance, developing autonomous charging systems for small-unit operations, and minimizing overall system size and weight and improving efficiency of system through the use of power electronics that suppress acoustic and thermal signatures.

Milestones/Metrics.

FY1998: Deliver prototypes of next-generation primary battery with 30% more energy (225 Whr/kg); develop low-temperature (–30°C) electrolyte for lithium-ion batteries, 50-W/200-Whr fuel-cell system weighing 1 kg, and 150-W/600-Whr fuel-cell system weighing 2.5 kg.

FY1999: Demonstrate universal vehicle-mounted field charger capable of charging six types of batteries, 100-W fuel cell-powered continuous duty silent charger, and fuel-cell battery (350 Whr/kg and 50 W/kg).

FY2000: Demonstrate (1) zinc-air, low-cost ($0.10/Whr) primary battery for training, battery recharging, and remote operations, (2) safer, higher energy (100-Whr/kg) rechargeable lithium-ion batteries, (3) liquid-fueled fuel-cell system providing 2,000 Whr/kg of fuel, and (4) diesel-fueled 500-W thermophotovoltaic portable power source with 13% efficiency.

FY2001: Demonstrate pouch primary battery with 50% more energy (250 Whr/kg) in flexible and conformal packaging and polymer rechargeable batteries capable of 120 Whr/kg.

Customer POC	Service/Agency POC	USD(A&T) POC
Mr. Tom Nycz	Mr. Rob Saunders	Dr. Susan Turnbach
USA CECOM	SARD-TT	DDR&E(SEBE)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602705A	H11	1.9	1.9	1.9	1.9	0.6	0
0602712E	MPT-01	1.8	2.4	1.8	0	0	0
	Total	**3.7**	**4.3**	**3.7**	**1.9**	**0.6**	**0**

SE.44.01 Power Control and Distribution

Objectives. Develop, demonstrate, and transition high-density, high-efficiency power conversion systems for microelectronics applications in the 1–100-watt regime that will advance the architectures, topologies, power devices and components, and control electronics. These devices (converters) must meet the power quality, density, and voltage requirements for the next-generation digital or analog avionics subsystems and power electronic building blocks (PEBBs) module applications. This DTO will also develop integrated high-density efficiency power supplies, solid-state switching devices (power ICs), and new materials and packaging technologies that combine low-profile passive components, sensors, circuit leads, high-density interconnections, and thermally efficient substrates.

Payoffs. This DTO will provide more performance and efficient power supplies that conform to system requirements while providing lower cost power components and devices through standardization and common architecture. Self-configuring power modules will provide a single subsystem for multiple applications.

Challenges. The challenges include the simultaneous development and advancement of microelectronics component power supply technologies while reducing the system cost. Power devices and microelectronics controls need to be integrated for reduced footprint, cost, and control PEBB functions. Development of 1,500-V isolation from PEBB module operation, composite substrates with thin film magnetic material and dielectrics materials, algorithms for self-configuring input/output, EMI resistance to PEBB and like environments, and power density are factors that must be considered.

Milestones/Metrics.

FY1998: Demonstrate 100-W power module using GaAs heterojunction biopolar transistors (HBTs) for analog radar applications.

FY2000: Demonstrate advanced power circuit designs that lead to a 300% improvement in power density; demonstrate multifunction 30-W power supply.

FY2001: Select candidate device materials and structures for 100-MHz power switches.

FY2002: Fabricate and test power devices up to 100-MHz switching rates.

FY2003: Demonstrate power devices in a high-frequency resonant power topology using high-density interconnect packaging approaches.

Customer POC	Service/Agency POC	USD(A&T) POC
LCDR Tim McCoy, USN	Dr. Ingham Mack	Dr. Susan Turnbach
NAVSEA-03Z	ONR	DDR&E(SEBE)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602121N		0.3	0.3	0.3	0.3	0	0
0602204F	6096	0	0	0	0.5	0.4	0.5
0602234N		0.3	0.3	0.3	0.3	0	0
	Total	**0.6**	**0.6**	**0.6**	**1.1**	**0.4**	**0.5**

SE.45.01 Forecast of Littoral Currents and Waves

Objectives. Develop and deliver for operational testing an on-scene forecast capability for small-scale currents and waves in littoral areas. This DTO provides capabilities required by Joint Readiness and Logistics and Sustainment of Strategic Systems, and Force Projection/Dominant Maneuver (M.02, Extending the Littoral Battlespace ACTD, and G.04, Joint Countermine ACTD).

Payoffs. This program will develop and demonstrate on-scene, workstation-hosted, four-dimensional ocean current and waves forecast capabilities for the littoral environment, which are important to contingency planning, operational planning, and execution of a number of naval operations in the littoral environment. Exploitation of accurate forecasts during a naval raid to improve ingress and egress locations and timing can lead to an increase of 15% combat power put ashore, an increase of 75% in the time period for full force operations, and a 20% reduction in high vulnerability/risk time in extracting the force ashore.

Challenges. Technical barriers include development of four-dimensional numerical ocean prediction models that incorporate adequate physics of the littoral ocean, and fast and efficient computer codes for workstation-hosted environments.

Milestones/Metrics.

FY1998: Inclusion of models with tidal and density-driven currents will allow a true near-shore capability. Upgrade the existing operational Navy standard surf model, including wave transformation caused by refraction and diffraction in shallow water coupled to an upgraded surf forecast module.

FY1999: Add effects of coupled waves and tides as an upgrade.

FY2000: Transition the additional inclusion of high-resolution coastal current capabilities to operational environmental systems afloat and to the NAVOCEANO Warfighting Support Center.

Customer POC	**Service/Agency POC**	**USD(A&T) POC**
CDR Dave Titley, USN	Dr. John Harding	Col Alan Shaffer, USAF
NAVOCEANO	NRL	DDR&E(SEBE)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
S&T Funding							
0602435N		1.7	1.2	1.2	0	0	0
Total S&T		**1.7**	**1.2**	**1.2**	**0**	**0**	**0**
Non-S&T Funding							
ACW		0.5	0.5	0.5	0	0	0
Total Non-S&T		**0.5**	**0.5**	**0.5**	**0**	**0**	**0**

SE.47.01 Autonomous Ocean Sampling Network: Mapping of Ocean Fields

Objectives. Demonstrate the utility of autonomous unmanned underwater vehicles (UUVs) for environmental characterization. Field trials will show the capability of acquiring, in a littoral zone, real-time ocean and bathymetric data necessary for mine warfare (MIW), amphibious warfare, and anti-submarine warfare (ASW) operations. This DTO supports Force Projection/Dominant Maneuver (G.09, Advanced Mine Reconnaissance/Minehunting Sensors) and Information Superiority.

Payoffs. This DTO will demonstrate a revolutionary capability in ocean mapping. The revolutionary nature of autonomous ocean sampling networks for naval warfare in the future has been endorsed by the Secretary of the Navy and the Chief of Naval Operations. Of great significance is the ability of UUVs to conduct ocean sampling in a covert manner, especially in those littoral operations where military interest must remain concealed but where environmental data are necessary prior to the operation. The need for a real-time covert or overt means of acquiring ocean environmental data is a high priority of the Naval Oceanographic Office (NAVOCEANO).

Challenges. Short-term technical barriers include multiple vehicle underwater communications, sub-surface navigation, and small, lightweight sensors for the variety of ocean properties.

Milestones/Metrics.

FY1998: Conduct joint operations off North Carolina with NAVOCEANO's remotely operated vehicles and autonomous vehicles to achieve programmed mapping of critical 3D ocean fields; establish intercomparative metric statistics; establish autonomous mapping capabilities in regions too shallow for survey ships.

FY1999: Integrate latest technology for ocean mapping with the UUV; develop field plans.

FY2000: Demonstrate an integrated autonomous ocean sampling network of oceanographic measurement nodes for high-resolution spatial and temporal characterization of complex ocean features—bottom bathymetry accurate to 1 m horizontal and 0.5 m vertical resolution—and for measurement of sound speed to 1 m/s; result will be metrics for military survey capability in terms of International Hydrographic Office standards.

Customer POC	**Service/Agency POC**	**USD(A&T) POC**
Mr. Pete Ranelli	Dr. Tom Curtin	Col Alan Shaffer, USAF
CNMOC	ONR	DDR&E(SEBE)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
S&T Funding							
0602435N		2.5	0.6	0.7	0	0	0
Total S&T		**2.5**	**0.6**	**0.7**	**0**	**0**	**0**
Non-S&T Funding							
ACW		0.3	0.3	0.3	0	0	0
Total Non-S&T		**0.3**	**0.3**	**0.3**	**0**	**0**	**0**

SE.52.01 Weather/Atmospheric Impacts on Sensor Systems

Objectives. Develop and validate models that translate the measured or forecasted state of the atmosphere into terms that define the impact of the atmosphere on specific combat systems and operations. A common requirement of combat systems is a knowledge of the propagation of EM energy at the required wavelengths (visible to microwave regions), with substantially increased spectral resolutions to support emerging hyperspectral and ultraspectral systems.

Payoffs. This DTO will provide joint service developments of atmospheric propagation models and comprehensive EO tactical decision aids (EOTDAs) that incorporate improved transmission and propagation models into a complete description of targets, backgrounds, and system characteristics.

Challenges. The primary barrier is expanding computer codes to fully account for the environment and its interaction with system performance via physically based models that execute efficiently on transportable computers.

Milestones/Metrics.

FY1998: Develop IR thermal model for advanced EOTDA with a 25% improvement in lock-on range; demonstrate 40%–60% increase in weather data input to mission planning and transition sea radiance model.

FY1999: Provide an enhanced MODTRAN (atmospheric transmission) code for a night vision goggles scene simulation tool; provide a model for aerosol beneath marine stratus.

FY2000: Provide a model of scintillation effects on near-surface IR transmission over water.

FY2001: Transition tactical targeting EO simulator to AF Mission Planning System, introducing the capability to specify detailed scenes based on spectral response of the weapon system.

FY2002: Develop an integrated multiwavelength atmosphere-cloud transmission/emission model that provides, for the first time, an out-of-the-cockpit, scene-rendering capability.

FY2003: Transition an airborne laser single-frequency transmission model for tactical decision aid.

Customer POC	**Service/Agency POC**	**USD(A&T) POC**
Col Jack Hayes, USAF	Mr. Paul Tattelman	Col Alan Shaffer, USAF
AFWA	AFRL-SNZ	DDR&E(SEBE)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
S&T Funding							
0602435N		1.7	1.7	1.6	1.0	1.0	0
0602601F	1010	1.5	1.5	1.5	1.0	1.1	0.7
0602784A	H71	3.1	3.3	3.0	2.7	1.3	0
0603707F	2688	1.4	1.4	1.4	1.2	0	0
Total S&T		**7.7**	**7.9**	**7.5**	**5.9**	**3.4**	**0.7**
Non-S&T Funding							
0603319F	4269	1.0	0.6	0.6	0	0	0
Total Non-S&T		**1.0**	**0.6**	**0.6**	**0**	**0**	**0**

SE.53.01 On-Scene Weather Sensing and Prediction Capability

Objectives. Develop local, regional, and global prediction systems that describe and forecast battlespace environment parameters to support the increased use of sophisticated environment-sensitive battlespace surveillance, communications, and weaponry assets for mission planning; ship, aircraft, and ground vehicles movement; logistics; and strategic and tactical operations.

Payoffs. The goal is a weather sensing, analysis, and forecast capability based on robust regional and battlespace models to satisfy joint service needs. This leads to a broad area 10% forecast improvement in militarily significant weather, with improvement of up to 40% for selected small-scale forecasts.

Challenges. The spatial resolution and physical-completeness of computerized forecast models are required, and new sensor systems and "through-the-sensor" data need to be incorporated into local analysis systems.

Milestones/Metrics.

FY1998: Ground-based mobile atmospheric profiler that can reduce the observatio0nalysis turnaround time by 4–8 hr, thereby reducing vehicle and personnel demands by one-third and completing the transition of weather algorithms for USAF Theater Battle Management support.

FY1999: Nested regional prediction system for operational implementation capable of improving forecast resolution by 5X, allowing prediction of tactical parameters such as visibility and EM refractivity; deliver to the USA's Integrated Meteorological System an upgraded battlefield forecast model reducing the error of cloud amount/precipitation forecasts by 40%.

FY2001: Assimilate all-source data into on-scene prediction systems for high-resolution 4D depiction of weather and sensor performance; validate a regional forecast model designed to provide, for the first time, support to contrail avoidance mission requirements.

Customer POC	**Service/Agency POC**	**USD(A&T) POC**
CAPT Bob Clark, USN	Dr. Scott Sandgathe	Col Alan Shaffer, USAF
CNO N961	ONR	DDR&E(SEBE)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602435N		1.4	1.1	0.8	0.7	0	0
0602601F	1010	0.9	1.0	0.8	0.5	0	0
0602784A	H71	0.9	1.0	0	0	0	0
0603707F	2688	0.5	0	0	0	0	0
	Total	**3.7**	**3.1**	**1.6**	**1.2**	**0**	**0**

SE.55.01 Space Radiation Mitigation for Satellite Operations

Objectives. Establish the relationship between the space radiation environment, satellite anomalies, and satellite systems degradation/failures, and develop techniques/instrumentation to mitigate these adverse effects or to provide alerts for hazardous space environments. DoD dependency on space-based assets makes it imperative that space systems provide uninterrupted support to military operations. Satellite operations are adversely affected by space radiation causing transients failure of electronic components and degradation of power systems.

Payoffs. Major benefits are increased understanding of the complex interactions of spacecraft systems, subsystems, and components with the space radiation environment and the implications of those interactions for both systems design and operations. The operational benefits include improved spacecraft reliability and availability, extended mission durations, and increased autonomy, which will reduce spacecraft development, operations, and maintenance costs.

Challenges. The technology challenges are to demonstrate in space highly miniaturized operational sensors systems for real-time alerts of space environmental hazards, and to develop and fly a compact system that can routinely determine the space environmental hazards to new and emerging space technologies. Specific demonstrations are the Compact Environmental Anomaly Sensor (CEASE) to provide real-time alerts; and the Small On-Board Environmental Diagnostic Sensors (SOBEDS) to provide in situ monitoring of the space radiation environment, determine and mitigate the effects of high-voltage interactions, and mitigate the effects of space radiation on components and materials.

Milestones/Metrics.

FY1998: Complete design and fabrication of SOBEDS; first proof-of-concept flight for CEASE in a moderate radiation environment aboard TSX–5; begin design of radiation effects experiment.

FY1999: Initial assessment of CEASE performance based on TSX–5 flight data; fly the second prototype CEASE unit aboard STRV–1c/d; deliver and fly the prototype CEASE units for flight aboard SBIRS; fly the SOBEDS.

FY2000: Continue analysis of CEASE flight data to assess operational effectiveness: goal of 90% local specification of hazardous space conditions for satellites flying CEASE.

FY2001: Begin design of high-voltage interactions experiments.

FY2003: Begin fabrication of high-voltage interactions experiments and component testing of radiation effects experiment.

Customer POC	Service/Agency POC	USD(A&T) POC
Maj M. Volek, USAF	Dr. Dave Hardy	Col Alan Shaffer, USAF
AFSPC/XPX	AFRL	DDR&E(SEBE)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0603410F	2822	2.1	2.9	3.5	3.7	3.8	4.0
	Total	**2.1**	**2.9**	**3.5**	**3.7**	**3.8**	**4.0**

SE.56.01 Satellite Infrared Surveillance Systems Backgrounds

Objectives. Develop and demonstrate integrated background clutter suppression and mitigation technologies required to ensure space surveillance and threat warning system operations for the detection and tracking of targets in cluttered optical and infrared backgrounds. This DTO will pursue advances in target-background discrimination through the development and integration of background clutter suppression tools into hardware simulators to optimize system performance prior to deployment for the full system design trade space and operational conditions.

Payoffs. The background clutter suppression and mitigation technologies developed under this DTO will specifically support the design and operations of the Space-Based Infrared System (SBIRS). Due to new space-based infrared surveillance system mission requirements, new IR sensors are required that will operate in new IR bands and at significantly higher spatial footprints and sensitivities. These new IR sensor designs depend critically on background clutter levels that are currently highly uncertain and may lead to poor system performance or system overdesign, hence added costs. This DTO will enable optimized system performance within cost for surveillance and threat warning (STW), theater and national missile defense (TMD and NMD), and intelligence, surveillance, and reconnaissance (ISR) systems. In addition, integrated background clutter suppression and mitigation technologies developed under this DTO will minimize theater system test and training costs.

Challenges. There are three major technical challenges being addressed by this DTO: data fusion of vast quantities of satellite data to provide radiometric and orthorectified scene depictions for predicting reliable background signatures for SBIRS trade space studies, reliable clutter rejection techniques to discriminate dim targets from high-background clutter; and real-time background clutter codes for target detection system operations.

Milestones/Metrics.

FY1999: Demonstrate 25% improvement in system band specification.

FY2002: Demonstrate 50% improvement in target image reconstruction.

FY2003: Demonstrate 50% improvement in real-time background clutter specification.

Customer POC	**Service/Agency POC**	**USD(A&T) POC**
Dr. William Frederick	Dr. William Blumberg	Col Alan Shaffer, USAF
BMDO/TOD	AFRL	DDR&E(SEBE)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
S&T Funding							
0602601F	1010	1.7	1.7	1.5	1.5	1.5	1.5
	Total S&T	**1.7**	**1.7**	**1.5**	**1.5**	**1.5**	**1.5**
Non-S&T Funding							
0603871C	1155	3.9	3.9	1.5	0.4	0.4	0.4
0603872C	1155	1.1	1.1	1.1	1.1	1.1	1.1
	Total Non-S&T	**5.0**	**5.0**	**2.6**	**1.5**	**1.5**	**1.5**

SE.57.01 Analog-to-Digital Converter

Objectives. Develop analog-to-digital (A/D) converters and related components to demonstrate digital receivers targeting military radar, EW, and C^4I systems, with the initial demonstrations in digital receivers and EW radar (E2C and AWACS). The A/D converter is the key component for managing all sensor data in a wide range of areas (e.g., space-based electronics, ASW, smart weapons, C^4I). Some specific impacts of these developments and demonstrations are a 16X improvement over current capabilities in over-the-horizon detection, detection of a submarine periscope in clutter, and precision tracking of horizon sea-skimming cruise missiles in clutter.

Payoffs. The application of advanced A/D converters in the building of digital receivers will enable substantial improvements in key military applications. A critical advantage of digital receivers will be agility, allowing a single receiver to support multiple applications over a broad range of frequencies and bandwidths. Elimination of analog circuitry will yield substantial improvements in system reliability, accuracy, and repeatability. Finally, elimination of bulky and costly down-conversion stages will reduce the size, weight, and cost of front ends for receivers. Programs that are expected to employ these technologies include the F–22, Comanche, JSF, Aegis SPY 1–D, F–15 APG–63 upgrade, F–18 APG–73 upgrade, E2C APS–145 surveillance radar, and B–2 APQ–181 radar.

Challenges. The challenges include developing high-speed, high-resolution A/D converters that require very high speed semiconductor devices with very low noise, innovative circuit design, accurate models for high-speed analog devices, and advanced packaging to overcome the performance-limiting factors of thermal noise, clock jitter, and device nonlinearities. The capabilities of many defense systems are currently limited by the performance of their A/D converters.

Milestones/Metrics.

FY1998: 10-bit, 1-Gsps A/D converter improvements for a single down-conversion receiver (1-GHz center frequency).

FY1999: 10-bit, 2-Gsps A/D converter; a direct conversion receiver (10-GHz center frequency); 16-bit, 125-Msps CMOS/SOS A/D converter; 4-bit, 20-Gsps CMOS/SOS A/D converter.

FY2000: High-resolution A/D converter, 16 bits, 100-MHz instantaneous bandwidth, and 100-dB Surrogate Future Digital Radio.

Customer POC	**Service/Agency POC**	**USD(A&T) POC**
Mr. Viktor Jonkoff	Mr. Tim Kemerley	Dr. Susan Turnbach
JSF	AFRL-RL	DDR&E(SEBE)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602204F	6096	0.7	0.1	0	0	0	0
0602234N		0.5	0.9	0.9	0	0	0
0602712E	MPT-02	12.5	11.0	2.0	0	0	0
0603203F	69CK	0.5	1.1	0	0	0	0
	Total	**14.2**	**13.1**	**2.9**	**0**	**0**	**0**

SE.58.01 Lookdown Bistatic Technology

Objectives. Develop and demonstrate passive (bistatic) airborne-spaceborne lookdown surveillance and target identification technologies, and transition them to operational assets such as UAVs, to reconnaissance assets such as Rivet Joint (DET–2 645th MATS), and to mission enhancements for the AWACS. Included in this development are bistatic imaging capabilities such as bistatic synthetic aperture radar (BISAR) technologies and adaptive interference cancellation techniques known as bistatic space-time adaptive processing (BISTAP).

Payoffs. Direct payoffs of this technology include covert, self-protection, long-range surveillance and target ID; augmented operating modes that enhance mission operations and performances; and quick transition into operational assets producing mission enhancements while avoiding the disruption of their standard performance.

Challenges. The technical challenges are lookdown clutter cancellation technologies and exploiting noncooperative, multiple illuminators sources. This includes the adaptive rejection of jammer-like signals—operating in high-signal-density environments and their associable interference in wartime conditions—and the constraints associated with operational platforms.

Milestones/Metrics.

FY1998: Demonstrate bistatic STAP algorithms on flight-ready hardware with 10-dB target detection improvement over conventional bistatic technology.

FY1999: Demonstrate airborne bistatic detection of targets between AWACS and a UAV surrogate platform; identify targets via multistatic topographic imaging-yielding structure accuracy within 3 m.

FY2000: Demonstrate combined coherent, noncooperative bistatic surveillance and target imaging in operational environments of moving lookdown clutter and ambient interference with classification repeatability within 95%.

FY2001: Condct tests onboard operational assets such as a selected Tier UAV and Rivet Joint. Detection/tracking performance to exceed 93% at 13-dB SNR.

Customer POC	Service/Agency POC	USD(A&T) POC
Dr. Joseph Worrell	Mr. Robert Ogrodnik	Dr. Jasper Lupo
Det-2, 645th MATS	AFRL-OCSM	DDR&E(SEBE)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
S&T Funding							
0602702F	4506	1.6	1.2	0.8	0.9	0	0
Total S&T		**1.6**	**1.2**	**0.8**	**0.9**	**0**	**0**
Non-S&T Funding							
0603178F	1697	0.7	0.8	1.2	0.6	0	0
0603889F	2787	2.5	2.0	2.0	0.5	0	0
Total Non-S&T		**3.2**	**2.8**	**3.2**	**1.1**	**0**	**0**

SE.59.01 Low-Light-Level Imaging Sensors

Objectives. Demonstrate solid-state visible and near and short-wavelength infrared (NIR, SWIR) sensors for a broad range of night vision applications, including pilotage and navigation, weapon sights, missiles guidance, surveillance, and targeting. The warfighter requires a means to amplify the available illumination in order to operate effectively at night.

Payoffs. The warfighter currently uses image intensifier (I^2) tubes, often used in unity-magnification, and direct-view night vision goggles (NVGs) mounted on the head. I^2 tubes are also used to amplify light onto charge-coupled devices (CCDs), which provide a video output capable of being enhanced, fused with other imagery, mixed with symbology, transmitted, and recorded. The payoff is a high-resolution, solid-state alternative for I^2. In addition, electronic readout located off the head (e.g., in a head-steered turret or other remote position) will facilitate flexible integration of the individual soldier into the digital battlefield. This will increase opportunities for enhanced situational awareness.

Challenges. Technical barriers include the development of alternative photon sensing materials such as Si, InGaAs, and wide bandgap HgCdTe that have the potential for significantly improving performance under extremely low-brightness and -contrast conditions. Additionally, the ability to develop solid-state visible, NIR, and SWIR sensors for a broad range of night vision applications will be a technology advancement in the warfighters ability to operate effectively at night.

Milestones/Metrics.

FY1998: Develop and demonstrate an RS–170-compatible, low-light-level CCD camera capable of useful operation at light levels below 10^{-2} lux (reflectance).

FY1999: Develop and demonstrate an NIR or SWIR solid-state device capable of operation at light levels below 10^{-2} lux.

FY2000: Develop and demonstrate a low-cost, lightweight low-light-level camera for miniature UAV.

FY2001: Develop and demonstrate an RS–343-compatible NIR or SWIR array suitable for rotary-wing pilotage application.

Customer POC	Service/Agency POC	USD(A&T) POC
Mr. Mack Faulk	Mr. Bill Markey	Dr. Jasper Lupo
PM-NVESD	NVESD	DDR&E(SEBE)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602232N		0.5	0.8	0.8	0	0	0
0602709A	H95	3.0	4.0	4.8	4.9	0	0
	Total	**3.5**	**4.8**	**5.6**	**4.9**	**0**	**0**

SE.60.01 Underwater Acoustic Communications

Objectives. Demonstrate the potential of a reliable, robust, high-data-rate acoustic communications capability for tactical use between submarines, surface combatants, unmanned undersea vehicles (UUVs), and other platforms. This capability includes the transmission of text data, video frames, and digitized voice from one operational unit to the other on a real-time (not including propagation time) basis over both short range (2.5 nmi) at high frequency and long range (35 nmi) at medium frequency.

Payoffs. This DTO will provide an order-of-magnitude improvement in the data rate of underwater acoustic communications, from 2 to 20 kbps. Newly developed underwater acoustic signals and signal processing algorithms employing joint, adaptive equalization and synchronization techniques have a theoretical performance of 100 kbps at 1 km. These new signal processing algorithms effectively eliminate multipath interference and should provide near errorless acoustic links even in harsh shallow-water acoustic environments, allowing a greatly expanded communications capability for submarines at speed and depth.

Challenges. Technical barriers include automated initialization of the algorithm parameters (to ensure convergence regardless of the acoustic environment), compensation for Doppler shift and smear, and non-Gaussian interference suppression. An additional constraint is the requirement to provide low-cost COTS implementations for planned upgrades to Navy legacy sonar systems.

Milestones/Metrics.

FY1998: Demonstrate packet message transmission rate = 70%, at mid frequencies, range @ 2.4 kbps = 15–43 nmi, at high frequencies, range @ 10 kbps = 1.9–3.0 nmi, 25% real-time processing, in 70% of environments, semiautonomous operation.

FY2000: Demonstrate packet message transmission rate = 90%, at mid frequencies, range @ 2.4 kbps = 20–67 nmi, at high frequencies, range @ 10 kbps = 2.2–3.2 nmi, 100% real-time processing, in 80% of environments, autonomous operation, multinet connectivity with Link–11 and Link–16, covert low data rate (10–100 bps) option.

FY2002: Same as FY00, with environmental and tactical adaptation.

Customer POC	Service/Agency POC	USD(A&T) POC
CAPT Bill Matzelevich, USN N872E	Dr. Tom Curtin ONR	Dr. Jasper Lupo DDR&E(SEBE)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602435N		0.5	0.5	0.5	0.5	0.5	0
0603792N	R1889	5.6	4.4	0	0	0	0
	Total	**6.1**	**4.9**	**0.5**	**0.5**	**0.5**	**0**

SE.61.01 Multiphenomenology Sensor Fusion for ATR and Tracking

Objectives. Provide multisensor fusion algorithms for automated target recognition (ATR) of land targets for multiple warfighter platform applications. The sensors to be fused include radar, infrared, laser, electro-optical, multispectral imaging (MSI), and hyperspectral imaging (HIS) sensors as well as electronic signals sensors. This DTO emphasizes cross-phenomenology fusion (e.g., radar with IR or EO, IR with laser, radar with electronic signals) algorithm development. The fusion algorithms will be demonstrated in prototype form on laboratory computing workstations and high-performance computing assets.

Payoffs. Successful completion of this program will provide improved ATR and tracking algorithms to accomplish robust search, tracking, and targeting performance under realistic battlefield scenario conditions. Sensor fusion aids for image analysts in ISR ground stations will provide improved location, recognition, and tracking of targets in realistic wartime deployment scenarios. Sensor fusion aids for shooters in airborne or ground platforms will provide more efficient target association and recognition for acquiring and killing mobile targets under operational deployment conditions. Sensor fusion for terminal guidance in unaided tactical or conventional missiles will provide more reliable selection of missile aimpoints under realistic battlefield conditions.

Challenges. The major barriers to overcome are (1) insufficient information from a single phenomenology sensor to adequately discriminate targets from backgrounds in difficult scenario conditions such as foliage, weather, and enemy camouflage, concealment, and deception; (2) insufficient timelines for manually comparing multiple phenomenology products on CRT displays in the targeting process; and (3) insufficient accuracies of target locations reports as determined by single sensors.

Milestones/Metrics.

FY1999: Reduce time for associating target ID from emitting targets with SAR imagery from minutes to seconds via automation.

FY2000: Reduce false alarm rate (FAR) to 0.2, while maintaining P_d of 0.85, over FLIR sensor alone by fusing dual-band FLIR and LADAR imagery.

FY2001: Reduce FAR to 0.1 per frame, while maintaining P_d 0.8 for target acquisition and recognition performance by fusing SAR and FLIR imaging sensor information in a fighter cockpit.

FY2003: P_d 0.9 and P_r 0.8 for FAR <0.01 for multisensor fusion of SAR, EO multispectral, and SIGINT in reconnaissance ground stations; maintain tracks of vehicle groupings through multiple platforms and missions.

Customer POC	**Service/Agency POC**	**USD(A&T) POC**
Col Michael Gentrup, USAF	Mr. L. Goodwon	Dr. Jasper Lupo
ACC/DRA	AFRL	DDR&E(SEBE)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602120A	H16	0.4	0.5	0.5	0	0	0
0602204F	6095	3.1	3.2	1.9	1.9	2.4	1.8
0602705A	H94	0.1	0.1	0.1	0	0	0
0603203F	69DF	2.1	2.1	1.5	2.1	3.5	4.4
0603253F	666A	0.3	1.1	1.5	3.0	3.1	3.3
	Total	**6.0**	**7.0**	**5.5**	**7.0**	**9.0**	**9.5**

SE.62.02 LADAR ATR for Conventional Weapons

Objectives. Provide laser radar (LADAR) automatic target recognition (ATR) capabilities in all mission areas of conventional guided weapons including the span of applications related to missiles, bombs, submunitions, and projectiles. Primary emphasis is the development of algorithmic methodologies necessary to detect, classify, recognize, identify, and characterize targets that are appropriate for conventional weapon scenarios. Secondary emphasis is directed toward investigating relationships between ATR functional components and overall system performance for characterizing algorithm sensitivity and extensibility.

Payoffs. This DTO provides for effective weapon engagement against a widely dispersed threat within the context of the digital battlefield. It will demonstrate extended-range capabilities for lock-on after launch (LOAL), which will play a crucial role in future soldier/weapon survivability. Successful completion of this program will provide algorithmic methodologies necessary to develop LADAR ATR capabilities for conventional weapons to accurately and predictably locate, acquire, track, attack, and destroy a given target. Proven methodologies will provide essential ATR components that can be combined to form prototype algorithms for LADAR sensors in conjunction with various weapon applications (e.g., LOCAAS, SSB, Warrior). Laboratory demonstrations of prototype algorithms will determine relationships between ATR algorithm performance and system characteristics such as sensor parameters, target sets, and mission scenarios; and will provide insight into processor requirements for weapons in terms of hardware packaging versus available volume, power/throughput requirements, heat dissipation, and cost. Relationships between ATR components and system performance will provide system-level performance criteria necessary to characterize algorithm sensitivity and extensibility for different applications. This, in turn, will provide the capability to optimize or configure LADAR ATR algorithms for a given mission scenario, thus aiding in preflight mission planning or inflight weapon preparation.

Challenges. The major technology challenge in developing algorithmic methodologies is to meet the diverse requirements of conventional weapon systems while providing robust functionality within their demanding physical environments. In order to achieve ATR performance prediction capabilities, performance metrics must be accomplished before the realization of optimized/configurable LADAR ATR algorithms can be achieved.

Milestones/Metrics.

FY1998: Demonstrate a fixed high value target algorithm for a direct attack munition with an aimpoint error $\leq$1 m; determine ideal expectations of LADAR ATR performance model.

FY1999: Demonstrate LADAR ATR technologies having predictable performance for inflight weapon systems with P_{acq} 80% and feature resolution <0.064 m^3.

FY2000: Quantify confidence in ATR performance.

FY2001: Develop an articulated target algorithm for a submunition weapon with P_{id} = 85%; characterize clutter for LADAR ATR.

FY2002: Identify performance domains critical to LADAR ATR.

FY2003: Automate LADAR ATR predictability to <5 min.

Customer POC	Service/Agency POC	USD(A&T) POC
Mr. Edmund Anderson	Mr. Rick Wehling	Dr. Jasper Lupo
PEO(CU)	AFRL-MNG	DDR&E(SEBE)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602111N		1.3	1.4	1.2	0.8	0	0
0602602F	2068	0.7	0.7	0.8	0.8	0.7	0.7
	Total	**2.0**	**2.1**	**2.0**	**1.6**	**0.7**	**0.7**

SE.63.02 Digital Beamforming Antenna Technology

Objectives. Build and test critical subsystems and components of digital beamforming array antenna systems with the ultimate goal of solving key deficiencies in existing Air Force and Navy radar systems. Component technology from microwave and analog front-end technology (MAFET), other DARPA programs, existing DTOs (i.e., SE.57.01, SE.29.01, and IS.33.02) will be integrated.

Payoffs. Present radar capabilities for detection and tracking of multiple targets in the presence of interference (clutter, jamming, etc.) are inadequate against the low-observable (LO) technology of the future. This capability is offered with a digital beamforming receive array. A second need is for a multifunction radar, using wideband-shared multifunction apertures, to use digital beamforming systems with frequency-selective front ends for receive and transmit operations.

Challenges. For the receive-only system, the challenge is of advanced algorithms for space-time adaptive processing (STAP) of multiple beams with jammer, platform and terrain clutter suppression, and array failure correction; and of design and development of lightweight subarrays for mobile platforms. For the multifunction system, transmit/receive (T/R) modules are needed for digital beamforming functionality.

Milestones/Metrics.

FY1998: Upgrade DBF receive-only array; complete real-time beamformer; complete and test brassboard digital T/R module for T/R system; develop calibration techniques.

FY1999: Complete advanced algorithms for STAP and failure correction on receive-only testbed; finalize lightweight subarray design; complete miniaturization of brassboard T/R module; complete tradeoff study for full system demonstrations.

FY2001: Complete algorithms for STAP; test failure correction on receive-only system.

Customer POC	Service/Agency POC	USD(A&T) POC
Mr. A. Budreau	Mr. Bob Mailloux	Dr. Susan Turnbach
ESC/AWO	AFRL	DDR&E(SEBE)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602232N		0.5	0.5	0	0	0	0
0602702F	4600	0.5	1.0	1.0	0.5	0	0
	Total	**1.0**	**1.5**	**1.0**	**0.5**	**0**	**0**

SE.64.02 Millimeter-Wave Gyro-Amplifiers

Objectives. Develop efficient, high-power, high-gain, wide-bandwidth amplifiers and the associated RF driving sources and high-power components for defense applications above 30 GHz. The millimeter-wave (MMW) amplifier technology is intended to support current and future high-performance radar systems.

Payoffs. Millimeter-wave systems offer order-of-magnitude performance improvements for high-resolution fire control, target identification, and imaging radars. Benefits include enhanced angular resolution, improved range resolution, and secure operation provided by high-gain, narrowbeam antennas with corresponding applications including ISAR classification of aircraft, detection of low-observable targets, and improved command guidance. Critical MMW components addressed as part of this effort include high-power duplexers, low-loss rotary joints, polarizers, and electronically scanned antennas.

Challenges. The primary technical challenges for this development are to surpass the bandwidth and power capabilities of existing MMW amplifiers while maintaining high efficiencies and compact volumes. The approach is to increase the bandwidth and power of existing traveling-wave-tube driving sources through the use of improved RF circuits and electron-beam confinement techniques; and to increase the power-bandwidth product of the current state of the art in high-power amplifier technology by one or more orders of magnitude through the development of fast-wave devices such as gyroklystrons and gyrotwystrons. These approaches exploit ongoing advances in modeling and simulation tools as well as advances in materials and materials processing.

Milestones/Metrics.

FY1999: 94-GHz gyroklystron with 100-kW peak power, 10% duty, and 600-MHz bandwidth. 94-GHz double-staggered-ladder TWT (driving source) with 1-kW peak power, 10% duty, and 3-GHz bandwidth.

FY2001: 94-GHz gyro-amplifier with 100-kW peak power, 10% duty, high pulse rate, and 3-GHz bandwidth.

Customer POC	Service/Agency POC	USD(A&T) POC
Mr. Frank Rucky	Dr. Ingham Mack	Dr. Susan Turnbach
NSWC Dahlgren Division	ONR	DDR&E(SEBE)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602234N		4.3	4.5	4.6	4.6	0	0
	Total	**4.3**	**4.5**	**4.6**	**4.6**	**0**	**0**

SE.65.02 Long- and Dual-Wavelength, Large-Area, Staring Focal Plane Arrays

Objectives. Develop long- and dual-wavelength, large-area, staring IR focal plane arrays for ground and space applications. Mercury-cadmium-telluride (HgCdTe) focal plane arrays (FPAs) as large as 2048 x 2048 for terrestrial applications and radiation-hardened versions as large as 256 x 256 for use in space will be built.

Payoffs. This new class of IR sensor will provide the warfighter with major improvements in the location and identification of forces, location and classification of missile launches, location of land mines, points of origin of bullets and munitions, search and track, and discrimination capability to extract targets from clutter.

Challenges. The major challenges for the sensor are (1) to develop the molecular beam epitaxy technology to grow two to three layers of HgCdTe of different composition monolithically, (2) to fuse the data obtained therefrom into a synergistically superior video image, and (3) to condense the smart readout circuitry into a 25-μm cell size for ground applications and a 60-μm cell-size, radiation-hardened cryogenic complementary metal oxide semiconductor (CMOS) for space. Space system challenges include developing technologies to discriminate distant, cold targets (warheads and satellites) against a cold background (space).

Milestones/Metrics.

FY1998: Develop process to fabricate uniform, rad-hard HgCdTe FPAs with cutoff above 13 μm.

FY1999: Develop a Si/HgCdTe detector architecture for simultaneous three-band IR detection; demonstrate uniform, rad-hard 256 x 256 HgCdTe FPAs with cutoff above 13 μm; demonstrate feasibility of large-format space LWIR quantum well infrared photodetector (QWIP) FPAs.

FY2000: Demonstrate a polarization approach for high-performance auto-cueing.

FY2001: Demonstrate a 2048 x 2048 LWIR HgCdTe sensor array fused with other bands.

FY2002: Demonstrate large format (1000 x 1000) space LWIR QWIP FPA.

Customer POC	Service/Agency POC	USD(A&T) POC
Mr. Erwin Myrick BMDO/TRS	Dr. B. Singaraju AFRL	Dr. Susan Turnbach DDR&E(SEBE)
Mr. C. Thornton USA DBBL	Dr. Stuart Horn NVESD	

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
S&T Funding							
0602204F	2001	0.2	0	0	0	0	0
0602601F	8809	2.3	1.7	1.7	2.6	3.8	0
0603401F	3784	1.5	1.5	1.9	2.3	2.2	0
0602709A	H95	0	0.7	4.5	4.9	0	0
Total S&T		**4.0**	**3.9**	**8.1**	**9.8**	**6.0**	**0**
Non-S&T Funding							
0603781C	240201	5.0	5.0	4.0	4.0	0	0
Total Non-S&T		**5.0**	**5.0**	**4.0**	**4.0**	**0**	**0**

SE.66.02 Packaging and Interconnect for Multiple Technologies

Objectives. Develop techniques for the fabrication, protection, assembly, and integration of digital, analog, microwave, and millimeter-wave signals into a single format. Mission-capable commercial electronic devices and packaging techniques will be developed for military applications. To realize the performance improvements at the system level, advanced packaging approaches such as mixed-signal multichip modules (MSMCMs), chip-scale packaging, extremely high bandwidth packages, chip-on-board, and three-dimensional interconnect techniques must be employed. Die optimization approaches that can provide 10X lower power and 4X speed enhancement must also be explored.

Payoffs. Significant military capabilities such as smart weapons, secure wireless communications, covert tags, and tactical information assistants will be enabled by more integrated advanced packaging and interconnect approaches. This will allow more functionality per unit area, higher reliability, and lower subsystem costs. As an example, integration of bare-die analog data accumulator circuits into a single, quad flat-pack footprint for airborne applications provides the same functionality in one-fifth the area.

Challenges. Packaging technologies must (1) reliably survive adverse military ground, sea, air, and space operating and storage environments; (2) leverage commercial packaging manufacturing capabilities; (3) meet low-weight and small-volume requirements of compact sensors; and (4) be affordable in low-to-moderate production quantities. Specific technical challenges that must be overcome include hermeticity, EM interference and isolation, thermal management, high-density interconnects, low-loss/high-Q circuits, and multitechnology design and simulation.

Milestones/Metrics.

FY1998: Demonstrate ChipSeal process for avionics systems with 2X–5X increase in life.

FY1999: Demonstrate buried passive components showing 50% reduction in passive component area for the Discriminating Interceptor Technology Program.

FY2000: Demonstrate a high-precision (2% impedance control, <5-mV noise suppression, 100-dB analog-digital isolation) MCM technology for packaging circuits.

FY2002: Demonstrate die-optimized interconnects integrated into 3D assemblies.

Customer POC	Service/Agency POC	USD(A&T) POC
Mr. Viktor Jonkoff	Mr. Al Tewksbury	Dr. Susan Turnbach
JSF	AFRL	DDR&E(SEBE)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602204F	2002	1.0	1.0	1.0	1.0	1.0	0
0602204F	6096	0.2	0.3	0.9	0.7	0.5	0
0603203F	69CK	0	0	0.1	0.4	0.9	0
0603401F	2181	1.1	1.1	1.1	1.0	1.2	0
0602601F	8809	0.5	0.9	1.1	1.1	2.0	0
0603739E	MT-04	16.7	0	0	0	0	0
	Total	**19.5**	**3.3**	**4.2**	**4.2**	**5.6**	**0**

SE.67.02 Hyperspectral Terrain and Target Classification Technology

Objectives. Develop and demonstrate hyperspectral (HS) imaging technology from air and space platforms for two promising domains of defense applications: first, for battlespace environment characterization of both the terrestrial and the littoral ocean environments; and, second, for tactical target detection, characterization, and identification.

Payoffs. This DTO will demonstrate real-time detection of tactical targets with high probability of detection (P_d) and low false alarm rate (FAR) whether targets are camouflaged, partially concealed, or exposed. It will demonstrate real-time optical characterization of broad swaths of littoral ocean to identify features including water depth and clarity, and it will provide data for developing and validating coastal oceanographic models. It includes characterizing the terrestrial battlespace—classifying soil and vegetation types, analyzing trafficability, and identifying features and lines of communication. This DTO provides the technology to characterize the battlespace and isolate targets from clutter and camouflage. Collaboration in joint data collection, cooperative analysis, and shared exploitation among HS technology efforts under this DTO and with the Central MASINT Office maximizes synergism.

Challenges. The principal challenges are developing, demonstrating, and validating the processing algorithm technologies tailored for specific applications domains that can provide the high P_d, low FAR required for tactical targeting and the high accuracy in terrain or littoral ocean feature identification required for battlespace environment characterization. Another major challenge is managing the large volume of data produced by HS imagery (up to 40 Gbytes per image. Extending HS sensing into the night from the current daytime-only, reflected-sunlight technology (visible to near-IR) requires development of both long wavelength infrared (LWIR) HS sensors and processing algorithms.

Milestones/Metrics.

FY1998: Initial demonstration of real-time tactical target detection and cueing from an aircraft using a 1–2-m ground sample distance (GSD) HS sensor and onboard processing to cue a high-resolution panchromatic sensor; includes initial evaluation of LWIR HS sensor.

FY1999: Demonstrate HS sensing from space at 8-m GSD over a 5- x 20-km image area with data downlink for follow-on ground processing for day detection of larger tactical targets or terrain characterization; 25% improvement in bandpass-dependent content of IR scenes.

FY2000: Demonstrate characterization of ocean environment from space with large area image to cover long strip of coastal zone (30 x 200 km) with a moderate GSD (30 m) to identify coastal oceanographic features; demonstrate real-time, on-board processing with direct downlink of analyzed data to ship tactical terminals; demonstrate development and validation of coastal oceanographic model using the HS data; demonstrate real-time, day-night detection and cueing for full range of tactical targets from a UAV with a 1–2-m GSD HS sensor cueing a high-resolution visible sensor (includes LWIR HS sensor for night detection and cueing). 100% gain in background data retrieval from IR scenes.

Customer POC
Dr. Bill Jeffrey
DARO

COL Robert Kirby, USA
TEC

CDR Dave Titley, USN
NAVOCEANO

Service/Agency POC
Dr. Curt Davis
NRL

Dr. Dave Fields
DARPA/TTO

Mr. Joe Swistak
USA TEC

Col Mike Havey, USAF
AFRL

USD(A&T) POC
Col John O'Pray, USAF
DDR&E(SA)

Col Alan Shaffer, USAF
DDR&E(SEBE)

Mr. Tom Wilson
DUSD(Space)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602232N		5.0	5.0	4.5	2.0	1.9	1.8
0602435N		2.0	1.1	0	0	0	0
0603401F	3834	16.8	19.5	11.6	4.1	4.0	0
0603762E	SGT-02	7.0	8.0	8.0	0	0	0
	Total	**30.8**	**33.6**	**24.1**	**6.1**	**5.9**	**1.8**

SE.68.01 Rapid Mapping Technology

Objectives. Provide the capability to rapidly extract and properly attribute features of importance to the warfighter, with focus on the high-resolution-feature data requirement. Integrated, automated, geospatial feature generation and attribution software will be developed. Feature data will be generated and attributed from a variety of disparate sources. The software ensures that multi-imagery formats, varying scale, spatial and thematic accuracy, temporal data, and high-resolution/-density data are integrated.

Payoffs. The result of this project will improve, by 75%, the detail of land cover classification maps and overlays and will decrease, by 50%, the time required to extract feature attributes. The ability to produce a high-resolution geospatial database in a timely manner will provide information superiority during the planning, preparation, and execution of military operations.

Challenges. Generating databases from a single imagery source is highly labor intensive, costly, and time consuming. The need for high-resolution geographically and dimensionally accurate databases requires the use of multisource data to guarantee greater accuracy, level of detail, and density of features required by the warfighter.

Milestones/Metrics.

FY1998: Incorporate techniques for processing SAR and interferometric SAR feature data into the Digital Stereo Photogrammetric Workstation (DSPW), showing a 15% improvement in feature detail.

FY1999: Develop initial automated feature extraction capability for spectral imagery and SAR, providing an additional 15% improvement in feature detail and 5% decrease in data extract time.

FY2000: Incorporate automated feature extraction techniques from spectral, SAR, and EO sources into the DSPW, providing an additional 15% increase in feature detail and 10% decrease in data extract time.

FY2001: Develop automated feature attribution capability for roads, bridges, buildings, vegetation, and soils based on terrain-reasoning software, providing a 10% decrease in data extract time.

FY2002: Demonstrate initial automated feature extraction and attribution capability on the DSPW, providing an additional 15% increase in feature detail and 20% decrease in data extract time.

Customer POC	Service/Agency POC	USD(A&T) POC
Mr. Dave Thacker	Mr. Bill Clark	Col Alan Shaffer, USAF
PD, CTIS	TEC	DDR&E(SEBE)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602784A	855	1.7	1.9	2.1	1.9	1.9	0
	Total	**1.7**	**1.9**	**2.1**	**1.9**	**1.9**	**0**

SE.69.01 Autonomous Distributed Sensors

Objectives. Demonstrate a capability to detect, track, classify, and report battlefield and undersea threats with distributed, unmanned sensors using a multiplicity of acoustic and magnetic emissions from the threat. Battlefield threats include tanks and other heavy vehicles, helicopters, and aircraft. Undersea battlespace threats to be detected are submarines, surface ships, and mine deployment activities. The use of these low-cost, battery-powered-netted sensor fields extends the situational awareness of the warfighter over a greatly increased area compared to that possible with manned systems and vehicles. These will be primarily passive receivers of emitted energy and as such are relatively clandestine and applicable to prehostilities battlespace preparation.

Payoffs. Autonomous distributed sensors provide the joint force commander with surveillance options in areas where current and projected capability is either too costly, too overt, too slow to deploy, or limited by the number of manned platforms available. This added capability will give daily updates of all threats operating in the surveillance field, precluding operational surprise, and give tactical options to the joint forces commander to either attack or evade.

Challenges. Technical barriers include autonomous processing for detection and classification; node designs for rapid deployment, long life, real-time operation, and low cost; sensor-to-gateway communications networks; communications gateways to the global network; and counting and classification by type of clustered vehicles on the battlefield.

Milestones/Metrics.

FY1998: Commercial technology underwater acoustic communications multinode network with 10-km node spacing and 100-bps data rate.

FY1999: Offline automatic detection and classification of submarines at useful ranges with testbed sensors. Testbed gateway node added to underwater communications network; connectivity to global network.

FY2000: Resolution of closely spaced multiple targets on the battlefield.

FY2002: Demonstrate deployable, distributed, multinode uncabled array.

FY2003: Real-time, in-node automatic detection and classification of submarines.

Customer POC	Service/Agency POC	USD(A&T) POC
CAPT J. Nifontoff, USN	Dr. Frank Herr	Dr. Jasper Lupo
SPAWAR PD18	ONR	DDR&E(SEBE)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602120A	H16	0.9	0.6	0	0	0	0
0602314N		6.5	6.7	6.2	5.4	4.8	4.6
	Total	**7.4**	**7.3**	**6.2**	**5.4**	**4.8**	**4.6**

SPACE PLATFORMS

Defense Technology Objectives
for the Defense Technology Area Plan

Space Platforms

SP.01.06	Cryogenic Technologies	II-252
SP.02.07	Thermal Management Technology	II-253
SP.03.06	Space Structures and Control	II-255
SP.05.06	Large Precise Structures	II-257
SP.08.06	Space Power System Technologies	II-258
SP.09.01	Satellite Control	II-259
SP.10.06	Liquid Boost Propulsion	II-261
SP.11.06	Orbit Transfer Propulsion	II-262
SP.15.06	Protection Technologies	II-263
SP.16.06	Threat Warning and Attack Reporting	II-265
SP.20.00	Spacecraft Propulsion	II-266
SP.21.00	Orbital Transfer Vehicle Technology	II-267

SP.01.06 Cryogenic Technologies

Objectives. Produce long-life, energy-efficient, lightweight mechanical cryocoolers capable of cooling loads up to 5 W at any temperature between 10K and 150K. The technical approach includes a mixture of in-house research and industrial cooperation to develop advanced mechanical cryocoolers for integration with SWIR, MWIR, LWIR, and VLWIR surveillance sensors and other important spacecraft subsystems requiring cryogenic temperatures such as superconducting electronics. An intermediate goal is to develop, by FY00, advanced technologies that will increase life expectancy to 5 years, reduce induced vibrations to 0.1 Nrms, reduce specific mass to 8 $kg/W_{cooling}$, and reduce specific power (watts of input power per watt of cooling) to 50 $W/W_{cooling}$. Currently, Stirling Cycle, reverse Brayton Cycle, and pulse tube cryocoolers are being built and tested with a goal of flight demonstration by FY01. This DTO supports a portion of the cryogenic bus work reported in SP.02.07, Thermal Management Technology.

Payoffs. Successful completion of the programs in this DTO will greatly extend the lifetime of surveillance missions that use IR sensors. This will circumvent the huge costs of replacing on-orbit satellites. Additionally, there are considerable launch mass and volume savings associated with exchanging the bulky Dewar cryostats currently used with small, easily integrated mechanical cryocoolers. The range of operation will be extended down to VLWIR sensors with long life and dependable operations. Advanced cryogenic systems will provide transparent capabilities to provide the cooling necessary at the optimal operating temperature for the payload sensor, antenna, or cryogen.

Challenges. Technology barriers or challenges include availability of lightweight components for use in cryogenic temperatures; excessive friction and material stresses in miniature-sized, high-frequency cycles; contamination of seals and orifices; lack of effective design and materials for cryogenic regenerators; poorly understood thermodynamic loss mechanisms; and ineffective vibration isolation control electronics and techniques.

Milestones/Metrics.

FY1998: Flight demonstrate a reverse Brayton cryocooler on STS–91.

FY1999: Ground demonstrate 50-$W/W_{cooling}$ protoflight 60K Stirling cryocooler; integrate reverse Brayton Cycle cooler onto Hubble Space Telescope.

FY2000: Delivery of a dual-stage 35K/60K protoflight cooler; flight demonstrate cryocoolers for SBIR–Low Flight Demonstration System and Low-Altitude Demomonstration Systems.

FY2001: Ground demonstrate proof-of-concept of 10K hybrid cryocooler system.

Customer POC	Service/Agency POC	USD(A&T) POC
Col Susan Goodrich, UASF BMDO/TOS	Lt Col David Lewis, UASF SAF/AQR	Dr. Donald Dix DDR&E(AT)
Col Kathy Roberts, UASF SMC/MTA		Dr. Hal Henry DUSD(Space)/SA&M

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0603401F	682J	0.7	1.0	1.2	1.3	0	0
0602601F	8809	0	0.2	0.2	0.2	0	0
	Total	**0.7**	**1.2**	**1.4**	**1.5**	**0**	**0**

SP.02.07 Thermal Management Technology

Objectives. Develop and demonstrate thermal management technologies to improve the performance and reliability of on-orbit assets while reducing the mass of the satellite thermal management subsystem. The major technologies addressing this objective are variable-conductance and loop heat pipes, capillary-pumped loops (CPLs), cryogenic bus integration, and composite material radiators. The technical approach is to accomplish in-house modeling and simulations, lab characterizations, and flight demonstrations to validate the effect of zero-g on moving fluids before transitioning to industry in FY03. The aim is to improve the capability of the thermal subsystem to eliminate excess heat from the space vehicle and provide the required thermal environment for optimal mission completion while being transparently integrated into the bus structure and weighing as little as possible. An intermediate goal is to develop, by FY00, advanced technologies that will increase heat flux to 3.8 W/cm^2, increase heat transport to 4.5 kW-m, decrease thermal subsystem mass to 0.038 kg/W, decrease electronic component temperatures to 120°C, and decrease space vehicle heater power to 0.088 W/W. This DTO supports a portion of SP.01.06.

Payoffs. Thermal management technology is a pervasive technology that reduces the cost and improves the performance of all space missions. By increasing heat flux and heat transport capabilities with loop heat pipes and CPL systems, large savings in launch weight and improved payload performance are realized. Advanced thermal management systems will be lightweight and will isothermalize the spacecraft, reducing the need for additional power generation in heaters and improving risk associated with thermal cycling and fatigue. Revolutionary thermal management technologies are enabling for modular, multifunctional satellite busses and high-density electronics packaging.

Challenges. Technology barriers for space thermal management include rapid and reliable startup and long-term operation of CPL systems and loop heat pipes; and development of (1) low-cost advanced composite materials and devices capable of dissipating high heat fluxes from microelectronics devices, (2) submicron wicks (1-μm pore size) for CPL applications, and (3) flexible or rotatable joints that allow for the efficient transportation of heat from the space vehicle bus outboard to a deployable radiator.

Milestones/Metrics.

FY1999: Deliver 1-μm CPL wicks for characterization.

FY2000: Optimize complete CPL system; flight demonstrations: SBIR–Low Flight Demonstration System, and (2) Low-Altitude Demonstration System.

FY2002: Deliver the advanced lightweight thermal bus protoflight model.

FY2003: Ground demonstrate a full-up, lightweight thermal bus.

Customer POC	Service/Agency POC	USD(A&T) POC
Col Susan Goodrich, USAF BMDO/TOS	Lt Col David Lewis, USAF SAF/AQR	Dr. Donald Dix DDR&E(AT)
Col Kathy Roberts, USAF SMC/MTA		Dr. Hal Henry DUSD(Space)/SA&M

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602601F	8809	2.1	1.1	1.3	1.4	1.8	1.5
0603401F	682J	0	0.2	0.5	0.7	0.8	1.0
	Total	**2.1**	**1.3**	**1.8**	**2.1**	**2.6**	**2.5**

SP.03.06 Space Structures and Control

Objectives. (1) Develop advanced space structural component technologies to reduce the weight and cost of spacecraft and launch vehicle structures while improving their producibility and reliability; and (2) develop enabling structural sensing, control, and vibration damping technologies for space platforms, precision surveillance sensors, space-based radars, space-based interceptors, missiles, and launch systems. An intermediate goal is to develop, by FY01, advanced technologies that reduce satellite structural mass 40% and cost 10%, reduce launch vehicle structural mass 40% and cost 75%, decrease satellite launch loads 80%, and decrease on-orbit disturbances 90%. The technical approach will be to develop and demonstrate satellite multifunctional structures; lightweight, composite launch vehicle structures; and a launch vibration isolation system by FY03. This DTO supports the objectives of SP.05.06.

Payoffs. This DTO addresses pervasive technologies that reduce the cost and improve the performance of all space missions. Reducing the structural mass fraction results in enormous cost savings due to the reduction of overall launch weight and the corresponding reduction of the launch lift class. Payload performance is also enhanced because larger payloads are possible. Further payload enhancements are realized by using smart structures and controls that allow precision operations on nonprecision platforms. Synergistic effects obtained in multifunctional bus designs are enabling for future space mission architectures, particularly those requiring small and precise satellite constellations.

Challenges. Technical challenges include developing rapid and less costly manufacturing techniques for large launch vehicle structures; accounting for the synergistic effects of the combined aspects of the space environment; developing high-fidelity simulations; reducing EMI effects and increasing the reliability and durability of multifunctional structures; ensuring satellite structural isolation without constraints on rattle space (clearance), weight, power, and volume, as well as interaction between the isolator control system and the launch vehicle control system; developing rapid nonpyrotechnic release mechanisms; and integrating neural network technology into structural control systems during operation.

Milestones/Metrics.

FY1999: Flight demonstrations: (1) flight-qualified, fiber-optic sensors, and (2) multifunctional structures on Deep Space One.

FY2000: Deliver cableless bus hardware.

FY2001: Flight demonstrations: (1) acoustic damping, and (2) cableless bus.

FY2003: Flight demonstrations: (1) advanced shroud, and (2) launch vibration isolation system.

Customer POC	Service/Agency POC	USD(A&T) POC
Maj Randy Correll, USAF AFSPC/XPXT	Lt Col David Lewis, USAF SAF/AQR	Dr. Donald Dix DDR&E(AT)
Col Kathy Roberts, USAF SMC/MTA		Dr. Hal Henry DUSD(Space)/SA&M

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602234N		0.5	0.5	0.5	0.6	0	0
0602601F	8809	4.6	5.1	6.3	6.0	7.2	8.7
0603302F	0003	0.6	0.6	0.6	0.6	0.6	0.6
0603401F	1026	0.9	1.8	3.2	3.9	3.5	3.6
	Total	**6.6**	**8.0**	**10.6**	**11.1**	**11.3**	**12.9**

SP.05.06 Large Precise Structures

Objectives. Develop key enabling technologies for ultra lightweight, deployable, large-aperture, space-based optics. Subscale components will be demonstrated in a laboratory environment. Applications include surveillance from space, directed-energy weapons, and communications. The approach is to develop new telescope mirror technologies. These mirrors may suffer from large aberrations, but the mirrors will be scalable to very large sizes. New adaptive optics technology will be developed to correct the aberrations and produce high-resolution images. This DTO relies on smart structures and controls technology from DTO SP.03.06.

Payoffs. This technology will produce a dramatic reduction of launch size and weight for satellites with 0.3-meter to 2.4-meter diameter optical payloads. It will make 3- to 20-meter optics possible for the first time. Missions currently restricted to low Earth orbit (LEO) satellites, such as high-resolution Earth surveillance, will become possible from geosynchronous orbit. This will give continuous rather than once-per-day coverage of the Earth. Only a small number of geosynchronous satellites are needed to provide better coverage than dozens of LEO satellites.

Challenges. High-resolution imaging requires primary mirror surface accuracies ranging from 0.2 μm rms at mid-infrared wavelengths to as low as 0.02 μm rms for visible light. Optics will be developed that can fold for launch using membrane mirror or other ultra lightweight technologies. Surface accuracies will be on the order of 100 μm rms. New types of adaptive optics compensation will be developed to reduce the effective surface error to the required 0.2- to 0.02-μm rms range. The primary metrics are mirror diameter, effective rms figure error after compensation, and f/# (f number). The f/# is the mirror focal length divided by the diameter. Higher f/#'s are easier to build but result in longer telescopes. Compact small-aperture telescopes require f/#s between approximately 2 and 8, while large aperture space telescope systems require f/#s between about 1.5 and 4.

Milestones/Metrics.

FY1998: Complete construction of 1-m diameter membrane mirror testbed.

FY1999: Ground demonstrate 1-m diameter f/20 membrane mirror with 0.1-μm rms effective figure.

FY2000: Ground demonstrate 5:1 mirror folding technology.

FY2002: Ground demonstrate a 2:1 foldable, 2-m diameter, f/20 membrane mirror with 0.1-μm rms effective figure.

Customer POC
Maj Rick Miller, USAF
AFSPC/XPXT

Ms. Janice Smith
SMC/MCX

Service/Agency POC
Lt Col David Lewis, USAF
SAF/AQR

USD(A&T) POC
Dr. Donald Dix
DDR&E(AT)

Dr. Hal Henry
DUSD(Space)/SA&M

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602601F	8809	1.0	1.4	1.6	1.3	1.0	0
0602601F	3326	3.1	3.1	3.1	3.2	0	0
	Total	**4.1**	**4.5**	**4.7**	**4.5**	**1.0**	**0**

SP.08.06 Space Power System Technologies

Objectives. Provide the technologies for a spacecraft electric power system (EPS) that is significantly more efficient, lightweight, and longer lived than currently available. The technical approach includes development, demonstration, and transitioning space power generation, energy storage, and power management and distribution (PMAD) technologies that constitute the EPS. The approaches to be pursued include advanced multijunction photovoltaics, high-specific power solar arrays, solar thermal converters (alkali metal thermal electric conversion (AMTEC)), high-specific energy batteries (NaS, Li-ion), flywheel energy storage and attitude control, high-voltage dc/dc converters, solid-state switch components, and advanced wide-bandgap semiconductors for high-temperature power management and distribution devices. This DTO supports DTO SP.21.00.

Payoffs. The programs contained in this DTO achieve payoffs that are pervasive and essential for all types of space vehicles including next-generation military and commercial missions with either high-power demands (MILSTAR III, NPOESS) or concentrated power-usage payloads. Large technology payoffs from dramatically increasing system-specific power will be realized in increased payload mass fraction, increased available usable power, increased space vehicle on-orbit life, decreased launch costs, and decreased attitude control subsystem mass.

Challenges. Technical barriers include growth and lattice compatibility of advanced semiconductor materials (GaInAsP, $CuInSe_2$) for multijunction and low-cost, ultra-thin solar cells; feasibility and reliability of solar thermal conversion; accelerated correlation of battery design with temperature, depth of discharge, cycling, and rate; minimizing electrical loss in magnetic bearings and availability of high-strength and high-cycle life composite materials for flywheel systems; availability of high-voltage (70–130-Vdc), space-qualified, silicon-based, solid-state components and circuits; and availability of higher efficiency wide-bandgap (GaAs and SiC) solid-state devices.

Milestones/Metrics.

FY1998: Flight demonstrations: (1) multijunction solar cells on STRV–2 and MightySat I, (2) sodium sulfur (NaS) battery on STS–87, and (3) AMTEC converter on STS–88.

FY1999: Delivery of 30-Whr/kg flywheel energy storage/attitude control system.

FY2001: Flight demonstrate a flywheel system and Li-ion batteries on Mars Surveyor lander and rover.

FY2002: Flight demonstrate AMTEC primary power on NASA Pluto Fast Flyby mission.

Customer POC	Service/Agency POC	USD(A&T) POC
Mr. Benjamin Gimeno NRO	Lt Col David Lewis, USAF SAF/AQR	Dr. Donald Dix DDR&E(AT)
Col Kathy Roberts, USAF SMC/MTA		Dr. Hal Henry DUSD(Space)/SA&M

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602601F	8809	3.2	3.8	5.1	4.6	3.9	0
0603401F	682J	3.0	3.6	4.3	5.7	5.4	0
	Total	**6.2**	**7.4**	**9.4**	**10.3**	**9.3**	**0**

SP.09.01 Satellite Control

Objectives. Develop and integrate satellite control technologies for the Air Force Satellite Control Network (AFSCN) and Naval Space Operations Center (NAVSOC) to provide autonomous ground and space operations, portable ground operations and data dissemination, and advanced operator environments for satellite control. Additional objectives include developing modeling and simulation technologies to support space technology development, investment decisions, satellite operations, space warfighter training, and wargaming. The technical approach is to develop in-house prototypes of intelligent consoles that improve the tools available to satellite controllers for scheduling, control, and training. Onsite experiments will be conducted to ensure that prototypes meet all requirements and constraints of the user. Appropriate intelligent tasks will be transitioned from the console to the satellite and tested by flight testing onboard autonomous satellite health, status, and mission payload software. Specifications for these concepts will be provided to industry for transition and integration into existing systems. This approach will be complemented by exploitation of existing commercially available systems. This DTO supports DTO SP.21.00, Orbital Transfer Vehicle Technology. Near-term modeling and simulation development will include surveillance payload technology simulations and payload/bus subsystem models for health and status feed into satellite-operated displays.

Payoffs. Development of systems will increase operational capability and lower acquisition and maintenance costs. Enhanced capability is achieved by providing immediate information to the warfighter through portable systems and providing a continuous upgrade process with flexibility so changing requirements can be easily satisfied. In addition, spacecraft simulations will reduce time, cost, and risk of space hardware technology development; enhance performance of operational concepts; and improve operator/warfighter training.

Challenges. Technology challenges include the verification of the correctness and safety of automated anomaly detection and resolution based on artificial intelligence techniques such as neural networks, case-based reasoning, model-based reasoning, expert systems, and statistical networks; the reduction of processing and storage requirements of autonomous systems so that they can be used onboard the satellite; the use of intelligent computer-aided training to reduce training manpower requirements; the development of innovative user interfaces and data visualization techniques to provide the warfighter with the capability to effectively assimilate large amounts of information; the development of techniques to perform satellite telemetry decommutation in software instead of hardware to reduce costs; the development of generic intelligent systems that can be used on more than one satellite family; the verification of correct performance of highly intelligent ground and space systems; and the development of technologies that will satisfy acquisition and O&M cost constraints.

Milestones/Metrics.

FY1999: Addition of decision support for anomalies.

FY2000: Reduce control costs by 30% (with an increase in capability); manpower requirements reduced by 50%.

FY2001: Reduce instructor manpower requirements by 50%.

FY2002: Flight demonstrate an onboard autonomous satellite health and status capability.

FY2003: Flight demonstrate autonomous mission payload software.

Customer POC	Service/Agency POC	USD(A&T) POC
Maj Douglas Howse, USAF 50th SW/XPSV	Lt Col David Lewis, USAF SAF/AQR	Dr. Donald Dix DDR&E(AT)
Maj Mitch Mefford, USAF SMC/XRT		Dr. Hal Henry DUSD(Space)/SA&M

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602232N		0.5	0.5	0	0	0	0
0602601F	8809	3.0	3.2	2.7	3.6	3.9	4.0
0603401F	2181	2.6	3.2	4.4	4.6	4.6	4.7
0603401F	3834	0.9	0	0	0	0	0
	Total	**7.0**	**6.9**	**7.1**	**8.2**	**8.5**	**8.7**

SP.10.06 Liquid Boost Propulsion

Objectives. Develop and demonstrate advanced spacelift propulsion capabilities for military and nonmilitary space launch systems. The technologies demonstrated by this DTO will provide critical enabling technologies for a follow-on DTO and for DTOs K.01, Post-Boost Control System Technology, and K.06, Missile Propulsion Technology. The Integrated High-Payoff Rocket Propulsion Technology (IHPRPT) program has already established the following goals for a successor DTO: reduction in stage failure rate by 50%, increase in Isp of 2% (cryo) and 15% (hydrocarbon), reduction in hardware and support costs of 25%, increase in thrust/weight ratio of 60%, and an MTBR of 40 missions. This DTO supports JWSTP Chapter IX in the area of Strategic Systems Sustainment by advancing propulsion technology for use by liquid post-boost strategic vehicles.

Payoffs. Advanced spacelift propulsion will lower cost, enhance performance, and provide responsive access to space for expendable or military multiuse vehicles. The technologies demonstrated for liquid propulsion, by FY00, will lead to an increased system payload of 31% and reduced system launch and O&S costs of 35%. When coupled with the orbit transfer vehicle (OTV) improvements in DTO SP.11.06, the combined IHPRPT payoffs for launch vehicles will be met.

Challenges. Technical challenges for liquid systems include improving material compatibility, reducing component weight and volume through the incorporation of advanced materials, increasing rotodynamic speeds (to decrease turbo pump assembly size), increasing turbine blade/disk capability of withstanding thermal shocks and high stresses at high temperatures, reducing composite processing costs, utilizing advanced bearing concepts, and identifying advanced bearing concept limitations. Technical approaches being employed are the development of a high-Pc, full-flow-cycle-state combustion cycle engine.

Milestones/Metrics.

FY1998: Complete the hydrostatic bearing tests for integration of the bearings into the integrated powerhead demonstration.

FY2001: Reduce stage failure rate by 25%; increase in Isp of 1% (cryo) and 13% (hydrocarbon); reduction in hardware and support costs of 15%; increase in thrust/weight of 30%; MTBR of 20 missions.

FY2002: Completion of lightweight TCA testing; begin transitioning technology into Phase II demonstration.

Customer POC	Service/Agency POC	USD(A&T) POC
Maj Randy Correll, USAF AFSPC/XPXT	Dr. Walter Jones SAF/AQR	Dr. Donald Dix DDR&E(AT)
Ms. Janice Smith SMC/MCX		Dr. Hal Henry DUSD(Space)/SA&M

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602601F	1011	13.7	16.7	18.6	18.3	17.3	0
0603302F	4373	6.6	11.3	11.8	12.5	14.7	0
	Total	**20.3**	**28.0**	**30.4**	**30.8**	**32.0**	**0**

SP.11.06 Orbit Transfer Propulsion

Objectives. Develop and demonstrate individual orbit transfer propulsion capabilities that significantly enhance low-cost, high-performance access to space via revolutionary propulsion techniques with improved designs, combustion and mixing technologies, and material advancements. The technologies demonstrated by this DTO will provide critical enabling technologies for follow-on DTOs. The Integrated High-Payoff Rocket Propulsion Technology (IHPRPT) program has already established the following goals for a successor DTO: reduction in stage failure rate by 50%; increased Isp of 2% (cryo) and 15% (hydrocarbon); reduction in hardware and support costs of 25%; increase in thrust/weight of 60%; and MTBR of 40 missions.

Payoffs. The technologies demonstrated for liquid orbit transfer vehicle (OTV) propulsion will lead to increased payload of 12% and a reduction in system launch/O&S cost of 6%. When coupled with the boost improvements in DTO SP.10.06, Liquid Boost Propulsion, the combined IHPRPT payoffs for launch vehicles will be met.

Challenges. Technical challenges or barriers include chemical combustion and mixing improvements for increased combustion efficiency and lightweight material developments to improve mass fraction in chemical systems. The technical approach being employed is development of a high-chamber-pressure-expander-cycle engine with increased thermal cooling capabilities.

Milestones/Metrics.

FY2000: Reduction in stage failure rate by 25%; increased Isp of 1% (cryo) and 13% (hydrocarbon); reduction in hardware and support costs of 15%; increase in thrust/weight of 30%; MTBR of 20 missions.

FY2002: Ceramic metal composite blisk for upper-stage turbopumps available for testing in full engine.

Customer POC	Service/Agency POC	USD(A&T) POC
Maj Randy Correll, USAF AFSPC/XPXT	Dr. Walter Jones SAF/AQR	Dr. Donald Dix DDR&E(AT)
Ms. Janice Smith SMC/MCX		Dr. Hal Henry DUSD(Space)/SA&M

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602601F	1011	2.6	3.6	3.1	4.0	5.2	0
0603302F	4373	2.3	2.3	2.3	1.3	0	0
	Total	**4.9**	**5.9**	**5.4**	**5.3**	**5.2**	**0**

SP.15.06 Protection Technologies

Objectives. Evaluate, through high-fidelity subsystem system models, the effects of the threats on U.S./Allied space systems, and then develop and demonstrate the efficacy of multithreat protection techniques against those threats. Principal efforts will address reducing the safety factor (design margin) required for the use of COTS components in military space applications; developing RF/HPM threat protection techniques for communication and sensor payloads; and identifying laser threat mitigation components for spaceborne sensor payloads. The approach will include the development or refinement of weapon effects prediction tools and their verification via benchmark effects experiments; comparison of laboratory and space radiation analysis and experiments on COTS microelectronics; and identification and evaluation via analysis and experiment of candidate protection techniques for low-level laser threats. This DTO depends on data from DTO SE.37.01, High-Density, Radiation-Resistant Microelectronics, and DTO SE.55.01, Space Radiation Mitigation for Satellite Operations. This DTO supports JWSTP Chapter IX in the area of Strategic Systems Sustainment by advancing threat identification/protection techniques for strategic missiles and military space systems.

Payoffs. The goal is to develop and demonstrate technologies required to assure operation of U.S./Allied military space assets in both the natural space environment and threat-stressed warfighting environments. The technologies developed and demonstrated will provide cost-effective, weight-efficient, performance-compatible protection techniques to withstand natural and manmade environments and preclude unacceptable mission or lifetime degradation. Technology goals will include reduction in COTS component safety factor (design margin) by approximately a factor of 4, reduction in RF/HPM susceptibility uncertainty to approximately 12 dB, and candidate protection techniques with factor of 4 increase in laser protection.

Challenges. Technical barriers include accuracy of the threat/subsystem interaction modules, accuracy of space debris prediction models, integration of threat-specific modules into multithreat prediction models, minimization of performance impact of threat countermeasures, and integration of balanced multithreat protection capability.

Milestones/Metrics.

FY1998: Flight demonstrations: (1) Advanced Space Computing Analysis Technology (ASCAT) launch, operations, and data retrieval, and (2) Microelectronics and Photonics Test Bed launch, operations, and data retrieval. Ground demonstrate initial threat-specific sensor weapon effects prediction module. Initiate development of integrated, multithreat response prediction and protection design tool.

FY1999: Analyze space flight data by comparing data with laboratory radiation test data and preflight predictions for COTS components. Ground demonstrate multithreat response prediction and protection design tool.

FY2000: Conduct benchmark experiments for RF response prediction code validation. Identify directed-energy threat (laser, RF/HPM) countermeasures for sensor protection.

FY2001: Initiate development of selected sensor protection technologies for RF and laser threat mitigation. Ground demonstrate candidate combined RF/laser/enhanced radiation protection techniques for sensors.

FY2002: Assess multithreat sensor protection (modeling and simulation). Ground demonstrate sensor brassboard (protection components) design, development, and fabrication.

FY2003: Ground demonstrate sensor brassboard multithreat protection.

Customer POC	**Service/Agency POC**	**USD(A&T) POC**	
Maj Brad Broemmel, USAF	Lt Col David Lewis, USAF	Dr. Donald Dix	Dr. Hal Henry
AFSPC/XPX	SAF/AQR	DDR&E(AT)	DUSD(Space)/SA&M

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0603401F	4400	0.6	0.3	0.8	1.5	3.3	3.1
0602234N		0.4	0	0	0	0	0
0602601F	1010	0.6	0.5	0.6	0.6	0	0
	Total	**1.6**	**0.8**	**1.4**	**2.1**	**3.3**	**3.1**

SP.16.06 Threat Warning and Attack Reporting

Objectives. Develop onboard sensor technologies to monitor, detect, identify, locate, characterize, and report a threat against critical U.S./Allied satellites; and demonstrate innovative, lightweight, low-power, miniaturized, and cost-effective EO/RF sensors, advanced microelectonics, and communication technologies. The approach will include identification or development of (1) critical EO/RF sensor component technologies (laser detectors, ultra compact optics, RF receivers, antennas); (2) highly integrated, miniaturized processors; and (3) innovative signal processing algorithms. Brassboard-level sensors will be integrated and lab tested and, where required, space mission-capable satellite threat warning and attacking reporting sensors will be flight demonstrated. This DTO depends on DTO SE.37.01, High-Density, Radiation-Resistant Microelectronics.

Payoffs. The goal is to develop and demonstrate onboard directed-energy weapon threat warning and attack reporting sensors to enhance battlespace situational awareness, assist in unambiguous operational anomaly resolution, and provide timely information for the initiation of protective counterspace survivability enhancement options.

Challenges. Technical barriers include the use of a single laser detector (e.g., pyroelectric, microbolometer) and ultra compact optics to achieve required sensitivity, bandwidth, and dynamic range for pulsed and continuous-wave sources; development and use of a cross-correlation receiver for RF threat detection; and miniaturization of the antennas and associated electronics to meet stringent weight and power goals.

Milestones/Metrics.

FY1998: Evaluate candidate detectors. Flight demonstrate Compact Environmental Anomaly Sensor (CEASE) II/Space Technology Research Vehicle (STRV) launch, operations, and data retrieval. Conduct critical design review of RF sensor.

FY1999: Ground demonstrations: (1) laser sensor brassboard (detector(s), optics, signal processor), and (2) integrated laser sensor brassboard (in laboratory). Develop and bench test RF sensor package.

FY2000: Ground demonstrate the RF sensor flight payload to AFRL.

FY2001: Flight demonstrate the RF sensor payload by Mightysat II.2 launch, operations, and data retrieval.

Customer POC	Service/Agency POC	USD(A&T) POC	
Maj Brad Broemmel, USAF	Lt Col David Lewis, USAF	Dr. Donald Dix	Dr. Hal Henry
AFSPC/XPX	SAF/AQR	DDR&E(AT)	DUSD(Space)/SA&M

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0603401F	4400	0	0.5	0.5	0.5	0	0
	Total	**0**	**0.5**	**0.5**	**0.5**	**0**	**0**

SP.20.00 Spacecraft Propulsion

Objectives. Develop and demonstrate advanced satellite propulsion technologies for orbit changes, orbit maintenance, and deorbit maneuvers of military and commercial satellites. The technologies demonstrated by this DTO will provide critical enabling technologies for a follow-on DTO.

Payoffs. The successful demonstration of IHPRPT spacecraft propulsion components objectives in FY00 will increase satellite on-orbit life by 25% and increase satellite payload by 10% or increase the number of repositioning maneuvers by 200%.

Challenges. Challenges include development of new higher energy fuels, reduction of the power processing unit weight, and increase of electric thruster efficiency for solar electric systems. Technical challenges for the solar thermal systems will be to demonstrate the newly developed pointing and tracking mechanisms so that high-temperature materials in the absorber cavity portion of the propulsion unit are incorporated and demonstrated and lightweight structures for the reflector and concentrator arrays are incorporated.

Milestones/Metrics.

FY1998: Subscale ground deployment of solar thermal balloon experiment consisting of concentrator, absorber, and tracking system; demonstrate life and improved thruster efficiency of Hall thruster.

FY1999: Full-scale ground deployment of system prior to launch in the year 2000; full-scale ground demonstration of IHPRPT Phase I goals for the solar thermal engine.

FY2000: Increase total impulse per wet-mass (Itot/wet-mass) 200% for EM systems (Hall Effects thrusters); improve Isp for chemical systems by 5% and solar thermal systems by 10%; improve the density-Isp for monopropellant systems by 30%; improve the mass fraction for solar thermal by 15%.

FY2001: Increase Itot/wet-mass by 20% for electrostatic systems (arcjets and pulsed plasma thrusters).

Customer POC	**Service/Agency POC**	**USD(A&T) POC**	
Maj Randy Correll, USAF	Dr. Walter Jones	Dr. Donald Dix	Dr. Hal Henry
AFSPC/XPXT	SAF/AQR	DDR&E(AT)	DUSD(Space)/SA&M

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602601F	1011	2.0	3.9	4.1	4.3	0	0
0603302F	6340	1.5	1.5	1.5	0	0	0
	Total	**3.5**	**5.4**	**5.6**	**4.3**	**0**	**0**

SP.21.00 Orbital Transfer Vehicle Technology

Objectives. Develop and demonstrate the technologies required to field orbit transfer vehicles for completely reusable spacelift architectures, and develop a high-capacity power generation system based on solar thermal energy conversion rather than on conventional photovoltaic arrays. The approach is to concurrently utilize a space demonstration with ground demonstration technology developments. The approach will leverage existing power, propulsion, and structure technologies to replace conventional chemical propulsion with solar thermal energy for orbital transfer propulsion from LEO to GEO and other higher orbits.

Payoffs. The ability to use solar power for propulsion presents huge cost savings in two ways. First, a reusable, long-life orbit transfer vehicle (OTV) eliminates repeated launchings of the fuel and structure necessary for LEO to higher orbit transfers. Second, since all launches will be for LEO insertion only, a stepdown to a smaller launch vehicle life class is possible. Additionally, the presence of a self-powered, self-propelled orbiting vehicle allows flexibility in mission adjustments for satellite recovery, debris removal, or tracking unknown orbiting objects. An offshoot from this program is the development of a high-capacity space power generation system that may be used for non-OTV applications (e.g., space-based radar).

Challenges. The technology challenges include reliable, long-life, precision-deployed structures for sunlight concentration; high-efficiency, long-life static energy conversion; high-temperature material solar receivers; accurate zero-g tracking and pointing technologies; and zero-g propellant delivery. Reusable OTVs require accurate and lightweight solar collectors. Area densities of solar concentrators of 1.0 kg/m^2 are needed. Thermal energy conversion efficiencies approaching 20% are required for reusable systems. Static conversion processes (e.g., thermionics, AMTEC) must achieve long life (15 years). Orbit transfer propulsion efficiency or Isp 250% greater than current storable chemical systems is needed for high-energy transfers. Tracking and pointing of solar concentrators within 0.1 degree tolerance must be demonstrated in a zero-g environment. Liquid hydrogen storage, delivery, and transfer in space is essential to high-Isp reusable OTVs. Tank mass fractions less than 15% must be demonstrated.

Milestones/Metrics.

FY1999: Ground demonstrate (1) 20% efficiency static converter test; (2) high-Isp (750 s), long-life solar receiver; and (3) 1.0- kg/m^2 lightweight deployable collector in a vacuum at high-concentration ratio (2,000:1).

FY2000: Ground demonstrate 5-kW, long-life (15 years), high-efficiency (20%) power subsystem. Flight demonstrate zero-g pointing and tracking to 0.1 deg, collector deployment, propellant acquisition, and delivery.

Customer POC	Service/Agency POC	USD(A&T) POC	
Col Robert Preston, USAF SMC/XR	Lt Col David Lewis, USAF SAF/QR	Dr. Donald Dix DDR&E(AT)	Dr. Hal Henry DUSD(Space)/SA&M
Col Peter Worden, USAF SAF/XOCP			

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602601F	8809	0	0.1	1.0	0	0	0
	Total	**0**	**0.1**	**1.0**	**0**	**0**	**0**

HUMAN SYSTEMS

Defense Technology Objectives
for the Defense Technology Area Plan

Human Systems

HS.01.02 Advanced Aircrew Escape II-270
HS.02.06 Advanced Hybrid Oxygen System II-272
HS.03.06 Aircrew Distributed Mission Training Technology II-273
HS.04.06 Knowledge Representation Technologies for Human Performance Enhancement II-274
HS.05.05 Ballistic Protection for Individual Survivability II-276
HS.06.01 Joint Cognitive Systems for Battlespace Dominance II-278
HS.07.06 Crew Station Integration Demonstrations II-280
HS.08.06 Crew System Engineering Design Tools II-281
HS.09.06 Development of Advanced Embedded Training Concepts for Shipboard Systems II-282
HS.10.05 Force XXI Land Warrior II-283
HS.11.06 Force XXI Training Strategies II-285
HS.12.02 Helmet-Mounted Sensory Ensemble II-286
HS.13.06 Human-Centered Automation Testbed II-288
HS.14.04 Human Performance Metrics for Theater Missile Defense II-289
HS.15.06 Integrated Personnel Management Technologies II-290
HS.16.06 Interactive Multisensor Analysis Training Technology II-291
HS.17.05 Panoramic Night Vision Goggle Technology II-292
HS.18.02 Precision Offset, High-Glide Aerial Delivery of Munitions, Equipment, and Personnel II-293
HS.19.05 Rotorcraft Pilot's Associate ATD II-294
HS.21.01 Decision Support Systems for Command and Control II-295
HS.22.06 Cogeneration for Field Services II-297
HS.23.02 Immersive, Adaptive Interfaces for Unmanned Vehicles II-298
HS.24.06 Deployable Sonar Training Technology II-299
HS.25.05 Multifunctional Fabric System II-300
HS.26.02 Smart Aircrew Integrated Life-Support System II-301

HS.01.02 Advanced Aircrew Escape

Objectives. Expand the safe escape envelope with regard to speed, altitude, attitude, and aircrew population for current and next-generation escape systems. Human escape exposure limits and tolerance criteria for impact and windblast will be developed. Development of performance evaluation methods and design criteria for ejection seat haulback and restraint systems, windblast protection, controllable propulsion, and bailout systems will be completed for potential retrofit to current systems. Human tolerance and design criteria for safely inserting small teams of special operations personnel to precise locations will be developed. The safe insertion of small teams of special operations personnel to precise locations will be demonstrated. Affordability will be a key issue as the DTO leverages foreign technology for potential improvements to U.S. systems.

Payoffs. The expected payoffs will be in reduced fatalities and major injuries during emergency escape up to 700 knots equivalent airspeed (KEAS) including ejections at combinations of low altitude and adverse attitudes. Safe accommodation of an expanded aircrew population will be achieved. A dramatic increase in our ability to deploy special teams with increased safety and precision will be realized. Lastly, improved affordability will be obtained through enhanced escape system supportability, maintainability, and production.

Challenges. Significant challenges exist in designing the ejection seat for the accommodation of the expanded range of aircrew sizes and weights and for determining injury potential for the expanded aircrew population.

Milestones/Metrics.

FY1998: Demonstrate fourth-generation escape system technology including controllable propulsion, flight controls, and windblast protection concepts at speeds up to 700 KEAS. Demonstrate successful performance of the K–36 3.5A demonstrator ejection seat at speeds up to 700 KEAS. Verify full aircrew accommodation weights of 103 to 245 lb.

FY1999: Demonstrate the improved seat stability of an ACES II ejection seat modified using a controllable propulsion system over a 0- to 600-KEAS airspeed range.

FY2000: Demonstrate an extended-mission, ejection-seat insert to improve pilot comfort and decrease pilot fatigue by 25% over extended flight missions.

FY2001: Develop a passive head/neck protection subsystem for high-speed escape. (Limit neck tension forces to less than 300 lb and neck shear loads to less than 250 lb over the airspeed range of 350 to 600 KEAS.)

FY2002: Develop human tolerance criteria for safely deploying troops to precise locations.

FY2003: Demonstrate technologies employing precision airdrop and protection from biodynamic hazards to deploy troops to precise locations.

Customer POC		Service/Agency POC	USD(A&T) POC
Mr. Thomas Hitzeman ASC/FBJ	Mr. Victor Santi ASC/YFAIC	MAJ Timothy Wieck, USA AFRL-HESA	Dr. Anna Johnson-Winegar DDR&E(E&LS)
LTC Jerry Reid, USA HSC/YACA		Mr. James Brinkley AFRL-CF	

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0603231F	2830	6.5	5.3	5.1	5.6	4.6	4.0
0602202F	7184	2.3	2.4	2.4	2.1	0	0
	Total	**8.8**	**7.7**	**7.5**	**7.7**	**4.6**	**4.0**

HS.02.06 Advanced Hybrid Oxygen System

Objectives. Develop and demonstrate technologies capable of generating and liquefying high-purity oxygen using electrical power or aircraft engine bleed air. This advanced technology program contains two individual developments, one targeted for heavy aircraft applications (Advanced Hybrid Oxygen System–Aircraft (AHOS-A)), and a smaller, portable unit for aeromedical evacuation and field casualty care operations (Advanced Hybrid Oxygen System–Medical). These systems are self-generating liquid oxygen systems that meet U.S. Pharmacopoeia requirements for medical-grade oxygen and high-altitude, low-opening-parachuting, pre-breathe concentrations.

Payoffs. The AHOS will eliminate the requirement for stored liquid oxygen and transport of oxygen production equipment to the war zone.

Challenges. The system must be designed within realistic weight, size, and power consumption specifications and require minimal maintenance. Specific critical technologies include turbomachinery, heat exchangers, concentrator, and integration and automation issues. Fluctuating budgets put the technology demonstration in FY01 at risk.

Milestones/Metrics.

FY1998: Detailed design of AHOS-A, with additional technical support from AFRL Phillips Site and an experienced systems/aircraft integrator.

FY1999: Fabrication of cryogenic refrigerator components for AHOS-A; fabrication of oxygen concentrator.

FY2000: System assembly and cryogenic testing for AHOS-A refrigerator; system integration of oxygen concentrator and cryogenic refrigerator.

FY2001: AHOS–A test and analysis. The system will generate and liquefy 175 lpm of 99% gaseous oxygen and limit oxygen subsystem maintenance requirements at the operational and intermediate (O&I) levels to a quick filter change at an estimated mean time between maintenance action of 500 flight-hours. Technology transition of AHOS–A.

Customer POC		Service/Agency POC	USD(A&T) POC
MAJ John Ewing, USA HQ AMC/SG	Mr. Dennis Schroll ASC/ENSN	Mr. James Brinkley AFRL-CF	Dr. Anna Johnson-Winegar DDR&E(E&LS)
MAJ Thomas Langston, USA HQ ACC/SG		Capt Jerold Fenner, USAF AFRL-HE	

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0603231F	2830	1.9	2.0	2.1	2.3	0	0
	Total	**1.9**	**2.0**	**2.1**	**2.3**	**0**	**0**

HS.03.06 Aircrew Distributed Mission Training Technology

Objectives. Develop, demonstrate, and evaluate affordable training technologies to improve aircrew training capability in local and geographically distributed modes of multiaircraft formations. The program will develop and adapt high-fidelity, low-cost simulation technologies that allow aircrews to train as they intend to fight. These technology areas include instructional design, cockpit simulation, visual simulation systems, threat system simulations, and instructor-operator station technology. The goal is to link virtual, live, and constructive simulation assets together to allow warfighters to learn and practice their combat individual and team skills in a synthetic battlefield.

Payoffs. This effort, which began in 1996, develops an aviation training strategy that makes the most effective use of simulators, training devices, and live exercises for initial flight skills through unit combat tasks. Currently, warfighters must alter their training approaches due to constraints (e.g., cost, security, safety), with the result that their training is less than totally realistic. This technology will permit training that is more realistic. Distributed mission training will also allow the military to reduce the cost of training, put less flight hours on aging aircraft, and help to reduce pressure on training ranges.

Challenges. Technical barriers include visual-system resolution that prevents aircrew trainees from determining aspect angle of friendly and enemy simulated aircraft at real-world distances. Threat systems are not fully representative of the real world (i.e., simulated threat systems tend to artificially simplify dynamic threats). Terrain databases are not large enough to accurately represent a theater-wide environment. Simulated sensor systems are not fully multispectral. Simulator instructor-operator stations frequently either constrain the way instructors want to train or make the interface with the simulator too complex. Simulator cockpit avionics systems are too artificial due to their use of lookup tables that are often not dynamic enough to represent the actual physics environment of flight.

Milestones/Metrics.

FY1998: Develop and demonstrate a multirole aircrew simulation testbed, integrating four advanced simulation cockpits with next-generation visuals in 360-deg displays, with an advanced control station and threat systems that will increase pilot capability to conduct air superiority missions by 30%, close air support missions by 25%, and interdiction missions by 35%.

Customer POC		Service/Agency POC	USD(A&T) POC
CAPT William Fetzer, USN NAVAIR, PMA205	COL William Powell, USA TRADOC, USAAVNC	Dr. Dee Andrews AFRL-HEA	Dr. Anna Johnson-Winegar DDR&E(E&LS)
LTC Joseph Hawkins, USA Air Combat Command		Dr. Dennis Wightman ARI RWARU	

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602785A	790	1.9	0	0	0	0	0
0603227F	2743	0.6	0	0	0	0	0
	Total	**2.5**	**0**	**0**	**0**	**0**	**0**

HS.04.06 Knowledge Representation Technologies for Human Performance Enhancement

Objectives. Develop a unified and comprehensive knowledge representation technology that supports the acquisition, storage, maintenance, retrieval, and application of digitally coded human knowledge and skill. This DTO will capitalize on cutting-edge cognitive science. The technology will enable (1) efficient methods for knowledge engineering (extraction and coding of human expert knowledge) and knowledge recoding (extraction and recoding of existing, knowledge-bearing digital data); (2) authoring tools for knowledge-based (individual and team, local and distal) courseware that capitalizes on these knowledge technologies; (3) tools for planning, deploying, and life-cycle management of courseware over local, wide-area, and global networks; (4) tools for human performance assessment, remediation, and support over local, wide-area, and global networks; (5) tools for rapid deployment of just-in-time and theater-specific training; (6) tools for automated feedback of human performance data to centralized human resource tracking facilities in order to support ongoing empirical improvement of personnel selection, training, job aiding, and workspace design; and (7) tools for searching, browsing, and otherwise utilizing archived knowledge to support all forms of training, education, and performance enhancement and media.

Payoffs. Maximum payoff will occur through widespread use of this enabling technology and resultant enhancement of enabled technologies at operational performance levels (in the form of job-aiding technologies), at logistical levels (in the form of personnel management technologies), and in the training arena (in the form of advanced courseware and courseware authoring systems). Large-scale implementation of knowledge-based courseware and courseware authoring technologies can significantly reduce the cost of military instruction while simultaneously increasing training effectiveness. Knowledge recoding techniques enable the efficient extraction of knowledge and skill information from existing data sources. Example sources include occupational survey data, technical databases, and legacy courseware. Knowledge-based job aiding can increase operational readiness and reduce human errors. Finally, knowledge archiving can eliminate systemic knowledge loss due to the attrition of expert personnel.

Challenges. The greatest challenge in this area derives from converting the DoD training establishment from a behavioral psychology of human performance to a cognitive psychology of human performance. Although the data supporting the power of this new approach is overwhelming, the behavioral approach to human performance is very entrenched in the internal DoD training hierarchies as well as among DoD training contractors. Policy definition and coordination activities must help create a commercial and federal environment that encourages this technology upgrade by providing carefully targeted examples.

Milestones/Metrics.

FY1998: Develop and demonstrate a generalized knowledge representation scheme with associated student modeling module for knowledge-based, intelligent computer-aided instruction (ICAI) application. Begin development of a knowledge-based ICAI authoring system. Initiate migration of existing simulation-based ICAI authoring environment to Java for platform independence and Internet compatibility.

FY1999: Complete migration of simulation-based ICAI authoring environment to Java. Demonstrate platform independence and Internet compatibility. Initiate development of knowledge-based technologies for automated curriculum planning and media selection.

FY2000: Demonstrate capacity to convert digitized occupational survey data and technical order data to partially populate knowledge bases. Demonstrate 70% reduction in time to develop student models for knowledge-based ICAI courseware.

FY2001: Complete validation of Java version of simulation-based intelligent tutor authoring environment and demonstrate knowledge representation (KR)-based intelligent tutor authoring. Demonstrate 80% reduction in time to develop knowledge-based and simulation-based ICAI that is Internet ready.

Customer POC		Service/Agency POC	USD(A&T) POC
Ms. Mariellen Cogan HQ JSF/PO	Mr. Dennis Richburgh AIA/CA	Dr. W. Regian AFRL-HEJT	Dr. Anna Johnson-Winegar DDR&E(E&LS)
Mr. Don Johnson OSD-R&T	LTC George Selix, USA AETC/XPRT		

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602202F	1123	1.7	1.6	1.8	1.7	0	0
0603227F	2743	1.3	1.4	1.5	1.5	0	0
	Total	**3.0**	**3.0**	**3.3**	**3.2**	**0**	**0**

HS.05.05 Ballistic Protection for Individual Survivability

Objectives. Develop and insert advances in materials technology to increase the protection and performance of armor systems for the individual warfighter while minimizing penalties associated with increased levels of protection.

Payoffs. Reducing casualties and increasing survivability are the basis for this work. Regardless of causal agent, burn injuries can result in high medical costs, lost duty time, and mental stress incurred in the long-term rehabilitation from burns. "Personnel armor is too heavy" continues to be a major complaint from all who use it, whether military or civilian law enforcement. This work focuses on developing and inserting materials and material systems that are substantially lighter in weight than currently fielded personnel armor. Any user with a requirement for personnel armor will benefit from these improved technologies. Additionally, as weapon developers drive their technologies to be more lethal against the individual warfighter, the technology advancements from this DTO will pave the way for personnel armor materials/systems to address future threats more effectively.

Challenges. Technical barriers include physical property limitations of current high-performance ballistic protective materials; excess weight, thickness, and cost; rigidity of materials; and manufacturing methodology. Other barriers include the fundamental understanding of materials behavior under ballistic impact at various environmental conditions, the design and synergistic effects of material components within a system, and the development of appropriate predictive models. This DTO leverages efforts ongoing at DARPA and U.S. Army Research Laboratory (DTO MP.05.01, Protective Materials for Combatant and Combat Systems Against Conventional Weapons) to address the broad range of technical challenges.

Milestones/Metrics.

FY1998: Demonstrate a 20%–30% reduction in areal density (weight for given area) over current small arms protection (known ball threats up to .30 caliber) without significantly increasing other penalties.

FY1999: Integrate and transition improved technology to modify existing and near-term personnel armor.

FY2000: Transition technology for 35% system weight reduction with equal protection to FY96 individual countermine protective system.

FY2001: Transition enhanced test methodology/assessment criteria for personnel armor systems.

FY2003: Demonstrate second-generation multiple ballistic threat protection prototype with 25% decrease in weight (or an increase in protection or a combination of both, depending on user assessments).

Customer POC		Service/Agency POC	USD(A&T) POC
COL Timothy Bosse, USA USA DBBL	Col Henry Kinnison, USAF TSM-Soldier, TRADOC	Mr. Phillip Brandler NRDEC	Dr. Anna Johnson-Winegar DDR&E(E&LS)
COL Philip Hamilton, USA PM-Soldier		Ms. Janet Ward NRDEC	

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602786A	H98	1.0	2.0	2.1	2.1	2.3	2.4
	Total	**1.0**	**2.0**	**2.1**	**2.1**	**2.3**	**2.4**

HS.06.01 Joint Cognitive Systems for Battlespace Dominance

Objectives. (1) Develop a total systems framework for improving the cognitive and information management processes associated with brigade and above and in theater air operations; and (2) through the optimized consideration of staff training and proficiency, organizational design, and digital technology insertion, identify a set of integrated solutions for overcoming decision-making bottlenecks induced by information overload, geographical dispersion, and high time stress. Cognitive systems engineering technology produces human-centered work domain and interface design methods and tools, cognitive and team performance models, and complete work-centered, human–interface systems that span a combat team.

Payoffs. Cognitive systems will improve sustained C^4I operations that fully leverage the services' investments in digital information systems technology (displays, intelligent assistants, distributed communication systems, etc.) through optimized warrior-system-organizational strategies for the information-age battlefield. Reductions in organizational standup, coordinated response timelines, and enhanced data fusion, group situation awareness, and flexible force deployment will also be realized.

Challenges. The principal technical barriers include (1) limited understanding of real-world cognitive processes in the C^4I setting and how those processes are affected by staff experience, time stress, and information uncertainty; (2) difficulty in articulating and structuring information requirements associated with battle command (versus control); (3) development of intelligent information displays, assistants, and agents that can support a "concept driven" cognitive process as well as a "data driven" process; (4) development of organizational, procedural, and information system design strategies that optimize collaboration between the human decision maker and the information system technology; and (5) immature paradigms, software architectures, and design support methodology for dynamic coordination and cooperation of taskwork and teamwork.

Milestones/Metrics.

FY1999: Demonstrate improved cognitive system strategies for improving battlespace visualization accuracy and timeliness (30% reduction in operationally significant errors).

FY2000: Demonstrate improved cognitive system strategies for improving the focus of the relevant common picture and articulation of commander's intent (100% improvement in assessed utility for maintaining a consistent mental model among key command elements). Demonstrate a joint cognitive crew system concept for assisted target acquisition that reduces false alarm rates by at least 30%.

FY2001: Demonstrate an improved cognitive system concept for reducing battle staff personnel requirements for sustained C^4I operations (30% reduction in TOC personnel).

FY2002: Demonstrate improved cognitive system strategies for increasing the flexibility of theater C^4I operations to respond to operations-other-than-war and other asymmetric military engagements (100% improvement in the assessed utility of information support systems to address the full range of politico-economic and military factors that must be considered by the rapid projection force command staff).

Customer POC

Maj Robert Braun, USAF
ACC/DRAC

Mr. James Homer
NAIC/TACN

Mr. Dick Brown
TPIO ABCS

Mr. Gary Martin
ASC/FBXT

Service/Agency POC

Mr. James Brinkley
AFRL-CF

Mr. Gil Kuperman
AFRL-HE

Dr. Dennis Leedom
ARL

USD(A&T) POC

Dr. Anna Johnson-Winegar
DDR&E(E&LS)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602202F	7184	2.0	2.0	1.9	1.6	1.1	0
0602716A	H70	1.2	1.6	1.7	1.7	1.8	0
0602785A	790	0.9	0.9	1.0	1.0	1.0	0
	Total	**4.1**	**4.5**	**4.6**	**4.3**	**3.9**	**0**

HS.07.06 Crew Station Integration Demonstrations

Objectives. Advance the state of the art in crew station integration technology, and demonstrate, in ground-based simulation and flight test, how crew-centered technologies, methods, and metrics can be synergistically integrated to improve crew performance throughout the platform's operational envelope. Specific technology goals include integrating helmet displays with speech recognition, large electronic displays, and pictorial/graphical display formats, thereby exploiting human capabilities to achieve acceptable workload levels that are comparable to or better than existing systems with larger crew complements.

Payoffs. This DTO will improve mission effectiveness, enhance crew station design suitability, and improve weapon system affordability and safety.

Challenges. The main technology challenge is to minimize task "shedding" by combat aircrews during high-stress and time-constrained operations, when the warfighter must make mission adjustments in response to rapidly changing combat conditions. When this challenge is met, operations with reduced crew size and the attendant affordability gains will be realized.

Milestones/Metrics.

FY1998: Deliver a version of COMBIMAN interfaced to AutoCAD using the CAD model of the U–2 cockpit. Perform cost-benefit analysis of alternative human–computer interface technologies for uninhabited combat aerial vehicle operator's console.

FY1999: Demonstrate, in flight test, 97% voice recognition system accuracy in high-performance, single-seat fighter to validate recognition system performance in high-g environment. Demonstrate, in ground-based simulation, multiple target attack per pass through integration of pathway-in-the-sky and weapon delivery symbology. Demonstrate, in ground-based simulation, enhancements to pilot situational awareness and aircraft survivability resulting from cockpit integration of Airborne Broadcast Intelligence system data.

FY2000: Demonstrate, in ground-based simulation, a 25% reduction in aircrew workload attributable to the integration of flightpath, synthetic terrain, and weapon delivery symbology. Demonstrate, in full mission simulation, integration of offboard and onboard data in an advanced "all glass" transport cockpit.

FY2001: Demonstrate, in ground-based simulation, an additional 25% reduction in aircrew workload through the integration of 3D audio cueing, helmet-mounted display, and voice recognition to the technologies demonstrated in FY00. Demonstrate, in full mission simulation, effective management of four UCAVs by two operators (50% crew reduction over planned systems).

Customer POC	Service/Agency POC	USD(A&T) POC
MAJ Evan Marlin, USA	Mr. James Brinkley	Dr. Anna Johnson-Winegar
ASC/XR	AFRL-CF	DDR&E(E&LS)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602201F	2403	2.2	2.2	2.2	2.2	2.2	2.2
	Total	**2.2**	**2.2**	**2.2**	**2.2**	**2.2**	**2.2**

HS.08.06 Crew System Engineering Design Tools

Objectives. Develop advanced human physical measurement and characterization technologies to increase the fit, protection, performance, and affordability of crew systems. Technical objectives include establishing advanced crew and maintainer system interface design tools, accommodation evaluation methods, electronic databases, and tools for insertion of the technologies into computer-aided design and manufacturing environments.

Payoffs. This DTO will increase the quality of fit, protection, and performance of Joint Helmet-Mounted Cueing System, Joint Primary Aircrew Training System, F–22, and JSF crew systems; increase affordability of these and future systems with expanding accommodation of crew member and maintainer populations; and increase system interoperability for planned joint service applications.

Challenges. Technical barriers include the limitations of CAD/CAM tools to incorporate human physical databases and information, visualization and analytic data distillation for the new increased volume of information, and linking fit and performance assessment with physical properties.

Milestones/Metrics.

FY1998: Create cockpit accommodation methods training tool for use in crew station design performance assessment with a 30% reduction in accommodation design error and potential for a 70% increase in female accommodation range.

FY1999: Develop generic 3D anthropometric CAD template tool; collect first 3D whole-body database; develop fit-based size prediction method for personal equipment and clothing.

FY2001: Finish gathering crew station accommodation database of inventory aircraft resulting in at least a 90% elimination of clearance and control actuation reach problems through screening or aircraft modification. Finish collection of NATO 3D anthropometric database for use in interoperability prediction.

Customer POC		Service/Agency POC	USD(A&T) POC
Mr. Robert Billings	Maj Kurt Tempel, USAF	Mr. James Brinkley	Dr. Anna Johnson-Winegar
ASC/ENFC	AETC/SAS	AFRL-CF	DDR&E(E&LS)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
S&T Funding							
0602202F	7184	6.0	6.0	6.0	5.3	0	0
Total S&T		**6.0**	**6.0**	**6.0**	**5.3**	**0**	**0**
Non-S&T Funding							
0603790F		0.4	0.4	0.2	0	0	0
Total Non-S&T		**0.4**	**0.4**	**0.2**	**0**	**0**	**0**

HS.09.06 Development of Advanced Embedded Training Concepts for Shipboard Systems

Objectives. Develop and demonstrate an advanced embedded training capability and other deployable instructional technologies to improve combat information center team decision-making performance.

Payoffs. This effort, which began in 1996, will develop a system that will automatically track team member behavior, assess performance, provide online feedback, and facilitate computer-assisted coaching. Instructional technology will also be provided that supports improved scenario generation, instructor training, on-the-job training, post-exercise debriefing, advanced tactical training, and shipboard refresher training.

Challenges. A promising solution to the challenges of escalating task complexity and shrinking budgets is that we provide robust shipboard training capabilities that allow the ships to tailor training resources to their particular needs. Ships need to train anywhere, anytime, on-demand, and more cheaply than ever before. From a technological standpoint, this means that we must investigate and apply emerging instructional and related human-performance technologies in the shipboard environment. Specifically, advances in automated performance assessment, intelligent diagnosis, automated scenario preparation and control, feedback mechanisms, and enhanced instructor training and aiding are needed. The challenge is to successfully integrate these developing technologies into a single, complex system. A second challenge is to assess the relative contribution of the contributing technologies. The intelligent diagnosis component is the key contributing technology, but has yet to be applied to a complex team environment.

Milestones/Metrics.

FY1998: Conduct an operational demonstration of advanced embedded training system, with an anticipated improvement of team decision-making performance of 25%–40%, reduction in training time of 40%, and reduction in required instructors of 50%.

Customer POC	Service/Agency POC		USD(A&T) POC
RADM George Huchting, USN PMS 400	Dr. Jan Cannon-Bowers NAWCTSD 4961	Mr. W. Harris NAWCTSD 4.9T	Dr. Anna Johnson-Winegar DDR&E(E&LS)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0603792N	R1889	4.0	0	0	0	0	0
	Total	**4.0**	**0**	**0**	**0**	**0**	**0**

HS.10.05 Force XXI Land Warrior

Objectives. Develop and demonstrate advanced technology insertions to the Land Warrior (LW) system, and measure the individual and small-unit operational effectiveness afforded by these advanced technologies.

Payoffs. Technologies will be developed to reduce overall system weight, provide reduced power electronics, improve reliability, reduce costs, increase lethality, improve C^2, improve mobility, reduce fratricide through the integration of combat identification functionality, and improve the human interface through the integration of system voice control. All successful products will be directly transitioned into the Land Warrior EMD program. An early user test (EUT) to validate the improvements afforded by each technology will be conducted in coordination with the testing community and PM to ensure easy transition. By working directly with the LW PM and testing community, some products should be ready for first production of the LW system.

Challenges. The challenge facing this DTO is the integration of these advanced technologies onto the LW platform in such a manner that they do not increase overall weight and power requirements of the soldier. Any increase in weight or power must come with a verified payoff to the soldier. Other challenges include electronics packaging, EMI, and ruggedness of the components to withstand a soldier's environment.

Milestones/Metrics.

FY1998: Perform proof-of-concept demonstrations: 1-W power savings on LW helmet display electronics, 50% decrease in target acquisition time when switching from night vision to thermal weapon views, 3.5X increase in LW soldier radio range, GPS-level position and navigation accuracy when GPS is not available.

FY1999: Conduct EUT and transition successful technologies: 4-lb weight reduction of LW weapon-mounted components, 25% cost reduction of LW weapon-mounted components. Transition MOUT-specific capabilities to MOUT ACTD.

FY2000: Complete future dismounted soldier system architecture analyses. Begin work on revolutionary/block upgrades to LW system: 100% improved weapons link reliability through the elimination of the LW hardwired weapon link.

FY2001: Demonstrate viability of new soldier architecture using modeling, simulation, and linkage to the digital integration lab: provide same system capabilities while reducing system overhead requirements by 25%.

FY2002: Integrate successful Small-Unit Operations/Situational Awareness Systems capabilities onto soldier platform. Demonstrate hardware/software extensions to soldier architecture: 5% reduction in overall soldier system weight, power, and costs.

FY2003: Validate highest payoff technologies through modeling, simulation, and virtual prototyping: 10% reduction in overall soldier system weight, power, and costs.

Customer POC		Service/Agency POC	USD(A&T) POC
COL Timothy Bosse, USA USA DBBL	Mr. Doug Davis MARCORSYSCOM(CSSLE)	Mr. Phillip Brandler NRDEC	Dr. Anna Johnson-Winegar DDR&E(E&LS)
Col Henry Kinnison, USAF TSM-Soldier, TRADOC		Mr. Patrick Snow DDR&E(E&LS)	

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0603001A	J50	10.7	9.3	6.4	6.4	7.7	8.0
	Total	**10.7**	**9.3**	**6.4**	**6.4**	**7.7**	**8.0**

HS.11.06 Force XXI Training Strategies

Objectives. Develop methods that provide training and performance evaluation techniques to support digital integration capabilities for Army Force XXI. Research will exploit the use of developmental simulation and advanced warfighting experiments as appropriate to demonstrate and evaluate prototype techniques.

Payoffs. The research will establish functional performance requirements for specific positions in Force XXI units and identify tasks needing special attention because these required skills decay rapidly. It will develop and demonstrate techniques for training and sustaining performance of these tasks, and provide performance evaluation techniques for assessing task proficiency.

Challenges. Technical barriers include how to redesign and redevelop functional performance requirements to keep pace with (1) evolving doctrine and organizational structures of brigade and battalion staffs, and (2) future fielding of training devices and simulations with digital capability.

Milestones/Metrics.

FY1998: Design a prototype training package using advanced digital technologies that will lead to a 25% improvement in training development efficiency as measured by time savings.

FY1999: Evaluate training and performance assessment tools developed for the digitized battlefield in terms of their ability to assess performance systematically.

FY2001: Develop and demonstrate new training and performance assessment technologies that prepare operators and commanders to take advantage of evolving digitized C^3 systems 35% more effectively as determined by expert ratings.

Customer POC	Service/Agency POC		USD(A&T) POC
COL William Betson, USA	Dr. Barbara Black	Dr. Beverly Harris	Dr. Anna Johnson-Winegar
Director, TRADOC	ARI	ARI, SARD-TR	DDR&E(E&LS)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602785A	790	1.2	1.3	1.2	0	0	0
0603007A	792	0	0.9	1.0	1.0	0	0
	Total	**1.2**	**2.2**	**2.2**	**1.0**	**0**	**0**

HS.12.02 Helmet-Mounted Sensory Ensemble

Objectives. Improve warfighter effectiveness by developing and demonstrating advanced helmet-mounted tracker/display (HMT/D) technologies. The Helmet-Mounted Sensory Ensemble (HMSE) program addresses human performance limitations and provides a pilot-acceptable, helmet-mounted display that reduces target acquisition time and significantly increases warrior survivability. In addition to tackling safety issues for ejection and emergency egress, research on fit, comfort, and helmet stability will ensure a human-engineered system for the expanded pilot population. Improved image sources, including flat panel displays, will be developed to improve display performance, reduce weight, lower costs, and optimize human interface capability. Advanced cueing and space-stabilized interactive display interfaces that address human control-loop issues will also be developed, integrated, and tested.

Payoffs. Warfighter payoffs include enhanced mission, upgraded lethality, increased situational awareness, and increased survivability. Since the HMSE is tied to emerging high-performance missile systems, the pilot will be able to "look and shoot" instead of having to "point the air platform and shoot." Considerable advances in maintainability and interchangeability will be realized through active pursuit of commonality across programs such as the Joint Helmet-Mounted Cueing System (JHMCS) program, the F–15 System Program Office, the USN/USAF AIM–9X missile program, and the Joint Strike Fighter program.

Challenges. HMT/D systems will need to be developed that are ejection capable (lightweight with correct centers of gravity), accommodate the smaller statures in the current pilot population, support commonality across airframes, and are interchangeable during flight with panoramic night vision goggle systems. Physical limitations of displays that reduce weight and volume yet keep the center of gravity of the helmet within limits have been reached. New technologies are required to bypass the barrier without compromising visual resolution, reliability, and cost goals. Software algorithms for image stabilization during high-g buffeting have reached limits where processing latency starts to compromise mission effectiveness. Miniature accelerometers hold significant promise of a hardware solution to the image stabilization challenges.

Milestones/Metrics.

FY1998: Fly VCATS-extended uplook HMT/D, low-latency control loop, and standardized interface in three F–15Cs for 100% improvement in first-shot/exclusive-kill ratios; integrate results into JHMCS. Initiate development of miniature flat-panel image source for HMT/D.

FY1999: Combine binocular HMT/D with electronically displayed image intensifier to get a comprehensive head-mounted sensor/symbology display suite (3:1 increase in ground targets killed per pass).

FY2000: Demonstrate first two-primary-color HMT/D: improves luminance (4:1) and resolution (2:1) in see-through visors yielding improved situational awareness of hostile aircraft and other JTIDS-type data.

FY2001: Transition upgraded full-color HMT/D with (5:1) variable transmittance visor and PNVG technology to support JHMCS P^3I.

Customer POC	Service/Agency POC		USD(A&T) POC
MAJ Thomas Tenpenny, USA HQ ACC/DRAW	Mr. James Brinkley AFRL-CF	Mr. Randall Brown AFRL-HE	Dr. Anna Johnson-Winegar DDR&E(E&LS)
Mr. Terry Witte PMA-202 (NAVAIR)	Mr. William King ONR		

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
S&T Funding							
0602122N		3.9	1.8	1.9	2.0	0	0
0602202F	7184	0.4	0.4	0.4	0.4	0	0
0603231F	3257	6.6	3.3	3.8	4.5	0	0
Total S&T		**10.9**	**5.5**	**6.1**	**6.9**	**0**	**0**
Non S&T Funding							
0603790F		1.9	1.3	0	0	0	0
Total Non S&T		**1.9**	**1.3**	**0**	**0**	**0**	**0**

HS.13.06 Human-Centered Automation Testbed

Objectives. Develop and demonstrate a field-deployable, simulation-based, automation testbed to quantify human system performance requirements. Performance data from constructive analysis and from warfighter-in-the-loop operational mission simulation can effectively characterize the human system interaction within analyses of alternatives (AoA), mission need statements, and operational requirements documents. Advances are anticipated in the requirements generation process for characterizing human system interaction, in state of the art in human performance modeling, and in the ability to interrelate performance and effectiveness data between constructive analysis and real-time operational mission simulation.

Payoffs. Warfighting commands can confirm automation requirements based on modeling and simulation performance data. This DTO will provide the capability to quantify automation requirements, relate crew performance to system effectiveness and cost, improve warfighter acceptance of combat automation, establish human effectiveness requirements verifiable by developmental and operational testing, and support clear accountability in requirements and design.

Challenges. Human interaction is not effectively captured in setting combat automation requirements. Current methods do not quantify payoff from crew system technology or link crew performance to system effectiveness. Technical barriers include the lack of an authoritative representation of human performance within constructive analysis, and poor connectivity of human performance data across analysis, design, development, test, and training. To meet these challenges, the automation testbed concept will be defined and exercised in two separate mission applications. Following concept definition, an ATD will demonstrate the testbed hardware and software in a battle laboratory environment.

Milestones/Metrics.

FY1998: Baseline automation requirements process; illustrate with Joint Direct Attack Munition (JDAM) example.

FY1999: Develop human model architecture; integrate with DoD-approved constructive model.

FY2000: Quantify crew/automation tradeoff in AoA; verify in real-time combat simulation; confirm AoA model projection with real-time test data to 0.85 correlation in mission effectiveness and 0.90 correlation in crew operability.

FY2001: Complete testbed predesign; demonstrate ability to extrapolate modeling and simulation data to set requirements.

FY2003: Demonstrate testbed in battle laboratory operational simulation; confirm 0.90 human effectiveness correlation between local mission simulation and distributed combat exercise.

Customer POC		Service/Agency POC	USD(A&T) POC
Lt Col Timothy Choate, USAF ASC/XRT	Maj Ken Verderame, USAF AFRL-VSD	Mr. James Brinkley AFRL-CF	Dr. Anna Johnson-Winegar DDR&E(E&LS)
Mr. John Price ASC/RAE			

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0603231F	2830	1.6	2.9	3.3	3.6	4.6	5.5
	Total	**1.6**	**2.9**	**3.3**	**3.6**	**4.6**	**5.5**

HS.14.04 Human Performance Metrics for Theater Missile Defense

Objectives. (1) Integrate metric research on human situation awareness and mental workload with state-of-the-art network modeling of human performance, resulting in a human performance measurement instrument usable in an operational test; and (2) demonstrate the proper combination and weighting of metric components, showing diagnostic validity for theater missile defense attack operations. The classes of measures included are individual performance, system performance, physiological measures, and subjective measures.

Payoffs. The operational effectiveness of combat aircrews to perform the TMD "Scud hunt" mission will increase by providing effective human performance metrics that improve tactics and identify weapon system software and sensor improvements. Results will apply to F–15E, F–16C, and JSF.

Challenges. Interrelating human performance metrics to assess human situation awareness, pilot workload, and human system performance in a single measurement instrument is a considerable technical challenge. Isolated approaches to individually probe each of those performance-related components have been partially successful, but the results are not generalizable. The task of reducing the large volumes of raw data from developmental and operational tests into data that are meaningful for human performance model evaluation is a very large effort. Concurrent improvement to the underlying theoretical models of workload and situation awareness, as they relate to operational performance, is required.

Milestones/Metrics.

FY1998: Evaluate five network models in laboratory simulation of TMD attack operations, per international cooperative effort via The Technical Cooperation Program, producing guidelines for weighting and reducing human performance data.

FY1999: Complete a modeling experiment in part-mission simulation, using a common performance weighting method derived from the network model comparison. Achieve 0.90 model correlation with real-time TMD simulation performance data.

FY2001: Develop TMD mission model representing operational systems and tactics; validate model through operational mission simulation or flight test verifying 140% increased range at target detection and permitting multiple target launch with 20% reduced pilot workload.

FY2003: Extend the TMD-derived human performance metrics to the C^4ISR domain for use in a global awareness testbed to assess complex performance in C^2 operations.

Customer POC		Service/Agency POC	USD(A&T) POC
Maj Robert Braun, USAF ACC/DRAO	Lt Col B. Uhle, USAF 85 TES/CC	Mr. James Brinkley AFRL-CF	Dr. Anna Johnson-Winegar DDR&E(E&LS)

Mr. Gary Martin
ASC/FBXT

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602202F	7184	1.0	0.9	1.1	1.2	1.1	1.2
	Total	**1.0**	**0.9**	**1.1**	**1.2**	**1.1**	**1.2**

HS.15.06 Integrated Personnel Management Technologies

Objectives. Develop and demonstrate mathematical, statistical, and information system technologies that will help personnel force managers maximize personnel readiness at minimum cost.

Payoffs. This DTO will develop tools that provide the capability to make informed and accurate planning, budgetary, policy, and execution decisions in the face of extraordinary financial, personnel, and social turbulence. At present, the impact of personnel policies cannot be measured across functional areas (e.g., recruiting, selection and classification, community management, training management, personnel inventory management). The impact of specific personnel policy changes (near- and long-term) on readiness at all levels is unknown. The overall impact as well as the impact on local areas, commands, types, communities, individual battlegroups, ships, squadrons, etc., cannot be determined. Integrated personnel management tools must be developed to allow for personnel wargaming. Alternative policies must be tested to assess their impact on the near- and long-term costs and readiness at all levels of the Navy. Failure to develop such capability leaves the Navy vulnerable when local-area readiness is insufficient to secure the peace, avoid casualties, or end hostilities quickly. The risks of insufficient funding, misallocated resources and, therefore, readiness deficiencies remain high without integrated personnel management tools.

Challenges. Technical barriers include (1) high-speed optimization algorithms capable of determining the readiness consequences of the millions of different person–job match alternatives; (2) linking models of widely differing scope, structures, and size; (3) variable dimensional modeling to adapt to new policy initiatives and dimensions; and (4) data reduction and scientific visualization techniques to enable personnel managers to comprehend the possible alternatives and their long-term consequences.

Milestones/Metrics.

FY1998: Demonstrate a 10% improvement in forecasting multiyear accession, promotion, and retention, preventing costly overruns in personnel appropriations while meeting skill requirements.

FY2000: Demonstrate an intelligent job advertising and selection system that will increase the number of assignments meeting personnel preferences while increasing skill matches and reducing moving costs by over $60 million per year.

FY2001: Demonstrate a personnel planning system that integrates manpower requirements determination and allocation with end-strength and skill-inventory management and personnel distribution and assignment. The result will be improved readiness assessment, more efficient policy execution, and more effective use of limited personnel appropriation.

Customer POC	Service/Agency POC	USD(A&T) POC
CAPT Steven Wolff, USN	Mr. Dennis Schurmeier	Dr. Anna Johnson-Winegar
BUPERS (PERS-22)	NPRDC Code 11	DDR&E(E&LS)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602233N		1.5	1.5	1.5	1.5	0	0
0603707N	R1770	3.0	3.2	3.2	3.3	0	0
	Total	**4.5**	**4.7**	**4.7**	**4.8**	**0**	**0**

HS.16.06 Interactive Multisensor Analysis Training Technology

Objectives. Develop and demonstrate new generalizable methods for training tactical and analytical tasks employing complex sensor systems for a range of undersea warfare applications.

Payoffs. The interactive multisensor analysis training (IMAT) effort, which began in FY92, is expected to demonstrate a performance improvement in acquisition and retention of operator skills through complete revision of submarine and air sonar training, and demonstrate a prototype advanced technology sonar employment training system to support an FY00 OPNAV N–87 Sonar Employment Training system procurement.

Challenges. Technical challenges include (1) development of systems that integrate computer models of physical phenomena with scientific visualization technologies to demonstrate the interactive relationships of threat, environment, and system for operator training and demonstrate interactions of multiple sensor systems for tactician training; (2) curriculum integration and training development using modeling and visualization technologies; and (3) evaluation of effects of training on high-level sensor operation and tactical planning skills.

Milestones/Metrics.

FY1998: Demonstrate a 25% performance improvement in acquisition and retention of operator skills through complete revision of submarine sonar technician training; demonstrate a prototype advanced technology sonar employment training system to support an FY00 OPNAV N–87 Sonar Employment Training system procurement.

Customer POC		Service/Agency POC	USD(A&T) POC
Mr. George Horn	Ms. Sandra Wetzel-Smith	Dr. Allen Zeman	Dr. Anna Johnson-Winegar
Head, Undersea Mp and Train	SPAWARSYSCEN D301	Dep Dir Navy Trg N-7B	DDR&E(E&LS)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602233N		0.4	0	0	0	0	0
0603707N	R1772	2.3	0	0	0	0	0
	Total	**2.7**	**0**	**0**	**0**	**0**	**0**

HS.17.05 Panoramic Night Vision Goggle Technology

Objectives. Demonstrate improved mission safety and effectiveness during night aviation operations. Specific goals include reducing pilot fatigue and enhancing escape safety by applying a unique optical technique combined with a next-generation, smaller format image intensifier tube and integrated display that will result in a first-ever low-profile panoramic night vision goggle (PNVG). Additionally, the development and integration of an ultra lightweight electroluminescent display will offer flight and navigation symbology to the pilot. This new display will also be able to integrate sensor data into the pilot's field of view.

Payoffs. In addition to increased safety and mission effectiveness, the PNVG technology will significantly increase the intensified viewing area that the warfighter sees. The coordinated Air Force/Army approach is expected to result in a 100-degree horizontal field of view (versus the current 40-degree) with enhanced sensitivity due to advancements in the image intensifier tube. Unlike other night vision systems, the low-profile design of the panoramic goggle will be less fatiguing on long missions and should allow it to be retained safely on the warfighter's head throughout the escape sequence. Retention is extremely important for evasion, escape, and rescue. The Night Vision and Electronic Sensors Directorate at Ft. Belvoir participates with the Air Force in this DTO's technical interchange discussions and reviews. This DTO leverages previous Army work conducted in image intensifier technology.

Challenges. Technical barriers include system stability, maintaining performance while increasing field of view, and integration of spectacles and laser eye protection. Additional challenges are to improve low-light-level resolution, extend the spectral range, and develop manufacturing methodologies.

Milestones/Metrics.

FY1998: 160% increase in the intensified field of view on Air Force, Army, and Navy/Marine Corps fixed- and rotary-wing platforms; 50% weight reduction of image intensifier tube.

FY2000: 50% increase in available sensor information; 50% increase in detection range; 100% increase in sensitivity.

FY2001: Initiate risk assessment for ejection retainment capability of PNVG.

Customer POC		Service/Agency POC	USD(A&T) POC
CMSgt Steve Culbreth, USA HQ ACC/DRSL	Maj Hank Sanders, USAF HQ AFSOC/DOXT	Mr. James Brinkley AFRL-CF	Dr. Anna Johnson-Winegar DDR&E(E&LS)
Maj Ed O'Connor, USAF USASOC	MAJ Tom Wiese, USA 160th SOAR(A)	Mr. Jeff Craig AFRL-HE	

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0603231F	3257	3.0	2.3	2.2	0	0	0
0602202F	7184	0.8	0.8	0.8	0.7	0	0
	Total	**3.8**	**3.1**	**3.0**	**0.7**	**0**	**0**

HS.18.02 Precision Offset, High-Glide Aerial Delivery of Munitions, Equipment, and Personnel

Objectives. (1) Demonstrate revolutionary technologies for the reliable precision-guided delivery of combat-essential munitions and sensors, equipment, and personnel using high-glide wing and high-altitude life support; (2) demonstrate an optional glide augmentation system, providing an offset range of 75–300 km; and (3) 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 standoff distances during night and limited visibility conditions.

Payoffs. High-glide technology will significantly enhance the military aerial delivery capability through substantially higher glide ratios than currently possible and will directly benefit the initial deployment of early entry forces. These technologies will enhance the covert mobility of early entry forces in urban terrain areas and greatly improve lethality and survivability.

Challenges. Technical barriers include accurate characterization of decelerator aerodynamic coefficients of performance for varied payload weights, integration of a glide augmentation system, and integration of improved high-altitude life support technologies.

Milestones/Metrics.

FY1999: Demonstrate precision high glide of a 2,000-lb payload, with a goal of 5,000 lb using high-glide wing (6:1 or better glide ratio); demonstrate a glide augmentation capability to increase offset ranges to 75–300 km.

FY2001: Complete concept evaluation of personnel-sized, high-glide decelerator technology.

FY2002: Demonstrate a 50% increase in airborne insertion offset distance.

FY2003: Demonstrate novel integrated high-altitude (35,000-ft) life support and high-offset airdrop technologies.

Customer POC		Service/Agency POC	USD(A&T) POC
CPT William Kifer, USA	Mr. Doug Davis	Mr. Phillip Brandler	Dr. Anna Johnson-Winegar
USA MSBL	MARCORSYSCOM(CSSLE)	NRDEC	DDR&E(E&LS)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0603001A	242	1.2	1.3	1.9	3.3	3.6	3.8
	Total	**1.2**	**1.3**	**1.9**	**3.3**	**3.6**	**3.8**

HS.19.05 Rotorcraft Pilot's Associate ATD

Objectives. Develop and demonstrate, through simulation and flight test, a knowledge-based associate system for real-time cognitive decision aiding. The Rotorcraft Pilot's Associate (RPA) ATD program is based on a crew-centered design principle that adopts an integrated, system-wide approach to arbitrating and trading off goals and constraints for recommending a coordinated solution to the helicopter crew. RPA will provide a mixed initiative interface that communicates effectively, efficiently, and appropriately to aid the warfighter in mission execution. RPA will provide high-speed data fusion processing, automated continuous mission planning, context-sensitive reconfiguration of mission controls and displays, efficient and intuitive cockpit information management, crew-intent estimation, and greatly improved situation awareness. In addition, RPA will serve as the mission equipment integrator for the aircrews and will collect, synthesize, and disseminate pertinent battlefield information.

Payoffs. Warrior payoffs include increased situational awareness, increased range in mission changes and contingencies, reduced fratricide, increased accuracy and timeliness of reports, decreased mission planning and replanning time, and increased area searched per time and fuel. By applying artificial intelligence and advanced computing technologies, the RPA ATD will create a cooperative man–machine system. RPA will use information gathered from onboard and offboard sensors, team mates, and organic mission equipment to develop plans that facilitate the achievement of mission objectives.

Challenges. Technical barriers include the entity-level data fusion from multiple, disparate sensor systems operating over large geographical areas; battlefield situation assessment; and context-sensitive decision aiding provided in real time. Additional barriers include algorithms for crew-intent estimation and context-sensitive information management. The technical challenge of the RPA program is the development and integration of the task network and plan goal graph architectures to provide context-sensitive decision aiding in real time, to dynamically allocate tasks, and to manage the information presented to the warfighters.

Milestones/Metrics.

FY1998: Demonstrate, via simulation, an 80% reduction in mission planning/replanning time; demonstrate, via simulation, a 25% reduction in exposure time.

FY1999: Program exit criteria: reduce mission losses by 30%–60%; increase targets destroyed by 50%-150%; reduce mission timelines by 20%–30%.

Customer POC	Service/Agency POC	USD(A&T) POC
CW4 Ron Ferrell, USA	LTC George Dimitrov, USA	Dr. Anna Johnson-Winegar
SFAE-AV-RAH-T	AMSAT-AR-T-DR	DDR&E(E&LS)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602211A	47A	1.5	0	0	0	0	0
0603003A	436	16.4	5.1	0	0	0	0
0603003A	B97	0.4	0.2	0	0	0	0
	Total	**18.3**	**5.3**	**0**	**0**	**0**	**0**

HS.21.01 Decision Support Systems for Command and Control

Objectives. Develop technologies to enhance the decision-making skills of military commanders and their battle staffs. Examples include robust computational models of human cognition, relational databases, powerful computational algorithms, advanced multimodal workstations, and innovative designs for embedding training strategies into decision support systems. The goals are to provide improved situation assessment, option generation, response selection, and resource allocation while reducing procedural errors in tactical decision environments and reducing blue-on-blue and blue-on-white incidents.

Payoffs. The technology will provide maintainable decision support systems that minimize system life-cycle and procurement costs, reduce manning, and enhance mission effectiveness and survivability of global forces. Implementations of decision support technology will significantly improve the quality, timeliness, and synchronization of command decision making. These technologies will yield performance-enhancing information management and decision support technology that helps the complete range of military C^2 systems.

Challenges. Technologies must be developed and validated to support the full range of tactical and strategic applications. Rule-based symbolic and neural net models of decision making and critical thinking must be further developed, refined, and adapted for real-time decision support applications. Capabilities are required to integrate tactical knowledge bases and computational algorithms for both data retrieval and workstation display management (e.g., target and threat deconfliction). Innovative human–computer interface concepts are required for rapid evaluation of tactical courses of action. Collaborative tools are required that will maintain a consistent tactical picture across multiple levels of command for joint and coalition operations.

Milestones/Metrics.

FY1998: Demonstrate command tactical decision-making improvements of 50%–75% in laboratory experiments with an advanced shipboard command center decision support system for air warfare.

FY1999: Produce prototype of advanced decision support system for Marine Corps Decision-Centered Combat Operations Center at the regimental level, permitting manning reductions of 30%.

FY2000: Demonstrate performance improvements of 60% in the quality and synchronization of tactical decision making of command teams during sea trials aboard an Aegis cruiser.

FY2001: Produce a prototype decision support system for joint and coalition force commanders (Third Fleet command ship); demonstrate improved capabilities in threat assessment (40%) and collaborative resource management (50%).

FY2002: Incorporate decision support technology into Global Command and Control System; demonstrate improvements in TMD planning (40%), 3D target motion analysis for undersea threats (30%), and strike and amphibious operations (50%).

FY2003: Demonstrate 60% improvement in C^2 team performance with a reconfigurable decision system that adapts to changes in architectures and organizational design.

Customer POC
Maj Jim O'Dwyer, USMC
Marine Corps Warfighting Lab

CDR Deborah Stiltner, USN
PMS-400 (Aegis Program Office)

CDR Ward Wilson, USN
Staff, COMTHIRDFLT

Service/Agency POC
Mr. Jeffrey Grossman
SPAWARSYSCEN

Dr. Jeffrey Morrison
SPAWARSYSCEN

Dr. Willard Vaughan
ONR

USD(A&T) POC
Dr. Anna Johnson-Winegar
DDR&E(E&LS)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602233N		1.7	1.8	1.9	1.9	2.0	2.1
0603707N	R1771	1.6	1.9	2.0	2.2	2.3	2.3
	Total	**3.3**	**3.7**	**3.9**	**4.1**	**4.3**	**4.4**

HS.22.06 Cogeneration for Field Services

Objectives. Efficiently cogenerate heat and electric power by integrating fuel cells (FCs) and thermophotovoltaic (TPV) generators with burners in mobile field services including kitchens, sanitation, laundries, and space heating.

Payoffs. Although electric power has been slow to come to military field kitchens, the services are now convinced that the benefits of having electric power cannot be ignored. However, there are several significant problems associated with standard generators, including weight, noise, air pollution, and maintenance. To solve these problems, DoD has invested in science and technology to develop FC and TPV technologies. These alternative approaches will be lightweight, quiet, and clean. Their solid-state architecture offers inherent reliability. Unfortunately, they are not nearly as efficient as engine-driven generators for generating electricity, and 70% to 90% of the available energy is lost as heat. Field services such as kitchens use heat. The energy balance of a typical kitchen is 95% heat energy and 5% electrical energy. Therefore, there is an opportunity to integrate these alternative generators in a field kitchen, to use the waste heat for cooking, and to avoid the problems of weight, noise, air pollution, and maintenance associated with standard generators. More importantly, cogeneration will maximize the efficiency and minimize the costs associated with field services.

Challenges. Technical barriers include the development of efficient and durable fuel reformers, burners, and heat exchangers to generate high-quality hydrogen and light for FC and TPV technologies, respectively; and the integration and balancing of heat and electric output with demand to ensure system equilibrium and efficiency. (This DTO applies CECOM-developed FC and TPV technologies for cogeneration in the SSCOM mission area of field services.)

Milestones/Metrics.

FY1999: Integrate a TPV generator with a thermal fluid heat transfer system; demonstrate a 50% decrease in fuel consumption in a mobile field kitchen; transition to advanced development.

FY2001: Demonstrate a fuel reformer with a diesel-to-gas conversion of at least 90% and an overall efficiency of 70% in an FC-powered, commercial-appliance-equipped, gas-fired kitchen; transition to advanced development.

Customer POC		Service/Agency POC	USD(A&T) POC
Mr. Doug Davis	COL Brian Keller, USA	Mr. Phillip Brandler	Dr. Anna Johnson-Winegar
MARCORSYSCOM(CSSLE)	PM-Soldier Support	NRDEC	DDR&E(E&LS)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
S&T Funding							
0603001A	C07	0.4	1.4	0	0.4	0	0
0602786A	H99	0.9	0.4	0.5	0	0	0
Total S&T		**1.3**	**1.8**	**0.5**	**0.4**	**0**	**0**
Non S&T Funding							
Industry		0.7	0.7	0	0	0	0
Total Non S&T		**0.7**	**0.7**	**0**	**0**	**0**	**0**

HS.23.02 Immersive, Adaptive Interfaces for Unmanned Vehicles

Objectives. Capitalize on the exploratory development of virtual visual, auditory, and haptic displays in conjunction with eye-line-of-sight, gesture-based, and virtual manual controls as applied to advanced command and control stations and remotely operated vehicles. This DTO will develop a totally immersive interface supporting future unmanned combat air vehicles (UCAVs). A predictive, computational, and individualized model of the operator will be used to modify characteristics of the interface in real time. The immersive, adaptive human–machine interface will measurably increase operator situation awareness, manage operator workload, and increase overall UCAV system performance.

Payoffs. The immersive, adaptive interface will support the Navy's Tactical Control Station (TCS) program by providing increased situation awareness and real-time workload management to the UAV warfighter. The integration of the immersive interface with the existing UAV control station designs leverage the development of future UCAVs, and ultimately aids the UCAV warfighter. Advancements in interface technology made within this program support existing validated system deficiencies for systems in which the operator must make dynamic decisions under great uncertainty and under severe time pressure, including the areas of search and rescue, precision strike, and aerospace control. The interfaces will be transitionable to remotely operated undersea vehicles.

Challenges. Increasing the reliability of computational models of operator state is the most prominent challenge. Successful operation of interface adaptation is dependent on reliable prediction of dynamic operator state. Current computational models do not possess the complexity to reliably predict operator status.

Milestones/Metrics.

FY1998: Demonstrate an increase in situation awareness for UAV operator of 25% as measured using Cognitive Compatibility–Situational Awareness Rating Technique (CC-SART) during nonoptimal flight environments such as vehicle failures and loss of real-time data from the remote system.

FY2000: Integrate immersive interface into fielded Predator Training/Engineering Research System.

FY2003: Demonstrate control station interface for follow-on UCAV demonstrations.

Customer POC	Service/Agency POC		USD(A&T) POC
Lt Col Mike Leahy, USAF ASC/RA	Mr. James Brinkley AFRL-CF	Dr. Jeffery Morrison SPAWARSYSCEN	Dr. Anna Johnson-Winegar DDR&E(E&LS)
CAPT Mike Witte, USN PEOCU-TCS	Dr. Michael Haas AFRL-HE		

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602233N		0.5	0.5	0.5	0	0	0
0602202F	7184	0.3	0.4	0.4	0.3	0.2	0.1
	Total	**0.8**	**0.9**	**0.9**	**0.3**	**0.2**	**0.1**

HS.24.06 Deployable Sonar Training Technology

Objectives. Develop integrated submarine sonar and tactics training systems for onboard instruction, tactical planning, and scenario reconstruction. Training systems and performance improvement will be evaluated through at-sea data collection and performance analysis. High-fidelity models and physics-based simulations will drive novel display interfaces for data fusion, tactics visualization, and employment training. The systems will include near-real-time input of ambient noise data, environmental data fusion from onboard systems, and input from NAVMETOCCOM environmental tactical support products for purposes of at-sea mission analysis and reconstruction.

Payoffs. Deployable submarine training will provide a 25% performance improvement in submarine-based antisubmarine warfare tactical planning and sensor employment. Deployable sonar training technologies will allow the submarine force to meet training requirements that are currently unaffordable due to reductions in shore-based training. Such improvements are absolutely required to meet the threat of increasingly quiet and capable opposing submarines.

Challenges. Technical challenges include (1) development of innovative training methods that help transfer understanding of the multidimensional properties and interrelationships of sensor-system functions to device operation, sensor employment, tactical planning, and situation awareness during mission execution; (2) development of deployable learning environments (including architectures, display technologies, and interfaces with organic equipment for onboard individual and team training) that promote developing operational and tactical expertise in context; and (3) assessment and evaluation of the outcomes of new training approaches, which require the adaptation and further development of advanced methods of operator and tactician performance assessment. The OPNAV N–87 requirement is explicit concerning the need for at-sea test and evaluation of products of this effort.

Milestones/Metrics.

FY1999: Develop sonar console and display simulations for at-sea use; these will be integrated with accurately modeled sonar targets, extremely high-resolution oceanographic databases, and advanced techniques for propagation and sensor modeling. Test prototype systems on in-port predeployment submarines. Goal is 25% performance improvement in submarine sonar systems employment.

FY2000: Develop a deployable simulation system for tactical instruction and practice; develop scenario-based training for sonar planning and tactics execution for selected submarine missions and operating areas; provide methods for rapid scenario construction and modification for use in predeployment exercise planning and at-sea mission rehearsal. Goal is 50% reduction in scenario development time.

FY2002: Complete system test and evaluation aboard ship including at-sea data collection and performance analysis. Goal is overall 25% performance improvement in ASW mission planning and performance.

Customer POC		Service/Agency POC	USD(A&T) POC
Mr. George Horn	Ms. Sandra Wetzel-Smith	Dr. Wally Wulfeck	Dr. Anna Johnson-Winegar
Head, Undersea Mp and Trng	SPAWARSYSCEN D301	SPAWARSYSCEN D301	DDR&E(E&LS)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0603707N	R1772	2.4	3.6	4.7	5.3	4.1	0
	Total	**2.4**	**3.6**	**4.7**	**5.3**	**4.1**	**0**

HS.25.05 Multifunctional Fabric System

Objectives. Develop cost-effective, flame-resistant textile materials, processes, or treatments so that flame protection can be integrated into all protective clothing, equipage, and soft shelters. Current state-of-the-art flame protective materials are too expensive to issue to all service personnel and, therefore, flame protective clothing systems are issued to only mounted crew members.

Payoffs. The payoffs include increased survivability and lethality of individual warfighters through reduced injuries from both combat and noncombat flame hazards and enhanced warfighter confidence in protective clothing, equipment, and shelters. Currently, the majority of burn injuries occur from accidental fires resulting in high medical costs, lost duty time, and mental stress incurred in the long-term rehabilitation from burns. The MOUT environment is riddled with flame hazards and warrants flame protection for all ground troops, which is currently outside the realm of affordability.

Challenges. The technical challenge entails the development of durable, low-cost flame protection technologies that can then be integrated into a textile system without adversely impacting other protection levels provided by the system, such as environmental, chemical, and electrostatic protection as well as signature reduction. Specifically, the challenges include integration of novel flame retardants into fibers without compromising fiber strength, dye affinity, and final product acceptability and development of novel flame-retardant processes and treatments that are also environmentally friendly.

Milestones/Metrics.

FY1999: Establish thrust-based flame protection performance criteria for dismounted, mounted, and MOUT protective clothing systems.

FY2000: Establish test methodology for flame-resistant material systems.

FY2001: 50% cost decrease over existing flame-resistant clothing systems while maintaining multiple threat protection levels.

Customer POC
Mr. Joseph Jones, US Infantry School
Ms. Suzanne Reeps, NCTRF
Ms. Patrice Hutson, HSC/YAG

Service/Agency POC
Mr. Phillip Brandler, NRDEC
Ms. Carole Winterhalter, NRDEC, SSCOM

USD(A&T) POC
Dr. Anna Johnson-Winegar, DDR&E(E&LS)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602786A	H98	0.7	0.8	0.8	0.9	0	0
0602202F	7184	0.3	0.3	0.3	0.3	0	0
0602233N		0.1	0.1	0.1	0	0	0
	Total	**1.1**	**1.2**	**1.2**	**1.2**	**0**	**0**

HS.26.02 Smart Aircrew Integrated Life-Support System

Objectives. Integrate Navy and Air Force efforts in the area of aviation life-support equipment (LSE). Specifically, the physiologic state of the pilot will be monitored and modified as requied via a Smart Aircrew Integrated Life-Support System (SAILSS). Through biofeedback, system parameters will be regulated to maximize the aircrew's ability to perform at optimal levels while experiencing high-g, high-altitude, extreme temperature, and nuclear/chemical/biological (NCB) warfare environments.

Payoffs. This DTO will result in a unified weapon system that interacts with the vehicle to maintain the optimal physiologic status of the pilot. Reduction of the physiologic symptoms induced by stress (fatigue, dehydration, loss of vision, loss of consciousness, loss of situational awareness) will lead to (1) enhanced pilot and mission performance (increased speed, increased accuracy), and (2) reduced loss of life and aircraft. SAILSS will enable the pilot to perform to his/her optimum capability.

Challenges. The challenges include (1) providing protection to 9 $+G_z$ at altitudes up to 70,000 feet against the "push-pull" effect and extreme environments; (2) maintaining physiologic homeostasis; and (3) providing early warning of g-induced loss of consciousness (G-LOC) and other altered states of awareness (ASA) induced by physiologic stress. Control will be accomplished by integration of physiologic sensors (unobtrusive, lightweight, transparent to the pilot) in current LSE, real-time adjustment of LSE based on biofeedback control, and integration of SAILSS with the overall weapon system.

Milestones/Metrics.

FY1998: Integration with Navy Combat Edge; implement biofeedback control with Combat Edge; demonstrate that Vehicle Management System (VMAS) is able to interpret SAILSS and smart escape systems (SES) algorithms.

FY1999: Demonstrate integration of existing cooling systems for SAILSS thermal control by assessing pilot cognititve motor ability, choice response performance, and accuracy. Advanced integration with VMAS and SES. Preliminary integration with pilot warning systems (G-LOC, ASA).

FY2000: Preliminary integration with recovery systems (pilot G-LOC/ASA and vehicle GCAS (Ground Collision Avoidance System)). Demonstrate modulation of SAILSS via aircraft databus.

FY2001: Advanced integration with recovery systems (VMAS, SES, GCAS, G-LOC/ASA). In a static ground environment, demonstrate control of SAILSS as demonstrated by modulation of recovery systems.

FY2003: Test and demonstrate SAILSS at altitude and in thermal environments. In a dynamic environment (centrifuge, dome), assess control of SAILSS as demonstrated by modulation of recovery systems.

Customer POC	**Service/Agency POC**		**USD(A&T) POC**
CAPT Stuart Ashton, USN NAVAIR PMA202	Mr. James Brinkley AFRL-CF	Mr. William King ONR	Dr. Anna Johnson-Winegar DDR&E(E&LS)
Mr. Dave Jackson JSF, NAWCPAX	CDR Timothy Steele, USN ONR		

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
S&T Funding							
0602202F	7184	0.2	0.2	0.3	0.5	0.5	0.5
0602122N		0.3	0.2	0.2	0.3	0.3	0.2
0602233N		2.6	0	0	0	0	0
Total S&T		**3.1**	**0.4**	**0.5**	**0.8**	**0.8**	**0.7**
Non S&T Funding							
0603216N	W0584	0	1.0	1.0	0.5	0.5	0.5
Total Non S&T		**0**	**1.0**	**1.0**	**0.5**	**0.5**	**0.5**

WEAPONS

Defense Technology Objectives
for the Defense Technology Area Plan

Weapons

WE.07.02 Future Missile Technology Integration Program II-304
WE.10.08 Ground-Based Laser Antisatellite System II-305
WE.12.02 Antijam GPS Flight Test II-306
WE.13.02 Counteractive Protection Systems II-307
WE.18.02 Direct Fire Lethality ATD II-308
WE.21.02 Fiber-Optic, Gyro-Based Navigation Systems II-309
WE.22.09 High-Power Microwave C^2W/IW Technology II-310
WE.23.08 Modern Network Command and Control Warfare Technology II-312
WE.25.02 Multimode Airframe Technology Demonstration II-314
WE.29.02 Antitorpedo Torpedo II-315
WE.32.02 Broadband Torpedo Sonar Demonstration II-317
WE.33.02 Electrothermal-Chemical Armaments for Direct Fire II-318
WE.34.02 Objective Crew-Served Weapon II-319
WE.35.02 Air Superiority Missile Technology II-320
WE.38.02 Highly Responsive Missile Control II-321
WE.39.02 Tactical Solid Rocket Missile Propulsion II-322
WE.40.08 Infrared Decoy Technology II-324
WE.41.04 Multimission Space-Based Laser II-326
WE.42.08 Laser Aircraft Self-Protect Missile Countermeasures II-328
WE.43.08 Advanced Multiband Infrared Countermeasures Laser Source Solution Technology ... II-329
WE.45.07 Sea Mines II-330
WE.46.08 Coherent RF Countermeasures Technology II-332
WE.47.08 Imaging Infrared Seeker Countermeasures Technology II-334
WE.48.08 Missile Warning Sensor Technology II-336
WE.50.02 Compact Kinetic Energy Missile Technology II-338
WE.51.02 Small-Diameter Antiair Infrared Seeker II-340
WE.52.02 Best Buy ATD II-341
WE.54.02 Reactive Material Warhead ATD II-343
WE.55.02 Reduced Size Torpedo Subsystem Demonstration II-345
WE.56.02 Electromagnetic Armaments for Direct Fire II-346
WE.57.02 Lethality/Vulnerability Models for High-Value Fixed Targets II-347
WE.58.02 Microelectromechanical Systems Inertial Navigation System II-349
WE.59.02 Hypersonic Weapons Technology Demonstration II-350
WE.60.09 High-Power Microwaves for Suppression of Enemy Air Defense II-351

WE.07.02 Future Missile Technology Integration Program

Objectives. Demonstrate a technology to build a multiplatform, multitarget, multimission extended-range (beyond 7 km) fire-and-forget missile that is compatible in size with the Tube-Launched Optically Guided Weapon (TOW) and Hellfire family of launchers. Aspects of the technology demonstration phase of the Future Missile Technology Integration (FMTI) Program include captive flight testing of missile components (including seeker, RF datalink, autotracker, and automatic target recognition), static firings of gel rocket motor, hardware-in-the-loop and digital simulation of all missile components, and developing a distributed interactive simulation of a virtual prototype of FMTI missile capability on the future battlefield. In addition, the FMTI technical demonstration phase will include in FY98 two live missile firings to demonstrate lock-on-before-launch, fire-and-forget guidance against an armored vehicle at ranges up to 5 km.

Payoffs. Lock-on-after-launch technology will be developed capable of locking onto both ground and airborne targets in clutter at 5 km. In addition, lock-on-after-launch (beyond 5 km) technology will be developed allowing engagement of ground and airborne targets beyond visual range at ranges up to 10 km. In FY97, the captive flight test of the seeker was accomplished, and a tower test of the RF datalink was performed. In FY98, propulsion system static test firing was accomplished and live missile firings will be performed.

Challenges. Technical barriers include locking onto ground vehicles in clutter at long range (up to 5 km), efficient packaging of all missile components in a TOW-size missile volume, and developing the capability to control gel-motor-delivered thrust during long-range flyout.

Milestones/Metrics.

FY1998: Complete FMTI technical demonstration phase.

Customer POC		Service/Agency POC	USD(A&T) POC
LtCol Damina Bianca, USMC PM, FOTT	COL Roy Millar, USA PM, EFOGM	Ms. Irena Szkrybalo SARD-TT	Dr. C. W. Kitchens, Jr. DDR&E(WT)
Maj C. L. Kirkland, USMC USMC Deputy PM	COL Richard Savage, USA PM, AGMS		

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0603313A	263	3.9	0	0	0	0	0
	Total	**3.9**	**0**	**0**	**0**	**0**	**0**

WE.10.08 Ground-Based Laser Antisatellite System

Objectives. Develop and demonstrate ground-based laser (GBL) technologies to support a system development decision for a GBL antisatellite (ASAT) system. The principal effort is the Air Force Integrated Beam Control Demonstration ATD. The ATD uses the 3.5-m telescope at Starfire Optical Range and will demonstrate, at full scale but very low power, all beam control functions associated with an end-to-end satellite engagement. The major functions include initial optical acquisition of the target satellite and coarse tracking using passive sensors, flood illumination of the satellite with an illuminator laser, handoff to precision active tracking, atmospheric compensation using adaptive optics and laser beacon sensing, designation of the desired aimpoint on the satellite target, laser beam propagation to the selected aimpoint, and aimpoint maintenance for the required engagement time. Primary metrics for this demonstration are atmospheric compensation performance, residual satellite tracking error, and laser beam pointing accuracy for aimpoint stabilization. Specific performance goals are classified, but they generally involve an improvement by factors of two to four over currently demonstrated capabilities at the subsystem level as well as the simultaneous demonstration of improved performance for all subsystems in integrated testing. A series of increasingly complex integrated beam control field tests will culminate in the final ATD demonstration in FY01. Low-power integrated beam control results will be extrapolated to high power through detailed simulation and performance analysis. (Additional details are classified.)

Payoffs. This DTO effort will demonstrate the enabling technology for a ground-based ASAT system, a significant technology for space control. It will also provide substantial capability for related applications in high-resolution imaging, power beaming, and laser communications as well as for tactical and strategic missions such as the airborne laser (DTO D.10, Airborne Lasers for Theater Missile Defense). In addition, there has been a significant transfer of technology to the astronomy community.

Challenges. The principal technology issues are (1) the development of scaled adaptive optics, laser beacon concepts and hardware, and control systems to meet atmospheric compensation performance goals for full-scale (3.5–4.0-m) apertures, using laser beacon sensing of distortions due to atmospheric turbulence; (2) the development of laser illuminators and track sensors and processors to meet requirements for 24-hour active tracking of satellites to the required precision; and (3) the development of aimpoint designation and maintenance techniques to meet requirements for laser beam pointing.

Milestones/Metrics.

FY1998: Install full-scale adaptive optics on 3.5-m telescope.

FY1999: Integrated beam control tests using lower (400-km) LEO satellites in nighttime testing.

FY2001: Final ATD demonstration conducted using higher (up to 1,200-km) LEO satellites during night and day.

Customer POC	Service/Agency POC	USD(A&T) POC
Maj Rick Miller, USAF	Mr. Michael Flynn	Dr. C. W. Kitchens, Jr.
AFSPC/XPXT	SAF/AQR	DDR&E(WT)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0603605F	3647	11.5	12.0	10.0	10.5	0	0
	Total	**11.5**	**12.0**	**10.0**	**10.5**	**0**	**0**

WE.12.02 Antijam GPS Flight Test

Objectives. Provide the best antijam capability for the lowest possible increment (less than $3,000) to the Joint Direct Attack Munition (JDAM) unit production cost. GPS signals arrive at a very low power level. Interference as low as 10 W can jam GPS as far away as 100 nmi. Inertial measurement unit (IMU) navigation is immune to Global Positioning System (GPS) jamming energy. However, IMUs drift with time causing a munition's accuracy to degrade. Higher quality IMUs can improve end-game accuracy but are more expensive. During Phase I, the antijam (AJ) concept was tested at the subsystem level against scenarios containing multiple jammers to demonstrate AJ performance capability. The fully integrated tail kit assembly, which was tested in a static and semidynamic environment, will be evaluated in the anechoic chamber at Eglin AFB to obtain antenna performance data of the actual flight hardware, which will be used to update the cost/performance model. The second ground test will use the Wright Laboratory Armament Directorate's mobile test vehicle to introduce the AJ-equipped JDAM navigation system to a low-dynamic jammed environment for risk reduction prior to flight testing.

Payoffs. To date, a number of accomplishments have occurred under this DTO. Phase I subsystem tests were conducted in anechoic-chamber (Naval Research and Development, Warminster, PA) and bench-test (Antenna Wavefront Simulator, Wright Laboratory Avionics Directorate) environments. Phase II of the program (Jan '96–Feb '97) integrated the AJ concept into a suitable carrier vehicle (a JDAM tail kit assembly) for ground and flight tests in a jamming environment. Phase III (Mar '97–Aug '97) involved ground tests. This DTO will develop and demonstrate a GPS technology to increase the accuracy provided by any munition GPS/IMU navigation system maintained in a jamming environment. Additionally, the program will develop a cost/performance modeling tool that will enable a user to determine the cost-per-jam resistance needed for his particular application.

Challenges. JDAM requires GPS navigation accuracy at the target (13-m circular error probable (CEP)) while in a jammed environment, with production cost incremented by less than $3,000, based on a 72,000-unit buy in FY92 dollars.

Milestones/Metrics.

FY1998: Flight test portion of the program in FY1998 will use a GPS-equipped F–16 to release the AJ-equipped munition in two jamming environments of increasing difficulty.

Customer POC	Service/Agency POC	USD(A&T) POC
Mr. Van Davis	Mr. James Moore	Dr. C. W. Kitchens, Jr.
ACC/DRPW	AGTFT	DDR&E(WT)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0603601F	670A	2.9	0	0	0	0	0
	Total	**2.9**	**0**	**0**	**0**	**0**	**0**

WE.13.02 Counteractive Protection Systems

Objectives. Develop and demonstrate techniques and technologies to allow antitank guided weapons (ATGWs) to defeat threat tanks equipped with active protection systems (APSs). Approaches for counteractive protection systems (CAPS) include jamming or deception of the APS sensors, firing the ATGW warhead before it can be damaged, and preventing fragment damage to warhead or related components. Specific CAPS techniques may work together or separately to achieve these objectives. Technology areas where advances are being pursued include small, inexpensive RF power amplifiers and conformal antennas, long standoff shaped-charge warheads, inexpensive onboard sensors for detecting munition attack, and lightweight ballistic protection of missiles from fragment impact.

Payoffs. Successful development of CAPS technology will enable the warfighter to defeat APS-equipped tanks with lightweight mobile ATGWs that can be deployed to a theater much more rapidly than other types of antitank weapons. APSs that are fielded or under development by potential adversaries can easily defeat most ATGMs. CAPS-capable ATGWs, man-portable or on lightweight vehicles or aircraft, will be able to defeat these threat APSs, eliminating the need for heavy armor in rapid deployment and small engagement scenarios. In larger engagements, the need for heavy armor will be much reduced.

Challenges. Technical challenges that must be met for successful CAPS development include conformal RF antennas for directing energy forward without aerodynamic or guidance sensor interference, RF receive/transmit component efficiency, long standoff penetration of frontal armor with shaped charges, and sensors for detecting and discriminating APS munition attack to ATGW warheads.

Milestones/Metrics.

FY1998: Lab demonstrate prototype RF jammer that can prevent detection or engagement of common antitank missiles for 90% of engagements.

FY1999: Flight demonstrate CAPS missile that defeats APS sensor 90% of time.

Customer POC		Service/Agency POC	USD(A&T) POC
Col James Gribschaw, USAF TRADOC Sys. Mgr	Mr. Ken Martz USA Infantry Center	Ms. Irena Szkrybalo SARD-TT	Dr. C. W. Kitchens, Jr. DDR&E(WT)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602303A	214	0	0	0	0	0	0
0602618A	H80	0.3	0	0	0	0	0
0602618A	H81	1.4	0	0	0	0	0
0603004A	232	0.5	2.8	0	0	0	0
0603313A	550	1.8	2.2	0	0	0	0
	Total	**4.0**	**5.0**	**0**	**0**	**0**	**0**

WE.18.02 Direct Fire Lethality ATD

Objectives. Enhance and expand the lethal battle space of the Abrams tank while reducing O&S costs. The DTO consists of two major elements: an advanced kinetic energy (KE) cartridge (for defeat of explosive reactive armor (ERA) and increased accuracy) and advanced drives and weapon stabilization (increasing probability of hit under moving conditions).

Payoffs. The DTO will provide the advanced technology necessary to maintain the Abrams tank as the most lethal tank in the world. The DTO supports the evolving Force XXI doctrine, which requires the expansion of the maneuver commander's battlespace, and DoD downsizing and cost-reduction philosophies by upgrading existing weapon platforms with affordable, high-payoff lethal weapon system technologies.

Challenges. Technical barriers for the advanced KE cartridge include precursor/penetrator aerodynamics, precursor axial/radial dispersions, integrated novel penetrator reliability, axial thruster ignition/timing reliability, and radial thruster accelerometer/control logic function and integration. Technical barriers for the advanced drives and weapon stabilization include maintaining gearless motor air gap, accuracy of long-gun-tube, fiber-optic sensor, and overall cost-effective approaches for retrofit.

Milestones/Metrics.

FY1998: Demonstrate axial thruster function and feasibility to compensate a KE penetrator aerodynamic jump error; conduct a hardstand dynamic demonstration of an electric direct-turret-azimuth-drive (gearless) technology.

FY2000: Demonstrate radial thruster capability to correct for multiple jump errors in achieving 30%–70% increase in system accuracy; demonstrate novel penetrator lethality up to 70% greater than the M829A2.

FY2001: Demonstrate up to 200% increase (at 3 km) in P_h over the M1A2 under dynamic scenarios and (by analysis) up to $8 million/yr O&S savings using gearless turret/gun direct drives, modern digital servo control, and optical fiber muzzle reference sensor. Demonstrate 120-mm KE cartridge to defeat the 2005 ERA-protected threat with up to 70% increase in lethality over M829A2 and 30%–70% increase in system accuracy under stationary conditions over the M829A2/M1A2.

Customer POC		Service/Agency POC	USD(A&T) POC
Mr. Joseph Godell	Mr. Chris Kimker	Mr. Anthony Sebasto	Dr. C. W. Kitchens, Jr.
PM ABRAMS	PM-TMAS	ARDEC	DDR&E(WT)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602618A	H80	0.4	0	0	0	0	0
0602618A	H81	0.5	0	0	0	0	0
0602624A	H18	1.4	1.1	0	0	0	0
0602624A	H19	1.3	0.8	0	0	0	0
0603004A	232	4.7	5.2	6.5	6.5	0	0
0603004A	43A	0	7.1	6.2	4.0	0	0
	Total	**8.3**	**14.2**	**12.7**	**10.5**	**0**	**0**

WE.21.02 Fiber-Optic, Gyro-Based Navigation Systems

Objectives. Develop and demonstrate technologies for affordable and robust guidance, navigation, and control, including a high-level hybridization of a fiber-optic gyro and etched-silicon-accelerometer-based inertial measurement unit (IMU) on a silicon wafer.

Payoffs. This DTO will meet warfighter needs for aircraft and affordable smart weapons that can maintain precision navigation during Global Positioning System (GPS) blackouts and will provide enough accuracy to enable the weapon to maintain the CEP specification. The hybridization will allow for high-accuracy performance at a price appropriate for tactical weapons such as Joint Standoff Weapon (JSOW) and Joint Direct Attack Munition (JDAM); the cost goal is one-half of the baseline IMU price while providing superior performance.

Challenges. Obtaining navigation grade performance (1 nmi/hour) with (1) silicon accelerometer over full military environment (-55° to +85°C); (2) interferometric fiber-optic gyroscope (IFOG) employing fiber (<50 meters); (3) polarizing polymer waveguides—the degree to which these waveguides polarize the light is directly proportional to the ultimate navigation performance; (4) interface the light source and detectors to the polymer waveguides; (5) phase modulator constant versus optical loss tradeoff; (6) level of integration—processes for each fabrication step must be devised so as to not adversely impact previous steps; and (7) heat management—temperature-gradient-sensitive elements in the fiber-optic-guided (FOG) optical circuit need to be thermally shorted or isolated without adversely impacting the package cost or size.

Milestones/Metrics.

FY1998: Produce 30 silicon accelerometers with performance of 50-micro-g bias and 50-ppm scale factor; demonstrate a 0.01-deg/hr FOG using a hybrid wafer.

FY1999: Deliver 8 Global Guidance Package units with functionality of components verified: 16-m SEP, less than 100 in^3, less than 7 lb, less than 25 W, and less than $15,000 per unit production; demonstrate a 1-nmi/hr IMU assuming a JSOW flight profile.

FY2000: Demonstrate an integrated flightworthy IMU/GPS system that meets the JSOW cost and operational effectiveness analysis requirement of no GPS aiding.

FY2001: Transition to program office.

Customer POC		Service/Agency POC	USD(A&T) POC
CAPT Burt Johnston, USN PMA-201	LTC Craig Naudain, USA BFVS	Lt Col Beth Kaspar, USAF DARPA/STO	Dr. C. W. Kitchens, Jr. DDR&E(WT)
Mr. Greg Makrakis PMA-209	Mr. Tim Summers Army PEO-TM	Mr. David Siegel ONR	

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0603217N	R2264	2.0	4.3	3.1	2.5	0	0
0603762E	SGT–01	10.0	4.6	4.0	0	0	0
	Total	**12.0**	**8.9**	**7.1**	**2.5**	**0**	**0**

WE.22.09 High-Power Microwave C^2W/IW Technology

Objectives. Develop and demonstrate high-power microwave (HPM) technology to disrupt, degrade, and destroy electronics in communication and information systems to support command and control warfare/information warfare (C^2W/IW) missions. Delivery systems such as missiles, UAVs, and ground vehicles will be evaluated as platforms for single-burst and multiple-burst, high-power damage systems. Submunitions and man-portable devices will be developed for the disruption option. Initial research will focus on ground-mobile or man-portable devices to demonstrate effectiveness before adapting to air-delivered packaging. Current technology, on a ground-based platform, will be used in an ATD against a representative command post in preparation for an HPM IW ACTD in late FY98. (Specific program, system design, and system effectiveness details are classified.)

Payoffs. Adversaries will be denied the use of electronic information collection, processing, and communications equipment through application of high-peak-power (damage) or high-average-power (disruption) wideband sources. HPM technology will provide a means of electronic attack that is nonlethal and causes little or no collateral damage. Only electronic systems will be damaged by the device(s). By the use of wideband source technology, guided by valid laboratory experimentation, limited prior target intelligence will be required. The high-power option will cause damage expected to require hours to days to repair and return to operation. The disruption option will provide persistent disruption of operations for the duration of pulsing. Both applications offer the added advantage of confusion and psychological effects in addition to the direct effect.

Challenges. The barriers in this technology include (1) understanding efficacy of available sources to cause disruption or damage in target equipment, (2) lack of adequate coupling data and models to predict penetration of various buildings, (3) limited simulation and measures of effectiveness codes, (4) developing high-average and high-peak power components to meet radiated field requirements, and (5) development of explosively driven prime power for air-delivered alternatives.

Milestones/Metrics.

FY1998: Demonstrate 50%–70% performance degradation of ATD target from operationally relevant ranges. Identify critical source parameters to cause reliable upset and damage to personal computers. Develop building penetration experiment protocol to predict first-order HPM coupling.

FY1999: Develop and demonstrate solid-state switches with a 10X increase in power throughput. Design man-portable device with effective range of tens of meters. Refine gas-switched sources to achieve 5X increase in radiated power.

FY2000: Demonstrate brassboard man-portable device, over 70% effective. For aerial delivery, develop low-power submunition payload and design high-power, gas-switched source.

FY2001: Proposed ATD for man-portable device, over 80% effective. Ground-based demonstration of air-delivered submunition payload, over 70% effective.

FY2002: Proposed ATD for air-delivered submunition, 80% effective. Ground-based demonstration of high-power, air-delivered munition, 50%–75% effective.

FY2003: Proposed ATD for high-power, air-delivered source.

Customer POC	**Service/Agency POC**	**USD(A&T) POC**
Lt Col Craig Goodbrake, USAF	Mr. Michael Flynn	Dr. C. W. Kitchens, Jr.
JCS/J39	SAF/AQRT	DDR&E(WT)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602601F	5797	1.1	1.5	1.8	2.0	1.0	0
0603605F	3152	0.8	3.1	2.8	3.3	3.5	3.6
0602715H	AC	4.9	0	0	0	0	0
0602715BR	AC	0	3.1	3.0	3.0	3.0	3.0
	Total	**6.8**	**7.7**	**7.6**	**8.3**	**7.5**	**6.6**

WE.23.08 Modern Network Command and Control Warfare Technology

Objectives. Develop and demonstrate multiple, synergistic capabilities to intercept and attack or counter advanced, global, military communication, navigation, and information networks from ground, seaborne, and airborne platforms.

Payoffs. This tri-service objective will demonstrate in-theater, joint operations technology capabilities for electronic support (ES) from dedicated command and control warfare (C^2W) platform assets systems; and for advanced, efficient electronic attack (EA) strategies to counter emerging, modern, complex C^2 formats. A successful joint warfighter campaign that can selectively influence an adversary's use of or confidence in its own information, control of forces, response/decision processes, and computer networks—through the use of offensive deceptive techniques to manipulate the information and its support/sources—necessarily translates into significant time delays in the enemy's ability to react. Therefore, success of this DTO will enable joint forces to wage proactive, offensive information warfare (OIW) against an enemy's C^2 information infrastructure and delay or deny effective enemy defense versus U.S. and coalition strike forces.

Challenges. Joint operations in a battlespace filled with dense RF/C^2 signals require the ability to counter multiple/simultaneous enemy C^2 and navigation aids with minimal collateral and fratricidal damage to own-forces C^2. The global move toward modern communications systems requires exploitation and recognition of such complex modulation formats, multiplexing schemes, and spread-spectrum coding (e.g., time-division, code-division, low-probability-of-intercept/-detection (LPI/LPD) signals) in order to detect, intercept, identify, and attack them—all in real time. Other technical barriers include the need to conduct beyond-line-of-sight/over-the-horizon precision targeting operations.

Milestones/Metrics.

FY1998: Demonstrate UAV-based ES and real-time relay to ground and air components of the Intelligence EW Common Sensor (IEWCS) system.

FY1999: Demonstrate a 10X increase in high-frequency wideband power generation in a comparable package volume.

FY2000: Demonstrate ES and EA strategies to counter emerging modern complex communication formats; conduct a joint test with DTO WE.46 for evaluation of SEAD.

FY2001: Demonstrate nonfratricidal EA techniques versus communication and navigation systems.

FY2002: Demonstrate ES/EA capability against LPI/LPD-class of specific communications links; demonstrate offensive deceptive techniques to manipulate the information or information sources that support them.

FY2003: Show a 1,000X improvement in effective use of available transmitter power, and a 1,000X improvement in EA spatial selectivity for jamming strategies.

Customer POC	**Service/Agency POC**	**USD(A&T) POC**
Mr. Edward Bair PEO-IEW	Mr. Rob Saunders SARD-TT	Dr. C. W. Kitchens, Jr. DDR&E(WT)
Lt Col Dave Bullock, USAF 645/MATS	CDR Robert Boyd, USN ONR 313	
CAPT Steve Enwold, USN PMA-234	Mr. Michael Flynn SAF/AQRT	

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602204F	2000	0.2	0.2	0.3	0.1	0	0
0602270A	906	4.0	2.9	4.0	4.0	4.0	4.9
0602270N		0.8	0.9	1.1	1.1	1.2	1.2
0603270A	K15	0.9	1.0	0	1.2	1.3	3.0
0603270F	2432	1.5	4.1	5.2	5.5	4.0	1.3
	Total	**7.4**	**9.1**	**10.6**	**11.9**	**10.5**	**10.4**

WE.25.02 Multimode Airframe Technology Demonstration

Objectives. Demonstrate, through modeling, simulation, and flight testing, a 40-km-range, day/night system that is compatible with the Multiple-Launch Rocket System (MLRS) family of missiles (MFOM) and that is capable of striking multiple, high-value, time-sensitive point targets while inflicting minimal collateral damage. The Multimode Airframe Technology (MAT) system will provide the capability to select priority targets after launch, conduct limited man-in-the-loop battle damage assessment, and provide target area reconnaissance in addition to target attack by means of variable cruise velocity over areas of interest. These capabilities will be achieved by means of integrated GPS and inertial navigation, variable threat air-breathing propulsion, composite material airframe providing low IR signature and low radar cross section, variable geometry wings, imaging IR seeker, and other appropriate technologies. The MAT system will provide an integrated airframe/turbojet with a velocity capability of 300 m/s and payload capability of at least 20 lb.

Payoffs. This DTO will provide the capability of striking multiple, high-value, time-sensitive point targets while inflicting minimal collateral damage. Bobbin design was accomplished in FY95, the captive flight test was performed in FY96, and the active missile sled test was accomplished in FY97. Transition to 6.3 program will occur in FY98.

Challenges. Technology barriers include 40-km fiber payout in missile-sized canister; low-cost turbojet technology for both boost and sustain; low-cost, long-range imagery datalink; and reconfigurable airframe for slow and fast flight.

Milestones/Metrics.

FY1998: 40-km flight tests.

Customer POC	Service/Agency POC	USD(A&T) POC
COL Barry Ward, USA	Ms. Irena Szkrybalo	Dr. C. W. Kitchens, Jr.
PM-MLRS	SARD-TT	DDR&E(WT)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602303A	214	2.0	0	0	0	0	0
	Total	**2.0**	**0**	**0**	**0**	**0**	**0**

WE.29.02 Antitorpedo Torpedo

Objectives. By FY00, demonstrate Antitorpedo Torpedo (ATT) homing and fuzing that can be incorporated into existing and planned torpedo and submarine regional warfare systems. The effort is to embed ATT homing and fuzing technology developed in the 6.2 program in a prototype guidance system and demonstrate performance against torpedo targets in clean, countermeasure (CM), salvo, ship-wake, and shallow-water environments. A new hard-kill torpedo defense homing and fuzing technology will be developed and demonstrated based on common hardware and software compatible with existing and future U.S. torpedo systems (i.e., 21-in, 12.75-in, and 6.25-in diameters). These technologies will be inserted (with minimal impact) into existing operational torpedo inventories, and their stockpile-to-target systems, to quickly provide significant and cost-effective warfighting capabilities.

Payoffs. Surface ships and submarines need a hard-kill torpedo defense capability to ensure their survivability in future conflicts. Fewer ships will be operating in littoral waters and will encounter an emerging threat posed by the proliferation of quiet, capable, diesel-electric submarines armed with modern, lethal weapons. Many of these encounters will be close in and will demand quick reaction.

Challenges. The technologies to be demonstrated include high-range-resolution, high-repetition waveforms; high-pulse-rate signal and image processing; adaptive CM processing; integrated homing and fuzing; acoustic intercept receiver; data fusion; and torpedo defense-specific tactics. Success of the DTO will be measured against the closest points of approach (CPAs) required to destroy antisubmarine warfare and antisurface ship warfare threat torpedoes. Demonstration of these CPAs will include operation against threat torpedoes in realistic surface-ship and submarine environments. The challenges are close-in, quick-reaction encounters; high-speed, highly maneuvering targets; development of high-range resolution, high-repetition rate waveforms; homing and fuzing in the presence of countermeasures and ship wakes; countering salvos of threat torpedoes; and the development of torpedo defense-specific tactics.

Milestones/Metrics.

FY1998: Demonstrate CPAs that meet or exceed the PEO (USW) requirements (number classified) in one-on-one engagements against a maneuvering threat with no CM or acoustic clutter.

FY1999: Demonstrate CPAs that meet or exceed PEO (USW) requirements (number classified) in complex engagements with CMs and acoustic clutter.

FY2000: Conduct in-water demonstration of full capability in realistic warfighting scenarios with system effectiveness that meets or exceeds PEO (USW) requirements (number classified).

Customer POC	Service/Agency POC	USD(A&T) POC
CAPT John Barry, USN N863E	Ms. Sharon Beermann-Curtin ONR	Dr. C. W. Kitchens, Jr. DDR&E(WT)
LCDR Timothy Hagan, USN N872E	Ms. Khine-Latt ONR	

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
S&T Funding							
0602633N		4.0	0	0	0	0	0
0603792N	R1889	0	5.0	5.0	0	0	0
Total S&T		**4.0**	**5.0**	**5.0**	**0**	**0**	**0**
Non-S&T Funding							
0603790D		2.5	0	0	0	0	0
Total Non-S&T		**2.5**	**0**	**0**	**0**	**0**	**0**

WE.32.02 Broadband Torpedo Sonar Demonstration

Objectives. By FY01, demonstrate a broadband torpedo guidance system for harsh shallow-water and advanced countermeasure environments. Specifically, the goal is to demonstrate a 40% improvement in torpedo effectiveness in harsh shallow-water environments and 100% improvement in torpedo effectiveness in countered environments. Performance improvements are sought in the areas of detection and classification, broadband sensing and processing, countermeasure resistance, homing, terminal homing, and intelligence tactical control for torpedoes operating against diesel-electric submarines and advanced CM devices in shallow water.

Payoffs. The torpedo guidance system developed and demonstrated in this DTO will provide significant and cost-effective enhancements to warfighting capabilities. The demonstrations will show detection ranges increased by a factor of two and false alarm probabilities reduced by a factor of two, relative to existing narrowband systems. The improvement of system performance (i.e., improvement of torpedo effectiveness) will be inserted into MK48 advanced capability (ADCAP) torpedoes. The ADCAP is currently pursuing the Block 4 software upgrade and the development of a new guidance and control (G&C) card box with COTS digital signal processing chips. Also, this broadband G&C technology will be transitioned to the Common Broadband Advanced Sonar System (CBASS) that is scheduled to be operational in FY03. This broadband G&C technology will also have transition potential for sonar processing on surface ships and submarines.

Challenges. The technical challenges are to develop transducer elements and arrays with five times the bandwidth of current weapon systems; develop algorithms, signal processing, and tactics to take advantage of the increased bandwidth; develop broadband techniques to increase detection ranges by a factor of two; develop broadband techniques to reduce false alarm probabilities by a factor of two; and develop covert detection and homing technologies.

Milestones/Metrics.

FY1998: Test magneto piezoceramic tonpilz array with 4X bandwidth; develop and test frequency agility/optimum frequency selection algorithms with 2X improvement in detection range.

FY1999: Test and evaluate multiprocess classifier with false alarm reduction by 2X.

FY2000: Test and evaluate prototype intelligent controller for countermeasure resistance, 50% improvement in torpedo effectiveness in countered environments. (The baseline system capability is classified.)

FY2001: Conduct major in-water testing to demonstrate torpedo effectiveness improvements of 40% in shallow water and 100% in countered environments.

Customer POC	Service/Agency POC	USD(A&T) POC
LCDR Timothy Hagan, USN	Dr. Kam Ng	Dr. C. W. Kitchens, Jr.
N872E	ONR	DDR&E(WT)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602633N		3.0	3.1	3.1	3.2	0	0
0603747N	R2267	2.5	2.6	2.9	2.9	0	0
	Total	**5.5**	**5.7**	**6.0**	**6.1**	**0**	**0**

WE.33.02 Electrothermal-Chemical Armaments for Direct Fire

Objectives. Improve the lethality of direct-fire ground systems by providing the technology to significantly increase available muzzle energy. Advances in armor technology, particularly explosive reactive armor, threaten the U.S. advantage in defeat of ground targets with fire from the M1 family of tanks. A well-established technique to improve penetration is to increase energy delivered to the target. One option is to provide a larger caliber cannon. For the M1A2 tank, this would mean replacing the 120-mm cannon with a 140-mm. However, this approach is not supported by the user as the increased caliber weapon requires a new turret with an autoloader and will likely reduce the total number of rounds that can be carried on board. Electrothermal-chemical (ETC) propulsion offers the possibility of providing 140-mm levels of lethality from a 120-mm cannon. As such, the battlefield advantage of U.S. direct fire would be maintained without major changes in the cannon or ammunition envelope. The program will demonstrate the technical feasibility of ETC propulsion for near-term (2005–2010) direct-fire weapons systems. By 1999, the program will show that 120-mm XM291 ETC cannon muzzle energy can be increased by 40% over the current 120-mm M256 cannon and is the level that would provide the equivalent lethality to an XM964 140-mm round. This would support Future Combat System goals.

Payoffs. ETC will enhance the lethality of tank cannon by permitting a significant increase in muzzle energy within the existing weapon envelope. For 120-mm cannon, ETC will provide the lethality of a 140-mm cannon. ETC provides this lethality increase at modest cost compared to that associated with upgunning (to 140-mm) the tank fleet. The ETC cartridge is essentially identical in mass and geometry to current 120-mm ammunition; thus, no changes to ammunition storage or handling is required.

Challenges. Technical barriers for ETC include high-energy, high-density propellant formulations and geometry; design of plasma generators for effective coupling of electrical energy into propellants; and control of propellant temperature gradient effects.

Milestones/Metrics.

FY1998: Demonstrate 14-MJ muzzle energy fire from an 120-mm M256 cannon.

FY1999: Demonstrate 16–17-MJ muzzle energy from an 120-mm XM291 cannon.

Customer POC	Service/Agency POC	USD(A&T) POC
COL R. Pawlicki, USA	Dr. Edward Schmidt	Dr. C. W. Kitchens, Jr.
PM TMAS	ARL	DDR&E(WT)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602618A	H75	2.4	2.5	0	0	0	0
0602715H	AC	10.0	0	0	0	0	0
	Total	**12.4**	**2.5**	**0**	**0**	**0**	**0**

WE.34.02 Objective Crew-Served Weapon

Objectives. Demonstrate by FY00 a highly lethal, suppressive, and deployable crew-served weapon system. The Objective Crew-Served Weapon (OCSW) will be a lightweight, two-man-portable, single replacement weapon system for the current 40-mm MK19 grenade machineguns and the caliber .50 M2 heavy machineguns. It will provide decisively violent and suppressive target effects out to 2,000 meters, including a high probability of incapacitation and suppression against protected personnel (body armor and in defilade) and a high potential to damage light and lightly armored material vehicles. The OCSW will exploit lightweight, high-strength materials; modular optoelectronic full-solution fire control (leveraged from the Objective Individual Combat Weapon (OICW) ATD program); miniature electronic time set fuzing; and high-explosive air-bursting munitions.

Payoffs. The OCSW provides for a high probability of incapacitation and suppression against individual and group protected targets. The system also provides an all new capability to defeat non-line-of-sight or defilade targets, which current systems have little or no capability of defeating. The OCSW system will be lightweight, two-man-portable allowing for dismounted crew-served weapon application as well as mounted vehicular application.

Challenges. Technical challenges for the OCSW program include efficient munition fragmentation, electronics miniaturization (fire control and fuze), overall system weight (including durability and reliability), and system integration. There are no significant technical barriers in the OCSW program.

Milestones/Metrics.

FY1998: Demonstrate an OCSW system with the following characteristics: *Threshold*—weapon less than 38 lb, ground mount less than 12 lb, ammunition less than 0.4 lb, and fire control less than 7 lb (est). *Goal*—weapon less than 25 lb,; ground mount less than 9 lb, ammunition less than 0.35 lb, fire control less than 4 lb (est).

FY1999: Integrate variant fire control system derived from DTO E.03, OICW ATD. Demonstrate the ability to communicate and set a precision airburst capability for the OCSW system.

FY2000: Demonstrate overall system performance including greater probability of hit, incapacitation, and suppression out to 2,000 m when compared to the current MK19 and M2 machineguns with a system weight reduction of greater than 50%. Demonstrate the technological maturity and operational utility of the OCSW in live-fire troop testing.

Customer POC		Service/Agency POC	USD(A&T) POC
Col G. Buchholtz, USAF USAF/SPX	CDR John Luksik, USN USN PMS340	Mr. V. E. Shisler USA TACOM-ARDEC JSSAP	Dr. C. W. Kitchens, Jr DDR&E(WT)
CAPT L. Hail, USCG US Coast Guard	Col Rick Owen, USMC MCSC CBG		
COL Robert Hobbs, USA USAIC	COL D. Voorhees, USA USSOCOM		

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602623A	H21	7.0	2.4	0	0	0	0
0603607A	627	1.0	0.8	3.0	0	0	0
	Total	**8.0**	**3.2**	**3.0**	**0**	**0**	**0**

WE.35.02 Air Superiority Missile Technology

Objectives. Through design, ground tests, and flight tests, demonstrate reaction jet flight control technologies that will significantly enhance air-to-air effectiveness in all phases of air combat. Air superiority missile technologies (ASMTs) will produce an "offensive sphere" around the launch aircraft to allow successful target intercepts without regard to target off-boresight angle or orientation.

Payoffs. This DTO will demonstrate technologies yielding a dramatically expanded weapon engagement zone, providing future pilots with the ability to engage multiple targets throughout all phases of air combat, regardless of initial engagement geometry. The ASMT reaction flight control technologies will provide unprecedented missile maneuverability without degrading beyond-visual-range performance. Laboratory manned air combat analyses have shown that this radically new missile kinematic capability will allow pilots to engage and defeat targets from defensive postures that significantly increase blue survival. ASMTs are projected to add less than 5% to the overall unit production cost of an Advanced Medium-Range Air-to-Air Missile (AMRAAM)-type weapon, resulting in an extremely favorable cost-benefit relationship for this new operational capability.

Challenges. Technical barriers involve developing reaction jet control implementations consistent with inventory AMRAAM rocket motors; form, fit, and function; reaction jet response time less than 10 ms; stable flight of modified AMRAAM at a 90-deg angle-of-attack; compact packaging of all new technologies within the length and weight constraints of an F–22 weapons bay; and development of over-the-shoulder guidance methodologies.

Milestones/Metrics.

FY1999: Design an agile AMRAAM missile employing reaction jet/tail fin control complete with flight software and 6-DOF computer simulations.

FY2000: Extensive developmental ground test firings of reaction jets on inventory AMRAAM P^3I rocket motors.

FY2001: Flight test hardware fabrication/ground tests.

FY2002: Flight tests demonstrating a full-spherical, minimum-time, beyond-visual-range target intercept capability.

FY2003: Guided flight demonstrations of the ASMT reaction jet control airframe with the AMRAAM radar seeker.

Customer POC	Service/Agency POC	USD(A&T) POC
Col Michael Gentrup, USAF	Mr. William Jones	Dr. C. W. Kitchens, Jr.
ACC/DRA	AFRL-MNAV	DDR&E(WT)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602602F	2068	1.5	2.9	2.3	2.9	2.9	4.4
0602602F	2502	0	0.1	0.3	0.2	0.2	0.3
0603601F	670B	3.0	4.8	5.6	7.1	8.7	5.4
	Total	**4.5**	**7.8**	**8.2**	**10.2**	**11.8**	**10.1**

WE.38.02 Highly Responsive Missile Control

Objectives. Through a series of simulations and test flights, demonstrate substantial improvements in maneuverability and response time of a missile by implementing integrated guidance and control (G&C) systems. Using new design techniques, response times will be less than one-third that of current missiles, and lateral maneuver levels will be twice that of current ship defensive missiles. Flight testing and simulations will demonstrate the advanced G&C design concept. Simulation will provide the design tools necessary to predict estimated performance levels, while flight testing will be used to validate simulations and demonstrate performance. Simulations, particularly hardware-in-the-loop (HIL) simulations, will provide the final demonstration of the overall concept by FY98. (Simulation must be used because there is no target capable of exercising the system as the projected threat would.) The preferred missile airframe for use is the Standard Missile Block IV variant, which provides a number of advantages including an available aerodynamic database and an advanced signal processing throughput capability.

Payoffs. Key demonstrations include projected missile capability and technical objectives, time-response improvements, guidance filter performance, and 6-DOF simulation (FY96); subsystem test results, flight software performance, and HIL and 6-DOF simulations (FY97); and flight tests and results, guidance performance, and EMD readiness (FY98). The expected products for transition of this advanced technology demonstration include a new autopilot design through the use of robust optimization techniques, a new guidance filter and guidance law design integrated with the autopilot to substantially reduce the overall guidance time constant, and an increase in maneuverability through the accommodation of cross-coupling effects at high angles of attack and structural strength of critical missile components. Additional benefits include improved performance against targets, jammers, and decoys and application to hit-to-kill interceptors.

Challenges. The principal challenge is the integration of guidance filter and guidance law design with the autopilot to substantially reduce the overall guidance time constant.

Milestones/Metrics.

FY1998: Provide final demonstration of the overall concept through the use of HIL simulations that will ultimately provide maneuver levels twice that of current ship defensive missiles.

Customer POC	Service/Agency POC	USD(A&T) POC
Mr. Jeff Pearl	Mr. David Siegel	Dr. C. W. Kitchens, Jr.
PMS-422	ONR	DDR&E(WT)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0603792N	R1889	3.4	0	0	0	0	0
	Total	**3.4**	**0**	**0**	**0**	**0**	**0**

WE.39.02 Tactical Solid Rocket Missile Propulsion

Objectives. Enhance the warfighter's overall capability and survivability by pursuing robust propulsion technologies that will increase weapon system's kinematic performance and utility. This DTO is an updated revision to a Space Platforms DTO (SP.13.06, Tactical Rocket Propulsion AT, which has been deleted). It has become a weapons DTO because missile propulsion is a weapons-related technology. The needs, goals, and payoffs for tactical missile technology are best determined by the weapon's technical operational community. Rocket propulsion technologies are divided into four technology areas: propellants, control systems, combustion and energy conversion devices, and propellant management devices. Objectives within each technology area are based on the DoD Integrated High-Payoff Rocket Propulsion Technology (IHPRPT) time-phased goals and include technologies that will result in increased propellant energy, increased motor volumetric loading, decreased component weight and volume, and increased component efficiency while not sacrificing system safety or increasing cost.

Payoffs. By achieving the time-phased goals of the IHPRPT program, warfighter capability will be enhanced through increased launch range, decreased time to target, increased average velocity, increased F- and A-pole, larger engagement envelopes and no-escape zones, and increased weapon lethality. Specific goals for years 2000, 2005, and 2010 for rocket propulsion are increases in delivered energy of, respectively, 3%, 7%, and 15%; increases in motor mass fraction of 2%, 5%, and 10% for motors without thrust vector control or thrust management; and mass fraction increases of 10%, 20%, and 30% for motors with thrust vector control or thrust management, while meeting safety requirements and maintaining cost.

Challenges. Challenges for rocket propulsion are high-energy propellant ingredients and formulations that are insensitive-munitions-compatible, affordable lightweight/high-strength/high-pressure case materials; thrust management devices and no-/low-erosion nozzle materials; and high-power, compact, efficient thrust-vector control devices.

Milestones/Metrics.

FY1998: Complete motor development for gun-launched rocket propulsion.

FY1999: Flight demonstration tests accomplished.

FY2000: Increase delivered energy by 3%; increase mass fraction by 2% (motors without thrust vector control (TVC)); increase mass fraction by 5% (motors with TVC).

FY2003: Increase delivered energy by nearly 6%; increase mass fraction by nearly 4% (motors without TVC); increase mass fraction by nearly 9% (motors with TVC).

Customer POC	Service/Agency POC		USD(A&T) POC
Mr. Rich Matlock	Mr. J. Michele Lyon	Mr. David Siegel	Dr. C. W. Kitchens, Jr.
PEO (TAD)	AMSMT-RD-PR	ONR	DDR&E(WT)
	Mr. Lee Meyer		
	PL/RK		

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602111N		3.0	4.0	4.0	4.0	4.0	4.0
0602601F	1011	3.5	3.0	3.0	3.0	3.1	3.1
0603217N	R0447	1.0	2.0	2.0	2.0	2.0	2.0
0603302F	6339	0.3	0.3	0.3	0	0	0
	Total	**7.8**	**9.3**	**9.3**	**9.0**	**9.1**	**9.1**

WE.40.08 Infrared Decoy Technology

Objectives. Develop and demonstrate IR decoy technology for enhanced self-protection of aircraft and surface ships. The program will develop materials and dispensing technologies for both air and sea applications and demonstrate such technologies against captive IR seekers.

Payoffs. Successful achievement of this DTO will enhance the survivability of airborne and seaborne combatants against advanced IR missiles with decoy rejection techniques and algorithms. With regard to aircraft self-protection, the DTO will demonstrate the ability of advanced IR decoy countermeasures to significantly improve aircraft self-protection against the advanced strategic and tactical expendable (ASTE) Tier II threats. These devices and technologies can then be applied in advanced flare-dispensing techniques using multiple expendables to enhance the current ASTEs designed to counter Tier I. Regarding ship IR self-protection, the DTO will demonstrate decoy technology that is compatible with the currently deployed MK–36 Decoy Launch System (DLS) and that provides increased seduction capability over currently fielded point source decoys.

Challenges. The key overall technical challenge is to improve the spatial/geometric behavior of countermeasures without sacrificing in-band intensity requirements or spectral balance between IR bands (e.g., mid wave versus short wave). The issue of spatial geometry is critical with regard to the need for replicating the spatial extent of a ship (versus easily discriminated IR point source decoys), and remains paramount in view of future imaging IR threats to all warfighter platforms. (Hence, IR decoy efforts beyond FY00 will be integrated into the demonstrations under DTO WE.47.08, Imaging IR Seeker CM.) In the aircraft self-protection case, the challenge is twofold: optimizing the spectral balance of conventional materials, and improving the aerodynamic performance of special IR materials. This latter class of materials exhibits good spectral balance but suffers from an inherently low ballistic coefficient (i.e., high drag), which causes rapid separation from the dispensing aircraft. For the ship decoy, the technical challenge is to dispense the IR payload in a timed sequence that is both tactically easy to implement and operationally compatible with the MK–36.

Milestones/Metrics.

FY1998: Demonstrate 25% improvement in aircraft self-protection against the ASTE Tier II threats via 25X improvement in the aerodynamic properties of special IR materials; demonstrate flare materials possessing greater mid-wave IR energy versus that of short-wave.

FY2000: Demonstrate MK–36 DLS-compatible ship decoy technology with 20X improvement in IR spatial extent while retaining sufficient mid-wave and long-wave IR intensity to decoy current antiship missile threats.

Customer POC		Service/Agency POC	USD(A&T) POC
Mr. William Allen NAVSEA, PEO (TAD)	Capt Wendy Fraser, USAF ASC/LNWA (ASTE)	CDR Robert Boyd, USN ONR 313	Dr. C. W. Kitchens, Jr. DDR&E(WT)
CDR Rich Fanney, USN PMA-272	Mr. Jack Van Kirk PM-AEC Huntsville	Mr. Michael Flynn SAF/AQRT	

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602204F	2000	0.4	1.4	1.4	0	0	0
0602270N		1.1	1.0	0.9	0	0	0
0603270F	691X	2.8	1.0	0.3	0	0	0
0603270N	E2194	3.5	1.7	0.6	0	0	0
	Total	**7.8**	**5.1**	**3.2**	**0**	**0**	**0**

WE.41.04 Multimission Space-Based Laser

Objectives. Develop and demonstrate space-based laser (SBL) technology to support a system development decision for a multimission SBL (theater missile defense, national missile defense, antisatellite, surveillance, target designation, and active and passive target discrimination). Previously demonstrated technologies—MW-class Alpha HF chemical laser, Large Aperture Mirror Program (LAMP) 4-m segmented telescope, and Large Optics Demonstration Experiment (LODE) outgoing wave beam control technologies—will be integrated in the Alpha/LAMP Integration (ALI) demonstration to be completed in FY98. The High-Altitude Balloon Experiment (HABE) will demonstrate, at low power in the target environment, a complete acquisition, tracking, and pointing suite scaleable to SBL operational requirements in FY1999.

Payoffs. SBL provides the nation with a highly effective, continuous, global boost-phase intercept option for both theater and national missile defense regardless of theater size, geometry, or weather conditions. An SBL system could defend against missiles without putting the lives of U.S. military personnel at risk. With its long range and speed of light defense, it accomplishes boost-phase intercept at the earliest possible moment, offering the highest probability that intercepted missile fragments (possibly containing active chemical/biological or nuclear materials) will fall within the attacker's territory, not on defended assets. This system can provide many ancillary capabilities, including air defense, global surveillance, and target detection and designation for other systems.

Challenges. The primary remaining technical issues for SBL involve integration of hardware components into a flight-weight, flight-ready configuration for final ground tests and an optional space flight/demonstration (readiness demonstration program), and integration of the target acquisition and tracking system, which will have been demonstrated in the HABE program. LAMP and LODE technologies are currently being integrated in a vacuum chamber (for space simulation) adjacent to the current Alpha vacuum chamber.

Milestones/Metrics.

FY1998: Demonstrate integrated generation, stabilization, and projection of a megawatt-class laser beam. Critical parameters of beam quality, wavefront error, and jitter will achieve near-weapon-scale performance with power and aperture area at one-fourth to one-half the scale of an operational SBL system.

FY1999: Conduct end-to-end tracking and fire control demonstration on HABE at 26-km altitude. Demonstrate pointing error budget in timeline equivalent to operational engagement.

FY2000: Complete an uncooled, remotely aligned Alpha laser resonator.

FY2001: Test an uncooled, remotely aligned Alpha laser resonator.

FY2003: Conduct demonstrations to increase brightness, such as phase conjugation and operation at HF overtone.

Customer POC	Service/Agency POC		USD(A&T) POC
Lt Col Leland Denard, USAF AFSPC/DRC	Dr. Charles Infosino BMDO/TOD	Col Douglas Loverro, USAF AFSMC/AD	Dr. C. W. Kitchens, Jr. DDR&E(WT)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0603173C	1360	122.0	58.8	58.6	58.4	58.2	57.9
	Total	**122.0**	**58.8**	**58.6**	**58.4**	**58.2**	**57.9**

WE.42.08 Laser Aircraft Self-Protect Missile Countermeasures

Objectives. (1) Establish the feasibility of low-drag/radar cross section conformal laser systems for use in both manned and unmanned advanced aircraft; and (2) transition this technology to demonstrate robust laser countermeasures (LCM) against next-generation imaging IR missile threats. The focus of the LCM effort will be on mechanisms to damage or destroy (D^2) the imaging seeker components. This program is a coordinated Army, Navy, and Air Force effort.

Payoffs. High-performance aircraft perform best without externally mounted pods. This restriction has discouraged the use of lasers and optical systems on many aircraft. Several new laser technologies offer the possibility of lightweight, compact, efficient arrays that can be conformally mounted on the skin of aircraft and steered electronically with minimal impact on the aerodynamic performance of the aircraft. The addition of conformal lasers would give aircraft new capabilities in IR missile countermeasures. However, deceptive jamming countermeasures for conventional SAM and AAM threats are not expected to be effective against most emerging imaging IR missile threats. The D^2 program offers the potential of a robust countermeasure for the advanced imaging threats by damaging or destroying the missile seeker components and thus rendering the missile inoperative. Low-to-moderate power lasers and highly accurate beam steering will be required for this mission.

Challenges. The principal challenges for this program include wide-angle beam steering, thermal control of high-power lasers and arrays, and wavelength versatile laser and beam control materials. The LCM program will require identification of optimum laser characteristics including pulse format, average power, and wavelength for a D^2 mission.

Milestones/Metrics.

FY1999: Static field demonstration of D^2 effect against imaging threat.

FY2001: Field demonstration of D^2 prototype laser/beam control system against imaging threat.

FY2002: Large aircraft demonstration of D^2 capability. Demonstration of laser and beam control technologies that can be configured as conformal, electronically steerable lasers.

FY2003: Field demonstration of D^2 against non-EO threat (RF or beamrider).

Customer POC		Service/Agency POC	USD(A&T) POC
Lt Col Larry Moore, USAF	Maj Mark Naumann, USAF	Mr. Michael Flynn	Dr. C. W. Kitchens, Jr.
HQ ACC/DRSP	AMC/XPR	SAF/AQRT	DDR&E(WT)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602601F	3326	5.8	5.3	4.6	4.5	4.6	4.7
0603605F	3151	3.9	6.6	8.0	9.3	9.7	10.1
	Total	**9.7**	**11.9**	**12.6**	**13.8**	**14.3**	**14.8**

WE.43.08 Advanced Multiband Infrared Countermeasures Laser Source Solution Technology

Objectives. Develop and demonstrate a multiband, mid-infrared semiconductor laser system. The focus of the multiband infrared countermeasure (IRCM) laser source solution effort will be fixed-wing and rotary-wing IRCM programs such as the DoD tri-service Advanced Threat IRCM program. This laser program will be a coordinated Army, Navy, and Air Force effort to develop and demonstrate semiconductor laser technology capable of countering advanced IR missile threats.

Payoffs. Countermeasures against the current threat of advanced IR-guided, surface-to-air, and air-to-air missiles will require laser sources to provide the precisely directed, high-intensity beams of coherent mid-IR jamming energy. Current incoherent IR jamming sources (lamps) are relatively large, heavy, and inefficient and do not provide adequate emission in the Band IV spectral region to counter advanced threats. Nearer term laser sources now under development offer higher jamming intensities but require relatively inefficient optical conversion into some of the required mid-IR bands or may be countered with filters; and their size, weight, and input power requirements are still too large for installation in tactical fixed-wing aircraft and smaller rotary-wing aircraft. However, semiconductor laser technologies offer the potential of very high electrical efficiency and brightness, lightweight, and compact packaging. These can make advanced laser countermeasures readily packageable for installation in tactical fixed- and rotary-wing aircraft.

Challenges. The principal technology issues are development of high-brightness, high-operating temperature Band IV semiconductor lasers and development of novel resonator configurations for current-generation mid-infrared laser sources. The metrics for this program will be far-field brightness in the mid-IR bands of interest, weight/volume, and electrical power requirements of the IRCM system. Specific performance goals are a factor of three improvement in the brightness over current generation Band I and Band IV semiconductor lasers using less than 500 watts of aircraft input power.

Milestones/Metrics.

FY1998: Demonstrate 2 W peak/0.5 W average from a Band I semiconductor diode laser.

FY1999: Develop a Band I and Band IV semiconductor laser subsystem for use in testing by ATD DTO H.02, Multispectral Countermeasures. The semiconductor laser module will meet interface requirements of the DoD tri-service Advanced Threat Infrared Countermeasure program.

FY2000: Demonstrate high-brightness (200–400 kW per steradian per cm^2) multiband semiconductor lasers emitting 2 W peak/0.5 W average per band; emphasis will be placed on electrical efficiency and size and weight.

Customer POC		Service/Agency POC	USD(A&T) POC
Lt Col Larry Moore, USAF	Maj Mark Naumann, USAF	Mr. Michael Flynn	Dr. C. W. Kitchens, Jr.
HQ ACC/DRSP	AMC/XPR	SAF/AQRT	DDR&E(WT)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602601F	3326	1.5	1.0	0.5	0	0	0
0603605F	3151	2.0	3.0	3.0	0	0	0
	Total	**3.5**	**4.0**	**3.5**	**0**	**0**	**0**

WE.45.07 Sea Mines

Objectives. Demonstrate a new minefield concept through advanced multisensor fusion, inter-mine and intra-field communications networks, and mine/minefield remote control (RECO). Specific demonstrated capabilities include acoustic and electromagnetic sensors for detecting slow, quiet surface ships and submarines to ranges of 1,000 meters; sensor fusion algorithms for accurate localization and tracking of targets over the mine/sensor field; automated classification of targets; two-way-command, node-to-implanted-mine communications for full RECO of minefields; and autonomous distributed network control.

Payoffs. This DTO will allow a commander to completely monitor and control a designated ocean battlespace. The Navy's current medium-water-depth mine (MK56) is 1950's technology, has very limited detection range, requires extensive numbers of mines (and delivery sorties) to achieve a significant level of effectiveness, and is being retired from service. 1960's deep-water mines (MK60 CAPTOR) lose effectiveness in the shallow waters of the littoral and are not optimized to counter diesel-electric submarines or surface ships. New underwater communications networking technologies will allow large area coverage with limited numbers of mines and enhance tactical flexibility. Advanced sensor technology will facilitate the development of an unsweepable mine actuator and provide effectiveness against very slow, shallow targets.

Challenges. Technical barriers include underwater detection of quiet targets; automated classification of targets; multisensor node coordination and real-time target decision algorithms; very shallow water underwater communications at tactically significant ranges; autonomous network control and coordination protocols; safe, reliable, low-volume/-weight, high-energy, long-life batteries; and data management.

Milestones/Metrics.

FY1998: Demonstrate shallow- and intermediate-water-depth, low-data-rate communications between mines and relay nodes; demonstrate use of low-cost acoustic transmitters/receivers to ranges of up to 5 nmi.

FY1999: Demonstrate timely and accurate classification (surface/subsurface with 95% accuracy; target type with 75% accuracy) of targets detected by acoustic and nonacoustic sensors integrated into a littoral sensor field.

FY2000: Demonstrate multiple concepts for RECO connectivity from manned air, surface, and subsurface platforms to shallow-water mines with 99% reliability (receipt/acknowledgement of command).

FY2001: Using actual autonomous node hardware embedded in a virtual simulation environment, demonstrate an armed autonomous surveillance network capability sufficient to reduce the number of mobile mines required to cover a given area by a factor of 10.

Customer POC	**Service/Agency POC**	**USD(A&T) POC**
Capt Hubert Broughton, USMC N852	CAPT Dana Richardson, USN OASN RD&A	Dr. C. W. Kitchens, Jr. DDR&E(WT)
CAPT William Shannon, USN COMINEWARCOM N8	Dr. Doug Todoroff ONR 322W	Dr. Jasper Lupo DDR&E(SEBE)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602315N		2.9	3.0	3.1	3.6	0	0
0603782N	R2226	0.5	3.6	5.0	4.5	0	0
	Total	**3.4**	**6.6**	**8.1**	**8.1**	**0**	**0**

WE.46.08 Coherent RF Countermeasures Technology

Objectives. Provide a power-efficient, coherent RF countermeasures (RFCM) capability to protect friendly airborne and surface platforms from high-power threat weapon systems that use advanced radar processing techniques. This tri-service effort will attack this objective on two technology fronts: digital RF memory (DRFM) architectures, and phased-array microwave power module (MPM) transmitters/jammers.

Payoffs. The pursuit of multichannel, modular chip-set DRFM designs as a core signal exciter at the electronic warfare (EW) receiver-transmitter (transceiver) interface will yield the ability to rapidly demodulate, accurately store, and precisely replicate or alter enemy radar waveforms for retransmission by a jammer, thus degrading or denying the hostile threat sensor's ability to acquire and track targets. Advancements in DRFMs will also speed the transition of digital EW receiver architectures being pursued by the services. Transmitters employing microwave and millimeter-wave power modules (MMPMs) have the potential of a tenfold volume reduction and a greater than twofold increase in prime power efficiency compared to typical traveling wave tube (TWT)-based transmitters. Advancements in EW MPM technology will also be applied to the constrained form factors of towed decoys. The emerging technologies being advanced under this DTO will provide new coherent countermeasures and high-efficiency transmitter capabilities for support, stand-in, and escort jamming missions—as well as self-protection countermeasures—thus enhancing the tri-service survivability of surface platforms and penetrating airborne platforms.

Challenges. Traditional, noncoherent ECM techniques such as noise jamming are largely ineffective against modern coherent threats. Such radar systems use sophisticated monopulse, pulse Doppler, or processing gain or filtering techniques to deny effective and deceptive masking of friendly forces' platforms. ECM signal coherency and power and spectral energy efficiency of jamming signals are absolutely critical to successfully penetrate such radar processing. In an upgrade/retrofit/P^3I environment, given the sheer number of operational EW systems involved, cost is also a challenge. Development goals of a low-cost ($5,000) miniaturized coherent exciter and ECM techniques generator and low-cost ($10,000) jammer power modules are key elements of the tri-service goals.

Milestones/Metrics.

FY1998: Demonstrate a high-power 2 x 8 MPM phased-array transmitter in a ground test environment. Demonstrate coherent exciter signal source via two-channel, monolithic DRFM "on-a-chip" EW techniques generator (three 6- x 9-in circuit card sets).

FY1999: Initiate design of miniature transceiver (15 in^3) compatible with DRFM technology for a coherent exciter. Multiple demonstrations of a high-power MMPM Rotman lens transmitter (laboratory); the 2 x 8 high-power array (flight test); and a polarization-agile MPM array design in both array-element and towed-decoy configurations (ground test).

FY2000: Integrate transceiver, monolithic DRFM, and technique controller to demonstrate a coherent exciter.

FY2001: Complete tri-service coherent CM architecture; initiate coherent CM jamming pod technology demonstrator ATD (integration of transceiver, DRFM exciter, MPM arrays, and controller technology subelements). Transition to Joint Support Jammer ATD (planned FY99 JWSTP DTO).

FY2003: Integrate coherent jamming architecture into pod or UAV configuration and ground testing thereof.

Customer POC	Service/Agency POC	USD(A&T) POC
Maj Frank Kelly, USAF NAVAIR SYSCOM (AIR 4.5.4)	CDR Robert Boyd, USN ONR 313	Dr. C. W. Kitchens, Jr. DDR&E(WT)
Mr. Jack Van Kirk PM-AEC Huntsville	Mr. Michael Flynn SAF/AQRT	
Lt Col Larry Moore, USAF HQ ACC/DRSP	Mr. Rob Saunders SARD-TT	

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602204F	2000	1.8	0	0	0	0	0
0602270N		1.4	1.5	1.6	1.7	1.7	1.8
0603270F	431G	0.8	2.2	1.2	0.6	0	0
0603270N	R2090	0.6	0.7	0.7	0.7	0.7	0.8
	Total	**4.6**	**4.4**	**3.5**	**3.0**	**2.4**	**2.6**

WE.47.08 Imaging Infrared Seeker Countermeasures Technology

Objectives. Develop techniques and requirements for infrared countermeasure (IRCM) technology necessary to defeat the next-generation staring and scanning focal plane array, imaging infrared (I^2R) seekers. Specific advanced threat technologies will be assessed and quantifiable requirements developed for advanced expendables, lasers, and signature control techniques. The overall goal is to improve effectiveness of countermeasures by 40–50 times the present day warfighter capabilities for air, land, and sea platform self-protection from "imagers."

Payoffs. It is envisioned that advanced, spatially extended decoys, possibly directionally dispensed, higher brightness laser jammers and advanced signature control technology, used alone or synergistically, may be needed to defeat the I^2R threat. Consequently, a major payoff will be the definition of new performance requirements from the parallel technology development efforts currently underway. Success of the tri-service effort will necessarily and significantly boost the survivability of both air and surface-based combatants against the imaging IR threat. The techniques developed will be of generic usefulness and will have wide application to a large percentage of the U.S. weapon platforms.

Challenges. Defeating the I^2R threat may require area decoys encompassing ten times more area than existing or near-term developmental decoys directionally dispensed to obscure the target. Laser jammers with 20–100 times the brightness may be needed to defeat the I^2R threat. This would require two to three times more powerful lasers with one-half to one-third the divergence used in conjunction with more precise pointing and tracking systems. Advanced signature control technology may also be needed to disrupt the I^2R tracker aimpoint. It is anticipated that all techniques must be brought to bear in cooperative fashion to defeat imagers.

Milestones/Metrics.

FY1998: Develop a reconfigurable imaging seeker digital model.

FY1999: Demonstrate effectiveness of potential IRCM techniques against modeled threats using expendables and lasers.

FY2000: Report on IRCM vulnerability of foreign and domestic focal planes using jamming and damage lasers.

FY2001: Identify and obtain surrogate I^2R hardware; demonstrate advanced large area decoy.

FY2003: Test and demonstrate IRCM devices against imaging seeker hardware (surrogate/real).

Customer POC	Service/Agency POC	USD(A&T) POC
CAPT Doug Henry, USN PMA-272	CDR Robert Boyd, USN ONR 313	Dr. C. W. Kitchens, Jr. DDR&E(WT)
Mr. Jack Van Kirk PM-AEC Huntsville	Mr. Michael Flynn SAF/AQRT	
Maj Mark Naumann, USAF HQ AMC/XPR	Mr. Rob Saunders SARD-TT	

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602204F	2000	0.2	0.2	0.2	0.2	0.2	0
0602270A	A442	3.9	0	0	0	0	0
0602270N		0.5	0.5	0.4	0.4	0.3	0.3
0603270F	691X	0.8	1.4	1.0	0.6	0.6	0
0603270N	E2194	0	0.7	0.7	0.8	0	0
	Total	**5.4**	**2.8**	**2.3**	**2.0**	**1.1**	**0.3**

WE.48.08 Missile Warning Sensor Technology

Objectives. Demonstrate advanced multispectral sensor and algorithm technology for long-range detection of IR guided missile threats and situation awareness (SA) capability for air vehicles. The SA capability will combine missile warning, defensive IR search and track (IRST), and forward-looking IR (FLIR) and navigation functions in a sensor/processor breadboard in order to achieve real-time demonstration of integrated algorithms. The advancements pursued are lower false alarm rates, extended declaration ranges, affordable multispectral sensor technology, and real-time processed algorithms.

Payoffs. Current missile warning technology limits detection to the last few seconds of the engagement, resulting in marginal survivability for the warfighter. From this tri-service DTO, the warfighter will gain enhanced and more accurate missile warning, plus the additional benefit of improved survivability through better SA capability for air vehicles. The operational customer will thus be able to define requirements to tailor the passive IR system from a missile-warning-only capability to an SA capability. The dual-band missile warning focus will provide missile warning at long range for detection and handoff for laser IRCM/expendable countermeasures. The SA capability focuses on an affordable IR sensor/processor suite for tactical air vehicles. The acquisition costs are being considered in advanced development to ensure an affordable threat warning and SA system. Success of this DTO will enable multiple transitions to new and retrofit platforms, including Joint Strike Fighter, Common Missile Warning P^3I, the Army's Top-Attack Protection Program, and the Navy's ship self-protection upgrades. The bottom line is greatly improved survivability for the joint warfighter with a totally passive intercept and SA capability.

Challenges. In comparison to current systems in the field, detection ranges must be extended and false alarms reduced (2–10 times) to provide unambiguous warning in time to initiate effective tactical maneuvers, deploy countermeasure decoys, or cue directed-energy jamming systems. The technical barriers include affordable multispectral focal plane arrays (FPAs) (both cryogenically cooled and uncooled detectors), multiaperture packaging, affordable processors, real-time processed algorithms, and clutter rejection techniques. The clutter rejection techniques require demonstration on real-time processors in flight or with real background data. The processors for running the algorithms for a six-sensor suite must be affordable to realize a low life-cycle cost. The multispectral FPA technology needed must have adequate sensitivity and simultaneous readout of multiple IR bands—increasing the severity of this particular challenge as long-range, accurate discrimination requirements (background vs. clutter vs. target) push the technology toward considering multispectral and hyperspectral IR bands.

Milestones/Metrics.

FY1998: Demonstrate 2X range increase in clutter rejection; demonstrate real-time missile warning sensor/processor in flight (with one sensor).

FY2000: Demonstrate integrated sensor/processor for SA (missile warning, defensive IRST, FLIR/navigation) in a single aperture, 50% volume reduction for functions, and 3:1 reduction in required apertures.

FY2003: Develop and demonstrate increased detection range of multifunction system.

Customer POC		Service/Agency POC	USD(A&T) POC
Mr. William Allen NAVSEA, PEO (TAD)	Mr. Jack Van Kirk PM-AEC Huntsville	CDR Robert Boyd, USN ONR 313	Dr. C. W. Kitchens, Jr. DDR&E(WT)
CAPT Doug Henry, USN PMA-272	Lt Col Mike Kemerer, USAF HQ AFSOC/XPQE	Mr. Michael Flynn SAF/AQRT	
		Mr. Rob Saunders SARD-TT	

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602270A	442	2.2	2.2	0	0	0	0
0602270N		0.5	0.7	0.7	0.8	0.8	1.0
0602204F	2000	0.8	0	0	0	0	0
0603270F	691X	0.8	1.4	0.9	0.5	0	0
0603270N	E2194	3.3	3.3	3.4	0.8	0	0
	Total	**7.6**	**7.6**	**5.0**	**2.1**	**0.8**	**1.0**

WE.50.02 Compact Kinetic Energy Missile Technology

Objectives. Develop and demonstrate kinetic energy (KE) missile technology necessary for the next-generation Line-of-Sight Antitank (LOSAT) missile. This program will demonstrate enhanced system lethality against advanced and active Future Combat System (FCS) threat armor target arrays with a reduced mass hypervelocity KE missile (40–50 kg) testbed. Miniature guidance inertial measurement unit (IMU) technology, compatible with the existing LOSAT target acquisition and tracking system, will be demonstrated to provide a 50%–100% increase in the LOSAT off-axis capability. A more efficient high-performance, nondetonable propulsion system will be developed and demonstrated to provide peak velocity at less than 500 m, while delivering more than 20 MJ on target at 4 km.

Payoffs. The technologies demonstrated will be transitioned to a LOSAT P^3I or the next-generation KE missile concept for the Army After Next (AAN) and FCS. These technologies will yield a compact KE missile (CKEM) testbed concept that maintains LOSAT lethality while reducing the LOSAT takeoff weight by 40%–50%. The technologies demonstrated will also yield the opportunity to expand the engagement area and more than double the number of stowed kills for a given launch platform. Demonstration of the boost-phase IMU orientation capability coupled with the advanced guidance capabilities increases LOSAT's horizontal field of regard by 50%–100%. Energy on target over the entire system range is more than three times the current muzzle energy of cannon launched projectiles. The flight body testbed will provide the maneuvering capability necessary to destroy attacking rotary-wing aircraft. The reduced mass LOSAT P^3I testbed component technology and the associated enhanced operational capabilities will more than double the weapon system platform survivability. This program will enhance system lethality against future advanced and active FCS threat armor target arrays. Additionally, the ability to fire on the move makes the LOSAT P^3I missile component technology and testbed a prime candidate for the main weapon system on the FCS for the AAN.

Challenges. The challenges in the CKEM program include (1) miniaturized guidance and continuous control actuation for Mach 6.5, 100-g lateral maneuver capability; (2) more efficient high-performance, minimum-smoke, nondetonable propellant with specific impulse (Isp) 250 and a burn time < 0.6 s; (3) enhanced lethality from novel reduced mass, KE penetrator/missile performance; (4) application of high strength-to-density-ratio composite in the propulsion unit; and (5) firing on the move.

Milestones/Metrics.

FY1998: Demonstrate high-performance motor and propulsion concepts with Isp >250 and burn time <0.6 s.

FY1999: Demonstrate airframe integrity, verify guidance communications, and characterize launch environment for Mach 6.5, 100-g lateral maneuver capability missile.

FY2000: Demonstrate 25% increase in missile lethality compared to existing equal mass KE missile.

Customer POC	Service/Agency POC	USD(A&T) POC
COL Robert Hobbs, USA DCD, Fort Benning	Ms. Irena Szkrybalo SARD-TT	Dr. C. W. Kitchens, Jr DDR&E(WT)
Mr. Alan Winkenhofer DFD, Armor School	Mr. George Snyder AMCOM	

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602303A	214	2.8	4.4	4.0	0	0	0
	Total	**2.8**	**4.4**	**4.0**	**0**	**0**	**0**

WE.51.02 Small-Diameter Antiair Infrared Seeker

Objectives. Develop and demonstrate a small-diameter (2.75-inch) IR imaging seeker that can provide improved target engagement capability for man-portable and lightweight crew-served air defense missile systems.

Payoffs. This DTO will enable air defense missiles such as Stinger, Avenger, and Linebacker to engage targets at long ranges in the presence of ground clutter. Specifically, this program will develop an improved form-factored seeker using a state-of-the-art midband IR focal plane array with breadboard electronics that has the ability to engage helicopter targets in terrain clutter at long ranges. The program will develop a completely form-factored seeker (including electronics) suitable for flight tests incorporating advanced signal processing tracker algorithms with infrared counter-countermeasures (IRCCM). When integrated into a system, this seeker will provide the soldier with the ability to engage helicopters, fixed-wing aircraft, cruise missiles, and unmanned aerial vehicles (UAVs) in hostile environments at ranges well in excess of present capabilities.

Challenges. Technical barriers include achieving effective engagement range capability against the full target set, developing and packaging the complete seeker including electronics in a 2.75-inch missile-compatible size, demonstrating advanced IRCCM capability against known and projected countermeasures, and achieving operational compatibility with a rolling airframe missile.

Milestones/Metrics.

FY1998: Demonstrate in tower tests, with tactical-sized electronics, the ability to engage helicopter targets in terrain clutter at ranges in excess of 3X current capability and to engage helicopter and fixed-wing aircraft deploying IR countermeasures.

FY1999: In captive-carry tests of this completely form-factored seeker (including electronics) incorporating advanced signal processing tracker algorithms with IRCCM, demonstrate the ability to acquire helicopters, fixed-wing aircraft, cruise missiles, and UAVs in hostile environments including countermeasures at the stated range requirement for short-range air defense systems.

Customer POC	**Service/Agency POC**	**USD(A&T) POC**
LTC Tom Newberry, USA	Mr. Michael Rithmire	Dr. C. W. Kitchens, Jr.
PM Stinger	SARD-SM	DDR&E(WT)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0603313A	549	2.7	2.7	0	0	0	0
	Total	**2.7**	**2.7**	**0**	**0**	**0**	**0**

WE.52.02 Best Buy ATD

Objectives. Develop and demonstrate a gun-fired, rocket-assisted, jointed-composite, 5-inch projectile with a high lift-to-drag ratio (L/D), double the number of carried submunitions compared to the Extended-Range Gun Munition (EX–171 ERGM, from 72 to 143), delivered from sea-based guns to at least 50% further range (from 63 nmi to 100 nmi), which match or exceed expected shore performance of the 155-mm M198 gun-fired projectile.

Payoffs. Current naval gun projectiles in development do not meet OPNAV goals or Naval Surface Fire Support COEA recommendations. The goals set forth are to use existing assets (Navy 5-inch gun) to support Marines' operational maneuver from the sea for effective at-sea fire support at a minimum range of 75 nmi with 125 submunitions. A unit production cost (UPC) savings of over 50% is required, when based on identical number of identical submunitions delivered to maximum range when compared to the baseline ERGM program. In other words, Best Buy will deliver twice the number of submunitions, to a longer range, in a single round at under a 50% increase in UPC.

Challenges. Composite projectiles with fine length-to-diameter ratios (110:5 inches) require significant design considerations from both the ability to guide the round with control surfaces located in the nose and the ability to survive the gun launch-loading environment. Technology for producing composites that are strong enough to carry launch loads but flexible or elastic enough to survive off-axis accelerations induced in exiting the gun is not currently available. Long composite airframes need to be sized and designed with a midbody joint that connects forward and aft burning rocket motor sections for a "burn through the joint" motor to achieve required range and payload goals and be compatible with existing naval gun autoloaders. The joint must be structurally strong to survive and distribute launch loads through the thin composite airframe and strong enough to survive internal pressures produced by the burning rocket motor propellant in the forward rocket motor section, but lightweight to meet weight goals. Guidance and control systems are derived from the EX–171 ERGM program with minimal adaptation in the control algorithms for the flexibility of a long, fine structure. The system is additionally complicated by the need to maintain weight and physical dimension compatibility with the existing 5-inch MK45 Mod 4 gun autoloader system for multiple ramming operations, which mate the two separate airframe sections together in the gun barrel. Technical barriers for developing a multiple ram, jointed airframe that is mated inside the gun barrel during Navy gun fire missions include gun launch survival of a jointed composite airframe; ignition and performance from a jointed, dual-pulse rocket motor from the same aft nozzle; controllable flight of a long slender airframe from the existing IMU system after launch that achieves range goals; and delivery of a lethal payload within the required CEP of the EX-171.

Milestones/Metrics.

FY1998: Ground test jointed rocket motor components and systems demonstrating 100-nmi range, tactical performance potential for triple ram, and double payload configuration. Complete gun launch subcomponent testing.

FY1999: Complete ballistic flights of unguided, gun-launched jointed rocket motor and projectile; demonstrate existing gun system autoloader compatibility; demonstrate submunition dispersal system/composite airframe compatibility; flight tests demonstrating accuracy, 100-nmi range, and payload capacity.

Customer POC	Service/Agency POC	USD(A&T) POC
Capt Dennis Morral, USMC	Mr. David Siegel	Dr. C. W. Kitchens, Jr.
NAVSEA PMS 429	ONR	DDR&E(WT)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0603792N	R1889	5.6	5.0	0	0	0	0
	Total	**5.6**	**5.0**	**0**	**0**	**0**	**0**

WE.54.02 Reactive Material Warhead ATD

Objectives. Demonstrate the ability of missile warheads to achieve catastrophic structural kills of cruise missile and manned aircraft targets by enhancing traditional kinetic energy defeat effects with fragment chemical energy that is released when fragments impact targets. The best candidate reactive material mixture will be incorporated into warhead prototypes, such that tests in a static arena environment against representative targets would demonstrate the potential catastrophic performance enhancement.

Payoffs. When launched into cruise missile and manned aircraft, reactive materials have shown the potential capacity to react, creating significant overpressure, rupturing heat, and incendiary effects, thereby improving the damage over the KE-only effects normally found in inert metal fragments available in most current warheads. Used for ship self-defense and air superiority, reactive materials offer the potential of significantly improved catastrophic kills at current miss distances or sustained lethality at misses up to twice that of current systems. Candidate solid reactive materials have the capability to double the mission kill or catastrophic kill radius in missile warheads for ship self-defense and other air defense applications. It is expected that the addition of reactive materials will have only minor impact on system unit cost but may provide major savings in the number of rounds required for target kill.

Challenges. Significant risk exists in the capability to explosively launch reactive materials, deliver them unreacted to the target, and trigger them to release lethal energy within the target. Additional challenges include packaging in a tactically effective configuration that has the ability to achieve effective fragment velocities and probability of hit on target.

Milestones/Metrics.

FY1999: Determine fragment design parameters for hydrocode and experiments. Determine final material characteristics for composition mix/morphology/reaction rates. Assess initial performance and perform analyses to verify capability to increase level of damage to catastrophic kill at 2X standoff.

FY2000: Demonstrate explosive launch and reaction on target to verify stable flightpaths and fragment flight distances, less than 10% of material reacts during flight, and reactions on target to verify capability to enhance damage level to catastrophic kill in appropriate encounters. Determine warhead/fragment design to weaponizable design—mechanical analysis and design layouts.

FY2001: Demonstrate repeatable explosive launch with prototype warheads for consistent fragment velocity, predictable fragment flightpaths, reactions at target with appropriate release rates, and lethal damage. Demonstrate prototype warheads in performance and lethality arenas to verify enhanced lethality, verify catastrophic damage at 2X standoff, verify 50% damage increase at current standoff. Conduct end-game performance analyses and validate 50% increase in missile system terminal effectiveness.

Customer POC	**Service/Agency POC**	**USD(A&T) POC**
CAPT Michael Mathis, USN	Mr. David Siegel	Dr. C. W. Kitchens, Jr.
PMS-422	ONR	DDR&E(WT)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
S&T Funding							
0603792N	R1889	0	4.4	4.7	5.2	0	0
Total S&T		**0**	**4.4**	**4.7**	**5.2**	**0**	**0**
Non-S&T Funding							
0603609N	U1821	1.0	0	0	0	0	0
Total Non-S&T		**1.0**	**0**	**0**	**0**	**0**	**0**

WE.55.02 Reduced Size Torpedo Subsystem Demonstration

Objectives. Develop and demonstrate by 2002 torpedo subsystems in reduced sizes so that these subsystems or components would be applicable to various sizes of torpedoes and counterweapons (21-, 12.75-, and 6.25-inch diameters). The technology developed would be compatible with existing and future U.S. torpedo systems and would be capable of insertion into existing operational weapon systems to quickly provide significant cost savings and improved warfighting capabilities.

Payoffs. The technology being developed offers payoffs in reduced cost of ownership due to the commonality of components among various sizes of weapons and counterweapons and the greatly reduced cost of support equipment and infrastructure required for the support of these systems. The development of these technologies, along with the successful development of high-power density propulsion subsystems, would permit the development of smaller weapons and counterweapons, which allows the deployment of a larger number of weapons or a greater weapon mix without an increase in platform size.

Challenges. The major technical challenge is to develop and demonstrate smaller components without sacrificing performance. This requires the development of energetics and warhead configuration concepts to maintain warhead performance in reduced size, and the development of microelectromechanical systems (MEMS)-based safe-and-arm (S&A) systems of the size typical of integrated circuits while maintaining the required multiple interlocks for safety.

Milestones/Metrics.

FY1998: Initiate development of multimode warhead technologies with 35% size reduction (goal of 50% reduction) for use as a common warhead for antisubmarine, antiship, and antitorpedo applications from a lightweight or reduced length heavyweight weapon.

FY1999: Initiate fabrication of multimode warhead system components applicable to all torpedo sizes; integrate MEMS-based S&A subsystem with volume reduction of 75% from current S&A subsystems into warhead concept.

FY2000: Demonstrate advanced antitorpedo torpedo warhead concept with 35% size reduction over current capability.

FY2001: Demonstrate warhead concepts for 35%–50% volume reduction over current warheads for half-length torpedo.

FY2002: Demonstrate torpedo subsystems with 50% reduction in length.

FY2003: Transition reduced-size torpedo technology to PEO (Undersea Warfare) for insertion into half-length torpedo program.

Customer POC		Service/Agency POC	USD(A&T) POC
CAPT John Barry, USN N863E	LCDR Timothy Hagan, USN N872E	Dr. Judah Goldwasser ONR	Dr. C. W. Kitchens, Jr. DDR&E(WT)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602633N		3.0	3.1	3.6	3.9	1.5	0
0603747N	R2267	0.5	1.4	1.8	1.9	1.9	1.0
	Total	**3.5**	**4.5**	**5.4**	**5.8**	**3.4**	**1.0**

WE.56.02 Electromagnetic Armaments for Direct Fire

Objectives. Significantly improve direct-fire ground combat vehicle lethality by providing electromagnetic gun systems with hypervelocity and hyperenergy launch capability. It is anticipated that within the 2015–2020 timeframe advanced armor systems such as explosive reactive armor and active protection systems will significantly degrade the penetration performance of current direct-fire tank rounds. Electromagnetic (EM) launches can fire projectiles at hypervelocity (2,500–3,000 m/s) compared to the current ordnance velocity (1,700 m/s) of tank cannon. This velocity increase coupled with novel kinetic energy projectiles has been shown to provide significant advantages against certain classes of armor. In addition, EM launches have the potential to provide two to three times the muzzle energy of a conventional cannon of the same bore diameter and length. This increased muzzle energy would permit defeat of even the most advanced armor. However, EM launch technology has significant technical challenges. The present program is structured to demonstrate that there are feasible approaches to solve these problems. By 1999, the program will show, first, that an EM pulsed power supply can be built that has the potential to meet the energy, power, space, and weight requirements of an armored fighting vehicle and, second, that hypervelocity provides significant improvement in penetrating
advanced armor.

Payoffs. EM launch has the potential to increase muzzle energy by a factor of two to three and provide hypervelocity. Both would yield a leap-ahead capability in defeat of future armor. The technical approach provides compact pulsed-power systems capable of high-energy, high-power discharges needed for EM guns, EM armor, active protection systems, and other future electrical systems; hypervelocity penetrators of novel configuration capable of defeat of advanced armor concepts; efficient launch packages; and launchers capable of repeated, accurate fire.

Challenges. Technical barriers for EM are high-strength, thick-section composites; high-current capacity, fast-actuating and -recovering solid-state switches; high-efficiency launchers; thermal management; and reduced mass armatures.

Milestones/Metrics.

FY1998: Demonstrate full performance of subscale compulsator (0.65–1.5 J/g). Launch base-push KE projectile from EM gun.

FY1999: Complete build and begin test of exit criteria compulsator (3.0 J/g). Show EM launch of projectile at 2.5 km/s, 7.0 MJ, and 50% mass in flight body. Assess battlefield utility of EM.

Customer POC	Service/Agency POC	USD(A&T) POC
COL John Kalb, USA	Dr. Edward Schmidt	Dr. C. W. Kitchens, Jr.
DFD, Ft. Knox	ARL	DDR&E(WT)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602618A	H75	9.0	5.1	0	0	0	0
	Total	**9.0**	**5.1**	**0**	**0**	**0**	**0**

WE.57.02 Lethality/Vulnerability Models for High-Value Fixed Targets

Objectives. Verify and validate (V&V) lethality/vulnerability (L/V) models for predicting weapon effects against high-value fixed targets. Current L/V tools that are used to assess the performance of conceptual and inventory weapons against high-value fixed targets have extremely large uncertainties. These tools are currently used to conduct studies and analyses in preparation for major acquisition milestones, thereby impacting critical decisions on advanced concepts and weapons technologies.

Payoffs. This DTO will reduce the time, risk, and cost involved in correctly identifying, developing, and applying emerging weapon system technologies best capable of holding high-value fixed targets at risk. This DTO will also ensure the most effective use of existing weapon systems to defeat high-value fixed targets by identifying the best means of exploiting target vulnerabilities through aimpoint selection and tailored delivery strategy. This increased sortie effectiveness will reduce the need for retargeting, which will reduce the exposure of warfighters and airborne assets to hostile fire. Cost of operations will be reduced by accomplishing the mission with fewer aircraft sorties, expending fewer munitions, and losing fewer aircraft.

Challenges. Recent advances in weapon technology have driven L/V models far beyond the range for which validation data exists. The technical challenge is to develop high-quality weapon's effects data necessary for validating L/V models. This requires executing well controlled tests or performing high-fidelity, physics-based analyses to obtain weapon effects data for current and developmental weapons against realistic target sets.

Milestones/Metrics.

FY1998: Increase size of the penetration database of inventory and developmental weapons into rock by 25%; expand the validation database for blast propagation models in complex structures by 30% to include realistic target weapon combinations that reduce blast prediction uncertainty by 30%.

FY1999: Reduce the uncertainty in penetration by 300% for targets constructed of concrete and 500% for targets constructed in rock; increase the size of the validation database for blast and fragment damage against chemical/biological (CB) containers by 80%.

FY2000: Reduce the prediction uncertainty for blast by 200% for blast damage from shock and a corresponding amount for late-time quasistatic pressure; reduce the prediction uncertainty by 200% for blast/fragment loading CB containers.

FY2001: Increase the validation database for synergistic effects of blast and fragments by 20%; reduce the prediction error by 30%; reduce the prediction error for blast/fragmentation damage to former Soviet bloc critical C^3I components by 50%.

FY2002: Finalize the system-level validation plan for inventory and development weapons against high-value fixed targets; 200% reduction in the failure uncertainty for blast fragment loading against former Soviet bloc critical C^3I components; 300% reduction in failure uncertainty for combined blast and fragment loading against reinforced concrete targets.

FY2003: Validate the system-level L/V models for fixed WMD targets using test data from a large-scale test; 200% reduction in overall system-level prediction error for WMD targets.

Customer POC	Service/Agency POC	USD(A&T) POC
LTC Hal Meyer, USA STRATCOM, J55	Mr. Ron Hunt AFRL-MN	Dr. C. W. Kitchens, Jr. DDR&E(WT)
LTC Steve Perez, USA EUCOM, J5-N/CP	Mr. Michael E. Giltrud HQ DSWA/WEL	

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602715H	AC	5.5	6.3	6.4	7.4	7.7	7.9
0602602F	2502	0.8	0.9	0.8	0.7	0.7	0.9
	Total	**6.3**	**7.2**	**7.2**	**8.1**	**8.4**	**8.8**

WE.58.02 Microelectromechanical Systems Inertial Navigation System

Objectives. Improve the silicon-based inertial sensors (gyros and accelerometers) and integrate them with navigation software into a low-power, small, lightweight, low-cost tactical grade inertial navigation system (INS). The Microelectromechanical Systems (MEMS) INS will be generic for insertion/embedding into military systems and in man-portable applications.

Payoffs. The MEM INS technology developed under this program will fulfill the low-end guidance performance gap and emphasize even smaller, lighter, lower cost, and lower power attributes as compared with other tactical and navigation grade technologies. Due to the expected low-cost, MEMS INS will be the ideal insertion candidate into low-cost, high-volume system and weapon applications. MEMS INS is thus transitionable to expendables—bombs, munitions (e.g., ERGM)—and to man-portable equipment. Field demonstrations will put these technology products into the hands of operators so they can exploit the unique guidance, navigation, and control attributes of MEMS INS.

Challenges. Challenges include selecting and refining foundries and foundry processes, designing the mechanical subsystems, selecting and refining the navigation software, and performing INS simulations of the modeled sensors. Additional challenges include developing low-power, power-managed IMU electronics for long-life operations and low-cost, small-size, environmentally robust sensor packaging.

Milestones/Metrics.

FY1998: Demonstrate MEMS gyroscopes and accelerometers; show progress toward 1-deg/hr gyro bias drift, 500-μg accelerometer bias performance; demonstrate initial fabrication processes.

FY1999: Deliver proof-of-concept gyroscopes and accelerometers with performance approaching 1-deg/hr gyro bias drift, 500-μg accelerometer bias.

FY2000: Demonstrate and deliver tactical grade (1-deg/hr gyro bias drift, 500-μg accelerometer bias) MEMS-based INSs for <$1,200, <1.0 W, and <10 in^3 package.

Customer POC	Service/Agency POC	USD(A&T) POC
COL Barry Ward, USA PM-MLRS	Lt Col Beth Kaspar, USAF DARPA/STO	Dr. C. W. Kitchens, Jr. DDR&E(WT)
LtCol Steven Welch, USMC PM, WCMD, ASC/YHW	Mr. Pete Wise AFRL-MNAG	

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0603762E	SGT-01	3.3	9.0	7.0	0	0	0
0602602F	2068	0.8	0.8	0.1	0	0	0
	Total	**4.1**	**9.8**	**7.1**	**0**	**0**	**0**

WE.59.02 Hypersonic Weapons Technology Demonstration

Objectives. By FY03, demonstrate the enabling technologies for a class of hypersonic strike weapons that meet Navy-unique requirements. Specifically, the objectives are to demonstrate critical technologies in the areas of propulsion, airframe, ordnance, and guidance and control, which will allow for hypersonic strike weapons that have an average velocity of Mach 5–6, a range of 400–700 nmi, cost less than $400,000 a unit, have a CEP of less than 3 m, and deliver ordnance that penetrates 18–36 feet of concrete.

Payoffs. Hypersonic weapons can be air- or surface-launched and can be used to effectively and efficiently destroy time-critical targets such as mobile missile launchers and mobile command and control posts; heavily defended targets such as C^3 nodes, leadership sites, and strategic surface-to-air missile and theater ballistic missile sites; and hardened targets such as aircraft shelters, weapons of mass destruction facilities, and deeply buried targets. The technologies developed and demonstrated in this DTO will allow for initiation of acquisition activities for affordable hypersonic strike weapon(s).

Challenges. The major technology challenges of this DTO involve developing high aerodynamic efficiency airframes capable of carrying large payloads at long ranges that are compatible with both Vertical Launch System (VLS) and aircraft carry. The propulsion challenges involve developing and demonstrating high-specific impulse engines for long range with high thrust for high speed and capable of being throttled but allowing continuous thrust for terminal maneuvers. For ordnance, the significant challenges are development of a warhead/case structure capable of surviving Mach 4+ ground penetrations and alternatively demonstrating submunition deployment at speeds greater than Mach 4. Guidance and control challenges include identifying and demonstrating thermal mitigation techniques for IR/RF windows and domes, low-drag control systems, and affordable RF/IR terminal seekers capable of operation in a high-thermal environment.

Milestones/Metrics.

FY1999: Complete direct connect tests of a dual-combustion ramjet engine.

FY2000: Demonstrate Mach 4 penetrator capability.

FY2001: Conduct free jet test of axisymetric dual-combustion ramjet engine configuration.

FY2002: Demonstrate Mach 6 penetrator warhead design.

FY2003: Demonstrate G&C thermal mitigation techniques; conduct free jet test of dual-combustion ramjet integrated with advanced blended body airframe configuration.

Customer POC		Service/Agency POC	USD(A&T) POC
CAPT Dennis Army, USN	CAPT Robert Taylor, USN	Mr. David Siegel	Dr. C. W. Kitchens, Jr.
N864	N88	ONR	DDR&E(WT)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602111N		1.9	3.0	3.0	2.8	2.0	1.5
0603217N	R0447	0	1.7	5.6	7.7	7.3	7.2
	Total	**1.9**	**4.7**	**8.6**	**10.5**	**9.3**	**8.7**

WE.60.09 High-Power Microwaves for Suppression of Enemy Air Defense

Objectives. Develop, demonstrate, and transition high-power microwave (HPM) technology to disrupt, degrade, and destroy electronic components of an adversary's integrated air defense system (IADS). A two-phase program of technology development and susceptibility and effects testing is underway. Phase I will develop and demonstrate explosively driven HPM warhead technology and measure the effects of HPM impulses on IADS subsystems. The warhead technology will be sized to fit within several candidate weapons. The second phase will develop and demonstrate a repetitively pulsed HPM weapon sized to fit a powered weapons platform such as a missile or unmanned combat air vehicle (UCAV). Since the Phase II device will not be explosively powered, multiple targets separated by distance can be attacked, depending on the ability of the platform to survive and engage multiple targets with the HPM weapon. Specific performance objectives are classified.

Payoffs. This technology will increase effectiveness of suppression of enemy air defense (SEAD) missions by enabling attack of mission-critical IADS components at reduced cost over conventional weapons. Phase I technology will be used to attack IADS electronics and other electronic systems with little or no collateral damage over areas larger than realizable with conventional munitions. The Phase II technology will enable sequential attack of multiple targets, limited by the range and survivability of the delivery platform, not by weapons carriage constraints. The Phase II HPM weapon will not damage people or buildings. If the platform is recoverable (e.g., UCAV), the capital and operational cost is expected to be far less than conventional munition solutions. A reduced logistics train will support recoverable HPM systems, and less base security and infrastructure will be necessary since munitions storage will not be required.

Challenges. The principal challenge for Phase I is design and packaging of a conformal antenna, which manages radiated power while avoiding atmospheric breakdown. Additional challenges in source technology are to increase single-pulse output energy and to energize with explosive pulsed power. The Phase II challenge is to develop efficient, repetitively pulsed HPM sources with high-average-power handling capability. Generic challenges for both phases include increased quantitative understanding of HPM effects on targets and validation of concepts for HPM battle damage assessment.

Milestones/Metrics.

FY1998: Complete Phase I source and pulsed power development; increase source pulse energy by 3X; demonstrate flux compression generator and pulse conditioning.

FY1999: Complete critical experiment of Phase I technology; demonstrate explosively driven HPM source; source pulse energy increased by 2X.

FY2000: Complete Phase I antenna development; radiate entire pulse without breakdown.

FY2001: Complete Phase I technology integration; demonstrate Phase I HPM warhead system (proposed ATD); complete Phase II source technology development; demonstrate multipulse burst.

FY2003: Conduct Phase II HPM weapon system technology demonstration.

Customer POC	Service/Agency POC	USD(A&T) POC
Maj Tim Parmer, USAF	Mr. Michael Flynn	Dr. C. W. Kitchens, Jr.
ACC/DRPW	SAF/AQRT	DDR&E(WT)

Programmed Funding ($ millions)

PE	Project	FY98	FY99	FY00	FY01	FY02	FY03
0602601F	5797	1.0	2.0	1.8	1.7	2.8	2.9
0603605F	3152	3.5	3.4	3.1	3.6	3.6	3.7
	Total	**4.5**	**5.4**	**4.9**	**5.3**	**6.4**	**6.6**

APPENDIX A

POINTS OF CONTACT

APPENDIX A

POINTS OF CONTACT

A

ABRAHAM, Dr. Phillip B.
Office of Naval Research
800 N. Quincy St
Arlington, VA 22217
(703) 696-4307; DSN: 426-4307
Fax: (703) 696-6887
abrahaph@onrhq.onr.navy.mil
JR&L/SSS

ADAMS, Mr. W.
ATSE-CD
(573) 596-7955; Fax: (573) 596-4089
Materials/Processes

AHN, Mr. Byong
Army Night Vision & Electronic
Sensors Directorate
555 Technology Square
Attn: Mail Stop 03
Cambridge, MA 02139
Materials/Processes

ALEXANDER, Dr. Allen
PEO Air and Missile Defense
Materials/Processes

ALLEN, Mr. William
Naval Sea Systems Command
PEO (TAD)
Arlington, VA 22202
(703) 602-7740 x408
Fax: (703) 602-2400
allen_william@hq.navsea.navy.mil
Weapons

ANDERSON, Mr. Bob
NAVSEA
Materials/Processes

ANDERSON, Capt Bruce
SAF/ST
Materials/Processes

ANDERSON, Mr. Edmund
PEO(CU)
(703) 604-0886
Precision Force; Sensors, Elec & BS Environment

ANDERSON, Mr. Les C.
Space & Naval Warfare Systems Center
53140 Systems St, Rm 129, Code D411
San Diego, CA 92152
(619) 553-4139; DSN: 553-4139
Fax: (619) 553-6405
les@nosc.mil
Info Systems Tech

ANDERSON, Mr. Todd
Program Manager, Office of Special
Technology
10530 Riverview Rd, Bldg 3
Ft. Washington, MD 20744
(301) 203-2642; Fax: (301) 203-2641
anderson@specialtech.com
Combating Terrorism

ANDREWS, Dr. Dee
Air Force Research Laboratory/HEA
6001 S. Power Rd, Bldg 561
Mesa, AZ 85206
(602) 988-6561; DSN: 474-6561
Fax: (602) 988-6561
andrews@alhra.af.mil
Human Systems

APPEL Mr. John
Office of the Assistant Secretary of the
Army for Research, Development &
Acquisition, Attn: SARD-TT
Pentagon, Rm 3E486
Washington, DC 20310
(703) 601-1537; DSN: 329-1537
appelj@sarda.army,mil
Force Projection/Dominant Maneuver

ARMY, CAPT Dennis
Chief of Naval Operations, N864
2000 Navy Pentagon
Washington, DC 20350
(703) 604-7667; DSN: 664-7667
Fax: (703) 604-1919
Weapons

ARTHUR, LTC John
US Atlantic Command J–34T
1562 Mitscher Ave
Norfolk, VA 23551
(757) 836-7857; DSN: 836-7857
Fax: (757) 836-0203
arthur@acom.mil
Combat ID

ASHTON, CAPT Stuart
USN Aircrew Systems Program
Naval Air Systems Command
47123 Buse Rd
Patuxent River, MD 20670
(301) 757-6991; DSN: 757-6991
Fax: (301) 757-6995
ashtonsa.ntrprs@navair.navy.mil
Biomedical; Human Systems;
Materials/Processes

AVRIT, Maj Jim
Chief, C^2 Warfare Requirements
HQ Air Combat Command/DRAS
204 Dodd Blvd, Ste 226
Langley AFB, VA 23665
(757) 764-6219; DSN: 574-6219
Fax: (757) 764-3596
avritj@hqaccdr.langley.af.mil
Elec Combat

B

BAHR, Mr. Walter
PMA-231
Sensors, Elec & BS Environment

BAIR, Mr. Edward
PEO-IEW
Attn: SFAE-IEW-&S-D
Ft. Monmouth, NJ 07703
(732) 532-0179; DSN: 987-0179
Fax: (732) 427-4167
Weapons

BARRINGER, Mr. Garry
USAF Space Command & Control
Agency
130 Andrews St, Ste 216
Langley AFB, VA 23665
(757) 764-4826; DSN: 574-4826
Fax: (757) 764-4101
gary.barringer@langley.af.mil
Info Systems Tech

BARRY, CAPT John
Chief of Naval Operations, Code N863E
2000 Navy Pentagon
Washington, DC 20350
(703) 697-1465; Fax: (703) 614-9073
barry.john@hq.navy.mil
Sensors, Elec & BS Environment;
Weapons

BASANY, Ms. Karen
SMC
(310) 363-0217
Sensors, Elec & BS Environment

BAUMAN, Mr. Dennis
Space & Naval Warfare Systems Center
San Diego, Code PD16, OT-1
4301 Pacific Highway, Rm 1003
San Diego, CA 92110
(619) 553-7253: DSN: 553-7253
Fax: (619) 553-7514
bauman@spawar.navy.mil
Info Systems Tech

BEARY, CDR William
PHIBCB-2
1815 Seebee Dr
Norfolk, VA 23521
(757) 464-7364; Fax: (757) 363-4122
JR&L/SSS

BEASLEY, CAPT Drew W.
Program Manager, Joint Simulation System Joint Program Office
12249 Science Dr, Ste 260
Orlando, FL 32826
(407) 384-5502: DSN: 970-5502
Fax: (407) 384-5599
beasleyd@jsims.mil
Info Systems Tech; JR&L/SSS

BEATON, Mr. Robert
Defense Advanced Research Projects Agency /Information Systems Office
3701 N. Fairfax Dr
Arlington, VA 22203
(703) 696-1122; DSN 426-1122
Fax: (703) 696-2203
rbeaton@darpa.mil
Info Superiority

BEAUCHEMIN, COL Richard
Office of the Assistant Secretary of Defense, Health Services Operation and Readiness (Health Affairs)
1200 Defense Pentagon, Rm 3E279
Washington, DC 20301
(703) 614-4157; DSN: 224-4157
Fax: (703) 693-2390
rbeauche@ha.osd.mil
Biomedical

BECKER, Mr. Eric
Air Force Research Laboratory/MLBC
Materials/Processes

BEERMANN-CURTIN, Ms. Sharon
Office of Naval Research
800 N. Quincy St
Arlington, VA 22217
(703) 696-0869; DSN 426-0869
Fax: (703) 696-6887
beermas@onr.navy.mil
Weapons

BELEN, Mr. Fred
Office of Naval Research
800 N. Quincy St
Arlington, VA 22217
(703) 696-1219; DSN: 426-1219
Fax: (703) 696-3731
belenf@onr.navy.mil
Force Projection/Dominant Maneuver

BESSLER, COL James
Director, USA Training and Doctrine Command, Program Inegration Office-Army Battle Command Systems
415 Sherman Ave
Ft. Leavenworth, KS 66027
(913) 684-4533; DSN: 552-4533
Fax: (913) 684-4538
besslej1@leav-emh1.army.mil
Info Systems Tech

BETSON, COL Williams
Training Development, USA Training and Doctrine Command
Bldg 1109, 6th Ave
Ft. Knox, KY 40121
(502) 624-8247; DSN: 464-8247
Fax: (502) 624-4133
betson@ftknox-dtdd-emh5.army.mil
Human Systems

BIANCA, LtCol Damina
PM, Follow-On to TOW
USA Missile Command
Redstone Arsenal, AL 35898
(205) 876-4700; DSN: 746-4700
Weapons

BIENHOFF, CDR Paul
Chief of Naval Operations (N873)
2000 Navy Pentagon
Washington, DC 20350
(703) 604-7846; Fax: (703) 604-7826
bienhoff.paul@hq.navy.mil
Ground & Sea Vehicles

BILLINGS, Mr. Robert
USAF Aeronautical Systems Center/ENFC
2530 Loop Rd, W.
Wright-Patterson AFB, OH 45433
(937) 255-8608; DSN: 785-8608
Fax: (937) 785-8063
billinr@asc-en.wpafb.af.mil
Human Systems

BLACK, Dr. Barbara
Army Research Institute, AFRU
Ft. Knox, KY 40121
(502) 624-3450; DSN: 464-3450
Fax: (502) 624-8113
black@ftknoxari-emh15.army.mil
Human Systems

BLAIR, LtCol John E.
Head, Training & Education Support Branch, Marine Corps Development Center
2008 Elliott Rd
Quantico, VA 22134
(703) 784-3714; DSN: 278-3714
Fax: (703) 784-3830
blairj@quantico.usmc.mil
Info Systems Tech

BLITCH, Maj John
HQ US Special Operations Command
7701 Tampa Point Blvd
MacDill AFB, FL 33621
(813) 828-4189 x2219
Air Platforms; Ground & Sea Vehicles

BLOHM, Mr. Gary
USA Communications-Electronics Command
Ft. Monmouth, NJ 07703
(732) 427-4277; DSN: 987-4277
Fax: (732) 427-2822
blohm@doim6.monmouth.army.mil
Info Systems Tech

BLUMBERG, Dr. William
Air Force Research Laboratory
29 Randolph Rd
Hanscom AFB, MA 01731
(781) 377-2951; DSN: 478-2951
Fax: (781) 377-8781
blumberg@plh.af.mil
Sensors, Elec & BS Environment

BONAIUTO, Mr. Joseph
APEO (CU)
(703) 604-4110 x5841
Air Platforms

BONSER, Mr. Wayne
Air Force Research Laboratory
Code IFGC, 525 Brooks Rd
Rome, NY 13441
(315) 330-3829; DSN: 587-3829
Fax: (315) 330-4206
bonserw@rl.af.mil
Info Systems Tech

BOOEN, Col Mike
Space & Missile Systems Center/TM (Airborne Laser System Project Office)
3300 Target Rd, Bldg 760
Kirtland AFB, NM 87117
(505) 846-2102; Fax: (505) 853-3770
booenm@plk.af.mil
Joint TMD

BORTHWICK, Mr. Jesse
AFDTC/EMX
DSN: 872-6397
Materials/Processes

BOSCO, Dr. Sal
Deputy Assistant to the Security of Defense for Counterproliferation and Chemical/Biological Defense
3050 Pentagon
Washington, DC 20301
(703) 604-1924; DSN: 225-1924
Fax: (703) 607-1243
boscosr@acq.osd.mil
CB Defense & Nuclear; CB Warfare/Counter WMD

BOSSE, COL Timothy G.
Deputy Director, USA Dismounted Battlespace Battle Lab, HQ Infantry Center, Rm 351
Ft. Benning, GA 31905
(706) 545-2489; DSN: 835-2489
Fax: (706) 545-3841
bosset@benning-emh2.army.mil
Human Systems; Info Superiority Info Systems Tech; Force Projection/ Dominant Maneuver; MOUT

BOWER, Mr. Joe
Air Maneuver Battle Lab
Precision Force

BOWMAN, Maj Charles
Chief, Air-to-Surface Weapons Branch,
Hq Air Combat Command/DRPW
204 Dodd Blvd
Langley AFB, VA 23655
(757) 764-7067; DSN: 574-7067
Fax (757) 764-5124
charles.bowman@langley.af.mil
Precision Force

BOYD, CDR Robert
Program Manager for Electronic
Warfare Office of Naval Research
800 N. Quincy St
Arlington, VA 22217
(703) 696-0561; DSN: 426-0561
Fax: (703) 696-1331
boydr@onr.navy.mil
Elec Combat; Weapons

BOYD, Mr. Robert
Director Defense Research and
Engineering, Director for Environmental
& Life Science
3080 Defense Pentagon, Rm 3D129
Washington, DC 20301
(703) 697-8535; (703) 693-7042
boyddrl@acq.osd.mil
Materials/Processes

BRANDLER, Mr. Phillip
Director, USA Natick RD&E Center
Natick, MA 01760
(508) 233-4700; DSN: 256-4700
Fax: (508) 233-5061
pbrandle@natick-emh2.army.mil
Human Systems; Materials/Processes

BRAUN, Maj Robert W.
Air Combat Command/DRAO
20 Dodd Blvd, Ste 226
Langley AFB, VA 23655
(804) 764-7067; DSN: 574-7067
Fax: (804) 574-3596
Braun@HQACCDr.langley.af.mil
Human Systems

BRINKLEY, Mr. James
Director, Crew Systems
Air Force Research Laboratory/CF
Crew Systems Directorate
2610 Seventh St, Bldg 441
Wright-Patterson AFB, OH 45433
(937) 255-5227; DSN: 785-5227
Fax: (937) 656-7617
jbrinkley@falcon.al.wpafb.af.mil
Human Systems; JR&L/SSS; Biomedical

BRINSON, Mr. Aaron D.
Air Force Research Laboratory/MNM
101 West Eglin Blvd, Ste 135
Eglin AFB, FL 32542
(850) 882-2200; DSN: 872-2800
Fax: (850) 882-4792
brinson@eglin.af.mil
Precision Force

BROEMMEL, Maj Brad
Air Force Space Command
Plans and Programs Division
150 Vandenberg St, Ste 1105
Peterson AFB, CO 80914
(719) 554-5928; DSN: 692-5928
Fax: (719) 554-6848
bbroemme@spacecom.af.mil
Space Platforms

BROUGHTON, CAPT Hubert
Head, Mine Warfare EOP Branch
Department of the Navy, N852
2000 Navy Pentagon, Rm 5E613
Washington, DC 20350
(703) 697-0044; DSN: 664-0044
Fax: (703) 697-3808
Force Projection/Dominant Maneuver; Weapons

BROWER, Mr. Bill
Office of the Assistant Secretary of the
Army for Research, Development &
Acquisition, Attn: SARD/TT
103 Army Pentagon, Rm 3E480
Washington, DC 20310
(703) 697-8432; Fax: (703) 695-3600
browerw@sarda.army.mil
CB Defense & Nuclear

BROWN, Mr. Dick
Program Office for Army Battle
Command Support/TPIO
PO Box 3318
Ft. Leavenworth, KS 66027
(913) 684-3137; DSN: 552-3137
Fax: (913) 552-4516
brown@leav-emh1.army.mil
Human Systems

BROWN, Mr. Richard
Director, Missile Defense & Space
Technology, SMDC-TC-WC
PO Box 1500:
Huntsville, AL 35807
(205) 955-3806; DSN: 645-3806
Fax: (205) 955-5959
brownr@smdc.army.mil
Materials/Processes

BROWN, Mr. Randall
HMST Program Manager
Air Force Research Laboratory/HE
2255 H St, Bldg 248
Wright-Patterson AFB, OH 45433
(937) 255-8895; DSN: 785-8895
Fax: (937) 255-8145
rbrown@al.wpafb.af.mil
Human Systems

BRYCE, Mr. Doug
Marine Corps Systems Command
(CSSLE)
2033 Bennett Ave, Ste 315
Quantico, VA 22134
(703) 784-5898; DSN: 278-5898
Fax: (703) 784-5899
bryced@mqg-smtp3.usmc.mil
CB Defense & Nuclear

BUCHHOLTZ, Col Gale R.
Chief, Plans, Policy & Programs Div,
Security Forces, Headquarters,
USAF/SFX (Plans, Policy & Programs)
1340 Air Force Pentagon
Washington, DC 20330
(703) 588-0021; DSN: 425-0021
Fax: (703) 588-0003
Weapons

BUDGE, Larry D.
Program Manager for STOW
Defense Advanced Research Projects
Agency/Information Systems Office
3701 N. Fairfax Dr
Arlington, VA 22203
(703) 696-2298, Fax: (703) 696-2203
lbudge@darpa.mil
JR&L/SSS

BUDREAU, A.
ESC/AWO
Sensors, Elec & BS Environment

BUHRMANN, Mr. Gilbert
Program Manager
Office of Special Technology
10530 Riverview Rd, Bldg 3, Code 60
Ft. Washington, MD 20744
(301) 203-2670; Fax: (301) 203-2641
gbuhrman@ostgate.com
Combating Terrorism

BULEY, LTC Don
Joint Project Office-Biological Defense
5201 Leesburg Pike Skyline #3 Ste 1200
Falls Church VA 22041
(703) 681-3468; DSN 761-3468
Fax: (703) 681-3454
buleyd@jpobd.osd.mil
CB Warfare/Counter WMD

BULLOCK, Lt Col Dave
Air Force Research Laboratory/MATS
Wright-Patterson AFB, OH 45433
(937) 255-2223; DSN: 785-2223
Weapons

BURCH, LTC James
US European Command, Joint
Reconnaissance Center
Unit 20400, Box 1000, APO-AE 09128
011-49-711-680-4192
DSN: (314) 430-4192
Fax: 011-49-711-680-4574
burch@hq.eucom.mil
Info Superiority

BUSBEE, Mr. Walt
Deputy Assistant to the Secretary of Defense (CP/CBD)
3050 Defense, Pentagon 3C126
Washington, DC 20301
(703) 693-9410; DSN: 225-9410
Fax: (703) 697-2199
busbeewl@acq.osd.mil
CB Defense & Nuclear

BUSS, Mr. Jim
Office of Naval Research
800 N. Quincy St
Arlington, VA 22217
DSN: 426-0590
Sensors, Elec & BS Environment

BUTRYN, CDR Kenneth
HQ Department of the Navy/N853
2080 Pentagon
Washington DC 20350
(703) 697-1462; DSN 227-1462
Fax: (703) 697-3808
butryn.kenneth@hq.navy.mil
JR&L/SSS; Materials/Processes

BYARS, Mr. C. Rocky
Joint STARS Joint Program Office
Warner Robins Air Logistics Center
Chief, AF Joint STARS Depot Supp
Div, 460 Second St, Ste 221
Robins AFB, GA 31098
(912) 327-2863; DSN: 497-2863
Fax: (912) 327-2854
byarsc@jslks.robins.af.mil
Info Systems Tech

BYRNE, Mr. Joseph A.
Director, Office of Shipyard
Revitalization, MAR 750
400 7th St, SW
Washington, DC 20590
(202) 366-1931; Fax: (202) 366-7197
joseph.byrne@marad.dot.gov
JR&L/SSS

C

CABEL, CDR Christopher
Chief of Naval Operations/N864D2
2000 Navy Pentagon
Washington, DC 20350
(703) 604-7671; Fax: (703) 604-1917
cabel.christopher@hq.navy.mil
Ground & Sea Vehicles

CALDWELL, COL John
TRADOC Systems Manager, Antitank Missiles, USA Infantry Center/ATZB-FS
Bldg 4, Rm 624
Ft. Benning, GA 31905
(706) 545-5510; DSN: 835-3911
Fax: (706) 545-7933
caldwellj@benning-emh2.army.mil
Force Projection/Dominant Maneuver

CALE, Mr. David B.
Aviation Applied Technology Directorate, AMSAM-AR-P-P
Ft. Eustis, VA 23604
(757) 878-2771; DSN: 927-2771
Fax: (757) 878-0007
Air Platforms

CANNON-BOWERS, Dr. Jan
NAWCTSD 4961
12350 Research Parkway
Orlando, FL 32826
(407) 380-4840; DSN: 960-4840
Fax: (407) 381-8738
janis_cannon-bowers@ntsc.navy.mil
Human Systems

CARAVELLO, Col Chris
USAF Aeronautical Systems Center/VX
102 West D Ave, Ste 300
Eglin AFB, FL 32542
(850) 882-4242; DSN: 872-4242
Fax: (850) 882-3039
carabell@eglin.af.mil
Precision Force

CARDINAL, COL Chuck
US Pacific Command, J-36
USCINCPAC/J39, Box 64013
Rm 216, Bldg 32, Elrod Rd
Camp H.M. Smith, HI 96861
(808) 477-3931; DSN: 477-1611
Fax: (808) 477-2851
Force Projection/Dominant Maneuver

CARLISLE, Mr. George
DAIM-ED-C
(703) 693-0551
Materials/Processes

CARROLL, CPT Jon
USA Infantry Center
Ft. Benning, GA 31905
(706) 545-4138; DSN: 835-4138
Fax: (706) 545-2517
carrollj@benning-emh2.army.mil
CB Defense & Nuclear

CATALDO, Mr. Paul
NAVOP N4
Materials/Processes

CELEC, Mr. Fred
Assistant to the Secretary of Defense for Nuclear, Chemical and Biological
3050 Defense, Pentagon, Rm 3C125
Washington, DC 20301
(703) 697-3060; Fax: (703) 697-2199
celec@hq.dswa.mil
CB Defense & Nuclear

CHAMBERS, Mr. Gregory
Maneuver Imperative Manager
Marine Corps Warfare and Tech Directorate
2033 Barnett Ave, Ste 315
Quantico, VA 22314
(703) 784-2761; DSN: 278-2761
Fax: (703) 784-2764
chambersg@quantico.usmc.mil
Force Projection/Dominant Maneuver

CHAMBERS, LTC James E.
Deputy Group Commander
7th Transportation Group
Ft. Eustis, VA 23604
(757) 878-3444; DSN 927-3444
Fax: (703) 878-4889
chambersj@eustis-emh10.army.mil
JR&L/SSS

CHAPA, Maj Joseph
Electronic Systems Center, AWACS
Hanscom AFB, MA 01731
(617) 377-1249; DSN: 478-1249
Fax: (617) 377-1069
chapaj@hanscom.af.mil
Info Systems Tech

CHARNICK, Mr. Brian
USA Communications-Electronics Command
Ft. Monmouth, NJ 07703
(732) 427-2024; DSN: 987-2024
Fax: (732) 532-6811
charnick@doim6.monmouth.army.mil
Info Systems Tech

CHAVIS, Mr. Al
Air Combat Command
DSN: 574-9339
Materials/Processes

CHEW, Mr. James S.
Program Manager for Weapons Technology, Office of Naval Research
800 N. Quincy St
Arlington, VA 22217
(703) 588-0703; DSN: 426-0703
Fax: (703) 696-4274
chewj@onr.navy.mil
JR&L/SSS; Precision Force

CHILDERS, Mr. Carroll
Branch Head, Marine Corps Systems Command, Amphibious Warfare Technology
2033 Barnett Ave, Ste 315
Quantico, VA 22134
(703) 784-2220; DSN: 278-2220
Fax: (703) 784-2764
childersc@quantico.usmc.mil
Info Systems Tech; JR&L/SSS

CHILDS, CDR Robert
Ballistic Missile Defense Organization/TOS (Surveillance & Interceptor Technology Directorate)
1725 Jefferson Davis Hwy, Ste 809
Arlington, VA 22202
(703) 604-3139; Fax: (703) 604-3926
robert.childs@bmdo.osd.mil
Sensors, Elec & BS Environment; Joint TMD

CHOATE, Lt Col Timothy
USAF Aeronautical Systems Center/XRT
2275 D St, Ste 10
Wright-Patterson AFB, OH 45433
(937) 255-2172; Fax: (937) 656-7889
choatetj@xr.wpafb.af.mil
Human Systems

CHOU, Dr. S. C.
Army Research Laboratory
Materials/Processes

CHRISTIANSON, Charles
Program Executive Office/Intelligence & Electronic Warfare
Ft. Monmouth, NJ 07703
(732) 532-0181; Fax: (732) 427-6189
christia@doim6.monmouth.army.mil
Sensors, Elec & BS Environment

CHU, Dr. David S. C.
RAND Corporation
1333 H St, NW
Washington, DC 20005
(202) 296-5000
Materials/Processes

CILLI, Mr. Matthew
USA TACOM Armament Research, Development and Engineering Center
Bldg 94
Picatinny Arsenal, NJ 07806
(973) 724-6655; DSN: 880-6655
Force Projection/Dominant Maneuver

CIRONE, Dr. Salvatore M.
Office of the Assistant Secretary of Defense, Health Affairs (Clinical Services)
1200 Defense Pentagon, Rm 3D366
Washington, DC 20301
(703) 695-7116; DSN: 225-7116
Fax: (703) 693-2548
scirone@ha.osd.mil
Biomedical

CLARK, Bill
Chief, Terrain Data Generation Branch
USA Topographic Engineering Center
7701 Telegraph Rd
Alexandria, VA 22315
(703) 428-6802; Fax: (703) 428-6425
Sensors, Elec & BS Environment

CLARK, CAPT Bob
Chief of Naval Operations N961
US Naval Observatory, Bldg 1
3450 Massachusetts Ave, NW
Washington, DC 20392
(202) 762-1002; Fax: (202) 762-1043
961@ocean.usno.navy.mil
Sensors, Elec & BS Environment

CLARK, LtCol Mike
Surface Warfare, Land Attack Warfare Branch (N864J)
Chief of Naval Operations
2000 Navy Pentagon
Washington, DC 20350
(703) 604-7662
Precision Force

CLARK, BG
USA Training and Doctrine Command
Ft. Monroe, VA 23651
(757) 727-2029; DSN: 680-3094
clarkr@emh10.monroe.army.mil
MOUT

CMARE-MASCIS, Ms. Noreen
Army Research Laboratory/VTC
Materials/Processes

COBLE, LtCol H. J.
Joint Staff, J7 #JETD
Pentagon, Rm 2B857
Washington, DC 20318
(703) 695-3026; DSN: 225-3026
Fax: (703) 693-4581
coblehj@js.pentagon.mil
JR&L/SSS

COCHRAN, Mr. Ronald
Office of Special Technology
10530 Riverview Rd, Bldg 3, Code 60
Ft. Washington, MD 20744
(301) 203-2638; Fax: (301) 203-2641
cochranr@specialtech.com
Combating Terrorism

COFFMAN, Col Sam
Depth and Simultaneous Attack Battle Lab, USA Army Field Artillery School, ATSF-CBL
Ft. Sill, OK 73503
(405) 442-3706/-6954; DSN: 639-6954
Fax (405) 442-5028
coffmans@doimexi.sill.army.mil
Precision Force

COGAN, Ms. Mariellen
HQ Joint Strike Fighter/PO
Pentagon
Washington, DC 20301
(703) 602-7390 x6690
coganm@jast.mil
Human Systems

CONNER, Ms. Margaret T.
Office of Naval Research
800 N. Quincy St, Code 35
Arlington, VA 22217
(703) 696-1575; DSN: 226-1575
Fax: (703) 696-3731
connerp@onr.navy.mil
Force Projection/Dominant Maneuver

CONNORS, Mr. Jay
Army Research Laboratory
Materials/Processes

CONVERSE, CMSGT James
AW Combat Command/LGMS
JR&L/SSS

CORBETTE, CAPT T.
CO PWC San Diego
(619) 556-2199; Fax: (619) 556-2184
Materials/Processes

CORDELL, Mr. Tobey
Air Force Research Laboratory/MLLP
(513) 255-9802
Materials/Processes

CORNELL, COL Charles O.
Chief, Global Distribution Group, National Reconnaissance Office
14675 Lee Rd
Chantilly, VA 20151
(703) 808-3402; DSN: 898-3402
Fax: (703) 808-3483
Info Systems Tech

CORRELL, Maj Randy
AFSPC/XPXT
150 Vandenberg St, Ste 1105
Peterson AFB, CO 80914
(719) 554-5039; DSN: 692-5039
Fax: (719) 554-5119
rcorrell@spacecom.af.mil
Space Platforms

COTHRAN, Mr. Julian L.
USA Missile Command
Missile Research, Development and Engineering Center
Redstone Arsenal, AL 35898
(205) 876-7424 x1687; DSN: 746-7424
Fax: (205) 876-1687
Precision Force

COWAN, RADM Michael
Joint Chiefs of Staff, J-4, JCS/J-4
4000 Joint Staff Pentagon, Rm 2E825
Washington, DC 20318
(703) 697-4346; DSN: 227-4346
Fax: (703) 697-0510
cowan@js.pentagon.mil
Biomedical

CRAIG, Mr. Jeff
Air Force Research Laboratory/HE
2255 H St, Rm 300
Wright-Patterson AFB, OH 45433
(937) 255-7592; DSN: 785-7592
Fax: (937) 785-8366
jcraig@al.wpafb.af.mil
Human Systems

CRANOS, Mr. Roger
Air Force Research Laboratory/SN
(937) 255-1108 x4060; DSN: 785-1108
Fax: (937) 656-4339
cranosrl@aa.wpafb.af.mil
Combat ID

CRISSEY, Capt James
Program Manager, Satellite Control Upgrades, Space & Missile Sys Center
Los Angeles AFB,
El Segundo, CA 90245
(310) 363-1867; DSN: 833-1867
Fax: (310) 363-3121
crissejm@slcspo.laafb.af.mil
Info Systems Tech

CRISTADORO, Mr. Franco
San Antonio Air Logistics Center, Nuclear Weapons Directorate/NWTE
413 N. Lake Drive
Kelly AFB, TX
(210) 925-9635; Fax: (210) 925-1999
CB Defense & Nuclear

CRONIN, Ms. Tracy
Program Manager
Office of Special Technology
10530 Riverview Rd, Bldg 3, Code 60
Ft. Washington, MD 20744
(301) 203-2719; Fax: (301) 203-2641
cronint@specialtech.com
Combating Terrorism

CROWE, Dr. Robert
Defense Advanced Research Projects Agency/Defense Sciences Office
3701 N. Fairfax Dr
Arlington, VA 22203
Materials/Processes

CULBRETH, CMSgt Steve
HQ Air Combat Command/DRSL
204 Dodd Blvd, Ste 226
Langley AFB, VA 23665
(757) 764-5892/-6099
DSN: 574-5892/-6099
Fax: (757) 574-6211
culbrets@hqaccdr.langley.af.mil
Human Systems

CULLEN, Mr. Richard
US Space Command
250 South Peterson Blvd, Ste 116
Peterson AFB, CO 80914
(719) 554-5714; DSN: 692-5714
Fax: (719) 554-9122
rcullen@spacecom.af.mil
CB Defense & Nuclear

CULLINANE, Dr. M. J.
CEWES
(601) 634-3723
Materials/Processes

CUNDIFF, Mr. Daniel
Director Defense Research and Engineering (LM/TT)
3080 Defense Pentagon, Rm 3D367
Washington, DC 20301
(703) 614-0205; Fax: (703) 695-0123
dcundiff@acq.osd.mil
Materials/Processes

CUNNINGHAM, Ms. Deirdre
PEO C^3 Systems
Horizontal Technology Integration Office
Ft. Monmouth, NJ 07703
(732) 427-2253; DSN: 987-2253
Fax: (732) 542-1364
cunningd@doim6.monmouth.army.mil
Info Superiority

CURLING, LTC Carl
HQ Department of the Army (DASG-HCO)
5109 Leesburg Pike, Rm 691
Falls Church, VA 22041
(703) 681-8185; DSN: 761-8185
Fax: (703) 681-4971
ltc_carl_curling@otsg-amedd.army.mil
Biomedical

CURTIN, Dr. Tom
Office of Naval Research
800 N. Quincy St
Arlington, VA 22217
DSN: 426-4119
Sensors, Elec & BS Environment

D

DALLAS, Andrew
Deputy PM for MARITECH
Defense Advanced Research Project Agency, Tactical Technology Office
3701 N. Fairfax Dr
Arlington, VA 22203
(703) 696-6015; Fax: (703) 696-8401
dallas@bsl.prc.com
JR&L/SSS

DALY, Dr. Judith A.
Assistant Deputy Undersecretary of Defense/AD
3700 Defense Pentagon
Washington, DC 20301
(703) 614-8436; DSN 224-8436
Fax: (703) 693-0145
dalyja@acq.osd.mil
JR&L/SSS; CB Warfare/Counter WMD; Info Superiority; Precision Force

DANIELSON, Col Jesse M.
Director, Directorate of Combat Development, US Army Aviation Center, ATZQ-CD
Bldg 515, Ave K
Ft. Rucker, AL 36362
(334) 255-3203; DSN: 558-3203
Precision Force

DARBY, CDR Mike
J4 Plans & Policy Division
US Atlantic Command/USACO/JY
(757) 322-5185
darbym@acom.mil
JR&L/SSS

DAS, Dr. Alok
Phillips Lab/VTS
Materials/Processes

DAVID, Mr. Brian J.
Joint Project Office Biological Defense
5201 Leesburg Pike
Skyline #3, Ste 1200
Falls Church, VA 22041
(703) 681-9602; DSN: 761-9602
Fax: (703) 681-3454
davidb@jpobd.osd.mil
CB Warfare/Counter WMD

DAVID, Mr. Jeffrey
National Program Manager
Office of Special Technology
Technical Support Working Group
10530 Riverview Rd, Bldg #3
Ft. Washington, MD 20744
(301) 203-2635; Fax: (301) 203-2641
davidj@specialtech.com
Combating Terrorism

DAVIS, Dr. Curt
Naval Research Laboratory
4555 Overlook Ave, SW
Washington, DC 20375
Sensors, Elec & BS Environment

DAVIS, Mr. Doug
Marine Corps Systems Command (CSSLE)
2033 Barnett Ave, Ste 315
Quantico, VA 22134
(703) 784-4278; DSN: 278-4278
Fax: (703) 784-4287
davisd@quantico.usmc.mil
Human Systems

DAVIS, Dr. Mark E.
Defense Advanced Research Projects Agency /Sensor Technology Office
3701 N. Fairfax Dr
Arlington, VA 22203
(703) 696-7445; DSN: 426-7445
Fax: (703) 696-2203
mdavis@darpa.mil
Info Superiority

DAVIS, Mr. Van
Air Combat Command/DRPW
20 Dodd Blvd
Langley AFB, VA 23655
(757) 764-7066; DSN: 574-7066
Weapons

DEADERICK, COL Robert
AMEDD C&S
2250 Stanley Rd, Ste 322
Ft. Sam, Houston, TX 78234
(210) 221-8600; DSN: 471-8600
Fax: (210) 221-8894
col_robert_deaderick@smtplink.medcom.amedd.army.mil
Biomedical

DEATON, Mr. Bill
CVX
(703) 418-4164
Materials/Processes

DEBUSK, COL Robert F. III
Chief, Reconnaissance and Surveillance Division
Hq Air Combat Command/DRR
204 Dodd Blvd, Ste 226
Langley AFB, VA 23665
(757) 764-6440; DSN: 574-7442
Fax: (757) 764-4143
r.debusk@langley.af.mil
Sensors, Elec & BS Environment; Force Projection/Dominant Maneuver

DEGEORGE, Mr. Drew O.
IHPRPT Air Force Coordinator, Air Force Research Lab/Propulsion Directorate, Rocket Propulsion Division
5 Pollux Dr, Ste 230
Edwards AFB, CA 93524
(805) 275-5713; Fax: (805) 275-5852
drew_degeorge@ple.af.mil
JR&L/SSS

DEL COLLO , Mr. Andy
NAVFAC 15R
(703) 325-8533; Fax: (703) 325-0253
Materials/Processes

DELGADO, Dr. Refugio
Defense Advanced Research Projects Agency /Information Systems Office
3701 N. Fairfax Dr
Arlington, VA 22203
(703) 696-2220; DSN: 426-2220
Fax: (703) 696-0564
rdelgado@darpa.mil
Info Superiority; JR&L/SSS

DEMONEY, COL Jerry
HQ, Intelligence and Security Command
8825 Beaulah Rd
Ft. Belvoir, VA 22060
(703) 706-2975; DSN: 235-2975
Fax: (703) 806-1163
dscops@vulcan.belvoir.army.mil
Elec Combat

DENARD, Lt Col Leland
AFSPC/DRC
150 Vandenburg St, Ste 1105
Peterson AFB, CO 80914
(719) 554-9180; DSN: 692-9180
Fax: (719) 554-2604
ldenard@spacecom.af.mil
Weapons

DERGANC, Mr. Steven
PMW-159-2A
Combat ID

DETTBARN, LCDR John
Chief of Naval Operations/N42
JR&L/SSS

DIAL, Mr. Ken
Office of Naval Research
800 N. Quincy St
Arlington, VA 22217
(703) 696-0806; DSN: 426-0806
Sensors, Elec & BS Environment

DIEHL, LTC William H.
Deputy Division
Chief, Joint Warfighting Center
Bldg 96, Fenwick Rd
Ft. Monroe, VA 23651
(757) 726-6637; Fax: (757) 726-6422
diehlw@jwfc.army.mil
JR&L/SSS

DIERSING, Mr. Vic
OEDP
SFIM-ED
Materials/Processes

DIMITOV, LTC George V.
AMSAT-R-TDRP
Ft. Eustis, VA 23604
(757) 878-3649; DSN: 927-3649
Fax: (757) 878-3108
Dimitrov@eustis-aatds1.army.mil
Human Systems

DINGER, Dr. R.
Space Warfare System Center
NCCOSC RDT&E Div, Code 755
53570 Silvergate Ave, Rm 2430
San Diego, CA 92152
(619) 553-2500; Fax: (619) 553-1130
Sensors, Elec & BS Environment

DIRIENZO, Col Anthony
PEO Air and Missile Defense
Attn: SFAE/AMD/NMD/R
PO Box 1500
Huntsville, AL 35807
(205) 895-3925; Fax (205) 895-3162
COL_DiRienzo@gbr.redstone.army.mil
Joint TMD

DIX, Dr. Donald M.
Director, Advanced Technology, Director Defense Research & Engineering
3080 Defense Pentagon, Rm 3D1089
Washington, DC 20301
(703) 695-0005; Fax: (703) 695-4885
dixdm@acq.osd.mil
Air Platforms; Ground & Sea Vehicles; JR&L/SSS; Precision Force; Space Platforms

DOBSON, Mr. Charlie
PEO Air and Missile Defense
Attn: SFAE-AMD-NMD-SE
PO Box 1500
Huntsville, AL 35807
dobson@msl.redstone.army.mil
(205) 895-3880; Fax: (205) 895-3857
CB Defense & Nuclear

DOGANIERO, Ms. Donna M.
USA Center, Health Promotion and Preventive Medicine (Medical Center Health Branch)
5158 Blackhawk Rd
Aberdeen Proving Ground, MD 21010
(410) 671-4171; DSN: 584-4171
Fax: (410) 671-4784
donna_doganiero@chppm-ccmail.apgea.army.mil
Biomedical

DONAHUE, CAPT Raymond
Head, Antiship Missile Defense
Chief of Naval Operations/N865D
2000 Navy Pentagon
Washington, DC 20350
(703) 604-7607; DSN: 664-7607
Fax: (703) 604-1918
donahue.raymond@hq.navy.mil
Elec Combat

DONOFRIO, Capt Mark
Defense Intelligence Agency/CMO, Central MASINT Office
3100 Clarendon Blvd
Arlington, VA 22201
(703) 907-1896; DSN: 283-1896
Fax: (703) 907-0797
donofrio@idonline.com
Info Superiority

DORMAN, Lt Col James L
US Atlantic Command /J62
1562 Mitscher Ave, Ste 200
Norfolk VA 23551
(757) 836-5880; DSN: 836-5880
Fax: (757) 836-5736
dorman@acom.mil
Info Superiority

DOW, Col Ryan S.
Chief, System Requirements Division
HQ Air Mobility Command
Director of Plans and Programs
402 Scott Dr, Unit 3L3
Scott AFB, IL 62225
(618) 256-2919; DSN: 576-2919
Fax: (618) 256-5001
dowr@hqamc.safb.af.mil
Air Platforms; Elec Combat

DRONKERS, Lt Col Anthony
Assistant Chief, Contingency Plans & Crisis Action Division
AF/ILXX
1030 Air Force Pentagon
Washington, DC 20330
(703) 695-1890; DSN: 225-1890
Fax: (703) 692-2470
dronkera@af.pentagon.mil
JR&L/SSS

DUHAMEL, Mr. Hank
AWACS Program Office
(781) 377-5647
Materials/Processes

DUNHAM, Maj John
Chief, Combat Identification Section
Headquarters Air Combat Command/DRAO
204 Dodd Blvd, Ste 226
Langley AFB, VA 23665
(804) 764-7067; DSN: 574-7067
Fax: (804) 764-2690
dunham@hqaccdr.langley.af.mil
Combat ID

DUNHAM, LTC John
USA Depth and Simultaneous Attack Battle Lab
Precision Force

DUSTON , Dr. Dwight
Ballistic Missile Defense Organization/TO
7100 Defense Pentagon
Washington, DC 20301
(703) 693-1594; Fax: (703) 693-1700
dwight.duston@bmdo.osd.mil
Joint TMD

DYER, MAJ Douglas
Defense Advanced Research Projects Agency /Information Systems Office
3701 N. Fairfax Dr
Arlington, VA 22203
(703) 696-7442; DSN: 426-7442
Fax: (703) 696-2201
ddyer@darpa.mil
Info Systems Tech

E

ECK, Mr. John
F-22 SPO
(937) 255-1580 x2344
Materials/Processes

EDMUNDS, Mr. David
F119 Program Office
2145 Monahan Way
Wright-Patterson AFB, OH 45433
(937) 255-8694 x3434
Fax: (937) 255- 7635
Air Platforms; Materials/Processes

EDWARDS, Col John
HQ DAMO-FD
(703) 614-2184
Combat ID

EICKMANN, Lt Gen Kenneth
Commander Aeronautical Systems Center
USAF Materiel Command
Wright-Patterson AFB, OH 45433
(937) 255-5714
Materials/Processes

ELDARD, Col
(210) 671-0870
MOUT

ELLER, Mr. Jack
Defense Information Systems Agency/D25
5113 Leesburg Pike, Ste 400
Falls Church, VA 22041
(703) 681-7929; DSN: 761-7929
Fax: (703) 681-6569
ellerj@ncr.disa.mil
Info Superiority

ELLIOT, CAPT William
US Atlantic Command, J-32
Combat ID

ELLIS, Mr. David
US Strategic Command/J671
901 SAC Blvd, Ste 2B10
Offutt AFB, NE 68113
(402) 294-5864; DSN 271-5864
Fax (402) 294-6075
ellisd@stratcom.af.mil
Info Superiority

ENG, LTC (P) Robert
Armed Forces Radiobiology Research Institute
8901 Wisconsin Ave
Bethesda, MD 20889
(301) 295-1210; DSN: 295-1210
Fax: (301) 295-4967
eng@mx.afrri.usuhs.mil
Biomedical

ENGEL, RADM Joan M.
USN Bureau of Medicine, Code 02
2300 E St, NW, Code 02
Washington, DC 20372
(202) 762-3462; DSN: 762-3462
Fax: (202) 762-3464
nmc0jme@bms220.med.navy.mil
Biomedical

ENGLANDER, Keith
Ballistic Missile Defense Organization/JNE
1725 Jefferson Davis Hwy, Ste 809
Arlington, VA 22202
(703) 604-7994; Fax: (703) 693-3014
keith.englander@bmdo.osd.mil
Joint TMD

ENWOLD, CAPT Steve
Naval Air Systems Command/PMA-234
1421 Jefferson Davis Hwy
Arlington, VA 22202
(703) 604-4480; DSN: 664-4480
Weapons

ERWIN, Dr. David
Det 1, Human Systems Center/ Occupation and Environmental Health
2509 Kennedy Circle
Brooks AFB, TX 78238
(210) 526-3095; DSN: 240-3095
Fax: (210) 240-2810
david.erwin@guardian.brooks.af.mil
Biomedical

ESSOGLOU, Mr. Milon
NAVFAC 15R
Materials/Processes

EVANS, Dr. Daniel
Air Force Research Laboratory/MLLM
Materials/Processes

EWING, MAJ John
Chief, AE Equipment Research and Acquisition, HQ AMC/SG, Office of the Command Surgeon
203 W. Losey St, Ste 1180
Scott AFB, IL 62225
(618) 256-5070; DSN: 576-5070
Fax: (618) 256-8250
ewingjr@hqamc.safb.af.mil
Human Systems

F

FAILLE, Marty
Air Force Center for Environmental Excellence/ER
Brooks AFB, TX
(205) 536-4331; Fax: (205) 536-4330
Materials/Processes

FALLON, Col Michael O.
Marine Corps Combat Development Command
Office of Science & Innovation
3300 Russell Rd, Ste 309
Quantico, VA 22134
(703) 784-5481; DSN: 273-5481
Fax: (703) 784-6083
fallonm@quantico.usmc.mil
Ground & Sea Vehicles; Force Projection/Dominant Maneuver; JR&L/SSS; *Info Systems Tech*

FANNEY, CDR Rich
Naval Air Systems Command/PMA-272
1421 Jefferson Davis Hwy
Arlington, VA 22202
(703) 604-2860, DSN: 664-2860
Weapons

FAULK, Mr. Mack
PM-Night Vision & Electronic Sensors Directorate
Sensors, Elec & BS Environment

FENNER, Capt Jerold E.
Chief Oxygen Systems
Air Force Research Laboratory/CFTS
Oxygen Systems
2504 Gillingham Dr, Ste 25
Brooks AFB, TX 78235
(210) 536-3361; DSN: 240-3361
Fax: (210) 536-2761
jfenner@alcft.brooks.af.mil
Human Systems

FENSTERMACHER, Mr. L.
HQ Air Combat Command/DRSL
DSN: 574-7595
Sensors, Elec & BS Environment

FERGUSON, COL C. M.
Director, Directorate of Combat Developments, USA Engineer School
Ft. Leonard Wood, MO 65474
(573) 563-4076; DSN: 676-4076
Fax: (573) 563-4089
Force Projection/Dominant Maneuver

FERRELL, CW4 Ron
SFAE-AV-RAH-T
Huntsville, AL 35809
(205) 842-7315; DSN: 788-7315
Fax: (205) 842-8825
ferrell@comanche.redstone.army.mil
Human Systems

FERRITER, Dr. John
Edgewood Research, Development and Engineering Center
5232 Fleming Rd
Aberdeen Proving Ground, MD 21010
(410) 671-5601; DSN: 584-5601
Fax: (410) 671-2991
jmferriter@cbdcom.apgea.army.mil
CB Defense & Nuclear; CB Warfare/Counter WMD

FETZER, CAPT William
Naval Air Systems Command/PMA205
Pax River, MD 20670
(301) 757-6944; DSN: 575-6944
Fax: (301) 757-6945
fetzerwww.jfk@navair.navy.mil
Human Systems

FIELDS, Dr. Dave
Defense Advanced Research Projects Agency /Tactical Technology Office
3701 N. Fairfax Dr
Arlington, VA 22203
Sensors, Elec & BS Environment

FINK, Mr. Martin D.
Assistant Project Manager
Naval Sea Systems Command/NAVSEA, PMS 385
2531 Jefferson Davis Hwy
Arlington VA 22242
(703) 602-7881; DSN: 332-7881
Fax: (703) 602-5385
fink_Marty@hq.navy.mil
JR&L/SSS

FISHER, Mr. Joe
HQ Air Combat Command/CEXX
(804) 764-7659, Fax: (804) 764-3566
Materials/Processes

FITZGERALD, Ms. Carol
USA Soldier Systems Command
CERDEC/Night Vision & Electronic Sensors Directorate
10221 Burbeck Rd
Ft. Belvoir, VA 22060
(703) 704-1427; DSN: 654-1427
Fax: (703) 704-1111
cfitzger@nvl.army.mil
MOUT

FLANK, Dr. Steven M.
Defense Advanced Research Projects Agency /Information Systems Office
3701 N. Fairfax Dr
Arlington, VA 22203
(703) 696-2309; DSN: 426-2309
Fax: (703) 696-2203
sflank@darpa.mil
Info Systems Tech

FLETCHER, COL Benjamin
USA Battle Command Battle Lab
HQ, Signal Center
Ft. Gordon, GA 30905
(706) 791-2057; DSN: 780-2057
Fax: (706) 791-8346
fletcherb@bcblg@gordon.army.mil
Info Systems Tech

FLYNN, Mr. Michael
Deputy for Vehicles, Sensors and Munitions, Secretary of the Air Force for Acquisition, Research and Technology
1060 Air Force, Pentagon
Washington DC 20330
(703) 558-7864; DSN: 425-7864
flynnm@af.pentagon.mil
Weapons; Precision Force; Joint TMD

FOLEY, LTC Beth
Office of the Deputy Chief of Staff, Personnel, HQ Department of the Army
Pentagon, Rm 2B659
Washington, DC 20310
(703) 697-2448; DSN: 227-2448
Fax: (703) 693-0212
foleyb@pentagon-dcsper.army.mil
Biomedical

FOLK, Maj Dan
Joint Precision Strike Office
Precision Force

FORCINO, CDR Doug
Program Officer, Biomedical S&T
Office of Naval Research
800 N. Quincy St, Code 341, Rm 823
Arlington, VA 22217
(703) 696-0367; Fax: (703) 696-1212
forcind@onr.navy.mil

FOWLER, Dr. Northrup III
Air Force Research Laboratory/IFT
525 Brooks Rd
Rome, NY 13441
(315) 330-3011; DSN: 587-3011
Fax: (315) 330-7989
fowlern@rl.af.mil
Info Systems Tech

FRASER, Capt Wendy
Air Force Research Laboratory
Attn: ASC/LNWA (ASTE)
Wright-Patterson AFB, OH 45433
(937) 255-6004 x3652, DSN: 785-3652
wfraser@ntnotes2.ascsm.wpafb.af.mil
Weapons

FREDERICK, Dr. William
Ballistic Missile Defense Origination
TRC CS2/552
7100 Defense Pentagon
Washington, DC 20301
(703) 693-1838 x5304
Fax: (703) 695-1179
william.frederick@bmdo.osd.mil
Sensors, Elec & BS Environment

FRICAS, COL John
Special Military Assistant, Deputy Undersecretary of Defense (Advanced Technology)
3700 Defense Pentagon, Rm 3E1965
Washington, DC 20301
(703) 614-0192; DSN: 225-0192
Fax: (703) 697-3585
dealb@acq.osd.mil
Combat ID; Info Superiority; MOUT

FRIEDL, LTC Karl
USAMRMC
MCMR/PLC, 505 Scott St, Ft. Detrick
Frederick, MD 21702
(301) 619-7304; DSN: 343-7304
Fax: (301) 619-2416
ltc_karl_friedl@ftdetrck-ccmail.army.mil
Biomedical

G

GAGORIK, Mr. Jim
Office of Naval Research
800 N. Quincy St
Arlington, VA 22217
(703) 696-4719; DSN: 426-4719
Ground & Sea Vehicles

GALLAGHER, Mr. Mike
Naval Surface Warfare Center – Carderock Division, Marine Corps Systems Command, Amphibious Warfare and Technology Division
9500 MacArthur Blvd, Code 2800
West Bethesda, MD 20817
(301) 227-1852; DSN: 287-1852
Fax: (301) 227-4389
gallaghe@oasys.dt.navy.mil
Ground & Sea Vehicles

GALLOWAY, Mr. Jim
ASAF Aeronautical Systems Center/OL/YUP
Eglin AFB, FL
(850) 882-4262 x3093
galloway@eglin.af.mil
Precision Force

GAMBLE, Mr. Allan
USA Aviation and Missile Command
Redstone Arsenal, AL 35898
(205) 876-2511
gamble-ae@redstone.army.mil
Force Projection/Dominant Maneuver; Precision Force

GANNON, LTC Tim
HQ Department of the Army, ODCSOPS
(703) 325-4483
JR&L/SSS

GANZ, Dr. Matthew
Defense Advanced Research Projects Agency /Sensor Technology Office
3701 N. Fairfax Dr
Arlington, VA 22203
(703) 516-7413; Fax: (703) 522-6108
mganz@darpa.mil
Info Superiority

GARN, Dr. Lynn S.
Chief, Automation Technology Branch
Army Night Vision & Electronic Sensors Directorate
10221 Burbeck Rd, Ste 430
Ft. Belvoir, VA 22060
(703) 704-1692; DSN: 654-1692
Fax: (703) 704-1753
lgarn@nvao.army.mil
Force Projection/Dominance Maneuver

GARRARD, LtCol David
Hq US Marine Corps
2 Navy Annex Code CSB
Washington, DC 20380
(703) 693-3124; DSN: 223-3124
garradd1@mqg-smtp3.usmc.mil
Combat ID

GASKILL, Maj Kenneth
MCCDC, Requirements Officer
Materials/Processes

GENTRUP, Col Michael
Chief, Air Superiority Division
Air Combat Command/DRA
204 Dodd Blvd, Ste 226
Langley AFB, VA 23655
(757) 764-5201; DSN: 574-5201
Fax: (757) 764-3596
gentrup.m@langley.af.mil
Force Projection/Dominant Maneuver; Sensors, Elec & BS Environment; Weapons

GILLIS, LtCol Paul F.
USMC Readiness Officer
US Atlantic Command /J32
1562 Mitscher Ave, Ste 200
Norfolk, VA 23551
(757) 322-7745; DSN: 836-7745
Fax: (757) 322-7608
J32m@hq.acom.mil
JR&L/SSS

GILTRUD, Mr. Michael E.
HQ Defense Special Weapons Agency/WEL
6801 Telegraph Rd
Alexandria, VA 22310
(703) 325-1048; DSN: 221-1048
Fax: (703) 325-2957
giltrud@hq.dna.mil
Weapons

GIMENO, Mr. Benjamin
National Reconnaissance Office
14675 Lee Rd
Chantilly, VA 20151
(703) 808-3842; Fax: (703) 808-2646
gimemob@sgate.com
Space Platforms

GLADBACH, Maj William
Dept. of the Army, Deptuy Chief of Staff for Operations (DAMO-FDI)
Pentagon. Rm 2C536
Washington, DC 20310
(703) 695-4222; DSN 225-4222
Fax: (703) 693-5336
gladbwr@dcsopspo1.army.mil
Info Superiority

GODELL, Mr. Joseph
PM ABRAMS
Weapons

GODFREY, COL Larry J.
HQ, US Southern Command
7701 Tampa Point Blvd
MacDill AFB, FL 33621
(813) 828-5442; DSN: 968-5442
Fax: (813) 828-2568
maxtracklj@aol.com
Biomedical

GOERING, Dr. Kent
Defense Special Weapons Agency/PMT
6801 Telegraph Rd
Alexandria, VA 22310
(703) 325-7140; DSN: 221-7140
Fax: (703) 325-2961
goeringk@hq.dswa.mil
CB Defense & Nuclear

GOLDWASSER, Dr. Judah
Office of Naval Research, Code 333
800 N. Quincy St
Arlington, VA 22217
(703) 696-2164, DSN: 226-2164
Fax: (703) 696-2558
goldwaj@onr.navy.mil
Weapons

GONZALEZ, Mr. Victor
National Imagery & Mapping Agency-TR
4600 Sanamore Rd
Bethesda, MD 20816
(703) 808-0838; Fax: (703) 808-0531
gonzalezv@nima.mil
Info Systems Tech

GOODBRAKE, Lt Col Craig
Joint Staff - J39
Pentagon, Rm 2C861
Washington, DC 20318
(703) 614-3127; Fax: (703) 614-7838
goodbrcc@js.pentagon.mil
Weapons

GOODRICH, Col Susan
Ballistic Missile Defense Organization/TOS, Surveillance & Interceptor Technology Directorate
1725 Jefferson Davis Hwy, Ste 809
Arlington VA 22202
(703) 604-3224; DSN: 354-3224
Fax: (703) 604-3926
susan.goodrich@bmdo.osd.mil
Space Platforms

GOODWON, Mr. L.
Air Force Research Laboratory
Sensors, Elec & BS Environment

GORAN, Mr. William
CERL
Champaign, IL 61820
(217) 373-6735, Fax: (217) 373-7227
w-goran@cecer.army.mil
Materials/Processes

GORTON, Mr. Charles
Naval Air Systems Command/4.4T
22195 Elmer Rd (Unit 4)
Patuxent River, MD 20670
(301) 757-0450; DSN: 757-0450
Fax: (301) 757-0542
gorton_charles%pax4a@mr.nawcad.navy.mil
Air Platforms

GRACEFFO, Ms. Lynda
Army Night Vision & Electronic Sensors Directorate
(703) 704-1692
Force Projection/Dominant Maneuver

GRANT, Ms. Gayle D.
USA Communications-Electronics Command
Ft. Monmouth, NJ 07703
(732) 427-3928; DSN: 987-3928
Fax: (732) 532-0788
grantg@doim6.monmouth.army.mil
Info Superiority

GREENE, Mr. Jim
AFCESA/ENC
(850) 283-6334, Fax: (904) 283-6219
greenej@afcesa.af.mil
Materials/Processes

GRIBSCHAW, Col James
USA Training and Doctrine Command
USA Infantry Center, Bldg 4
Ft. Benning, GA 31905
(706) 545-5510; DSN: 835-5510
Fax: (706) 545-7933
Weapons

GROSSMAN, Mr. Jeffrey D.
Space & Naval Warfare Systems Center,
Code D44210
53560 Hull St
San Diego, CA 92152
(619) 553-3625; DSN: 553-3625
Fax: (619) 553-4698
hufac@nosc.mil
Human Systems

GULLICKSON, Mr. Richard
Defense Special Weapons Agency/ES
6801 Telegraph Rd
Alexandria, VA 22310
(703) 325-1235; DSN: 221-1235
Fax: (703) 325-2959
gullickson@hq.dswa.mil
CB Defense & Nuclear

GUNNING, Dr. David
Defense Advanced Research Projects
Agency /Information Systems Office
3701 N. Fairfax Dr
Arlington, VA 22210
(703) 696-2218; DSN: 426-2218
Fax: (703) 696-2203
dgunning@darpa.mil
Info Systems Tech

GUNZELMAN, COL Karl
USA Mounted Battlespace Battle Lab
(502) 624-7809; Fax: (502) 942-1696
gunzelman@ftknox-mbbl-lan.army.mil
Air Platforms

H

HAAS, Dr. David J.
Program Manager
Naval Surface Warfare Center
9500 MacArthur Blvd West
Bethesda, MD 20817
(301) 227-1397; DSN 287-1397
Fax (301) 227-2584
JR&L/SSS

HAAS, Dr. Michael W.
Technical Director
Air Force Research Center/HE
2255 H St, Bldg 248
Wright-Patterson AFB, OH 45433
(937) 255-8768; DSN: 785-8768
Fax: (937) 255-8752
mhass@al.wpafb.af.mil
Human Systems

HABAYEB, Mr. R.
Naval Air Systems Command/4.OT
(703) 604-3555 x8981
Sensors, Elec & BS Environment

HAGAN, LCDR Timothy
N872E
2000 Navy Pentagon
Washington, DC 20350
(703) 697-2860; DSN: 664-2860
Weapons

HAIL, CAPT Laird H.
Chief, Office of Cutter Management
Commandant, US Coast Guard
2100 2nd St, SW
Washington, DC 20595
(202) 267-1768; Fax: (202) 267-4415
lhail@comdt.uscg.mil
MOUT; Weapons

HALE, CDR Lawrence
J6K, Joint Staff (Inforrmantion
Assurance Division)
Pentagon, Rm 1C826
Washtington, DC 20350
(703) 697-1199; DSN: 227-1199
Fax: (703) 614-7814
halel@js.pentagon.mil
Info Superiority

HALL, Mr. George
Air Force Research Laboratory/FIVC
(850) 283-3734; DSN: 523-3734
Fax: (850) 283-9797
Materials/Processes

HAMILTON, COL Philip E.
Program Manager for Soldier
10401 Totten Rd, Bldg 399, Ste 121
Ft. Belvoir, VA 22060
(703) 704-3816; DSN: 654-3816
Fax: (703) 784-3820
hamiltop@pmsoldier.belvoir.army.mil
Human Systems; Info Systems Tech

HANNAH, Dr. Barry
USN Strategic Systems Program
1931 Jefferson Davis Hwg
Arlington, VA 22202
(703) 607-1132; Fax: (703) 607-2127
CB Defense & Nuclear

HANSON, Dr. Don
Air Force Research Laboratory
26 Electronics Pkwy, Bldg 106
Rome, NY 13441
(315) 330-7781; Fax: (313) 330-2014
hansond@rl.af.mil
Sensors, Elec & BS Environment

HARDEBECK, Dr. Ted
Strategic Command
901 SAC Blvd
Offutt AFB, NE 68113
(402) 294-4122; DSN: 271-4122
Fax: (402) 294-1094
hardebet@stratcom.af.mil
CB Defense & Nuclear

HARDING, Dr. John
Naval Research Laboratory
4555 Overlook Ave, SW
Washington, DC 20375
DSN: 485-4661
Sensors, Elec & BS Environment

HARDY, Dr. Dave
Air Force Research Laboratory
29 Randolph Rd
Hanscom AFB, MA 01731
(617) 377-3102; Fax (617) 377-5688
hardy@plh.af.mil
Sensors, Elec & BS Environment

HARMON, Col D.
Human Systems Program Office/YA
8107 13th St
Brooks AFB, TX 78235
(210) 536-3475; DSN: 240-3475
Fax: (210)536-2153
d.harmon@fermes.brooks.af.mil
Biomedical

HARRIS, Dr. Beverly
Army Research Institute Liaison, Office
of the Assistant Secretary of the Army
for Research, Development &
Acquisition,
103 Army Pentagon, Rm 3E479
Washington, DC 20310
(703) 697-8599; DSN: 227-8599
Fax: (703) 697-3257
harris@ari.army.mil
Human Systems; JR&L/SSS

HARRIS, W.
Naval Air Warfare Center, Training
Systems Division, 4.9T
12350 Research Parkway
Orlando, FL 32826
(407) 380-8376; DSN: 960-8376
Fax: (407) 380-4007/-4811
william_harris@ntsc.navy.mil
Human Systems

HART, Ms. Marsha
Defense Intelligence Agency
3100 Clarendon Blvd
Arlington, VA 22201
(703) 907-0636; Fax: (703) 907-0111
AFchenfx@dia.osis.gov
Info Superiority; Info Systems Tech

HART, Ms. Mary
Program Manager, SAVE
Defense Logistics Agency
(703) 767-1637
JR&L/SSS

HART, Mr. Stephen
Space & Naval Warfare Systems Center,
Code D856
53560 Hull St
San Diego, CA 92152
(619) 553-4016; DSN: 553-4016
Fax: (619) 553-3791
harts@nosc.mil
Info Systems Tech

HASTIE, COL William
Ballistic Missile Defense
Organization/AQQ
7100 Defense Pentagon
Washington, DC 20301
(703) 693-1780; Fax: (703) 693-1703
william.hastie@bmdo.osd.mil
Joint TMD

HAVEY, Col Mike
Air Force Research Laboratory
Sensors, Elec & BS Environment

HAWKINS, LTC Joseph
Air Combat Command
204 Dodd Blvd, Ste 226
Langley AFB, VA 23665
(757) 764-5832; DSN: 574-5832
Fax: (757) 764-6211
hawkins@hqaccdr.langley.af.mil
Human Systems

HAYES, Col Jack
USAF Weather Agency/Control Center
106 Peacekeeper Dr, Ste 2N3
Offutt AFB, NE 68113
(402) 232-5749; Fax: (402) 232-4153
hayesj@afwa.af.mil
Sensors, Elec & BS Environment

HEARDING, CAPT David W.
CINC Liaison Office
US Strategic Command
Defense Pentagon, Rm 4D166
Washington, DC 20330
(703) 695-3192; DSN: 225-3192
Fax: (703) 693-7346
heardingd@execnet.hq.af.mil
JR&L/SSS

HEBER, Mr. Charles
Defense Advanced Research Projects
Agency, Tactical Technology Office
3701 N. Fairfax Dr
Arlington, VA 22203
(703) 524-5199; Fax: (703) 243-2803
cheber@darpa.mil
Info Superiority

HENRY, CAPT Doug
Naval Air Systems Command/PMA-272
1421 Jefferson Davis Hwy
Arlington, VA 22202
(703) 604-2860; DSN: 664-2860
Weapons

HENRY, Dr. Hal
Deputy Undersecretary Defense for
Space
Space Acquisition and Management
3900 Defense Pentagon, Rm 3E1044
Washington, DC 20301
(703) 693-0290, Fax: (703) 697-3218
henryhv@acq.osd.mil
Space Platforms

HERNANDEZ, LCDR Rene
USN Bureau of Personnel
PERS-601E, 2 Navy Annex
Washington, DC 20370
(703) 695-4082; DSN: 225-4082
Fax: (703) 614-5582
p601e@bupers.navy.mil
Biomedical

HERR, Dr. Frank
Office of Naval Research
800 N. Quincy St
Arlington, VA 22217
(703) 696-4125; DSN: 426-4125
Sensors, Elec & BS Environment

HILLENBRAND, LTC Edward, USA
Product Manager Information Warfare
Research, Development and Engineering
Center
7484 Candlewood Rd, Ste L&M
Hanover MD 21076
(301) 677-7991; DSN: 923-7991
Fax: (703) 243-7796
Info Superiority

HITZEMAN, Mar. Thomas A.
ASC/FBJ
Human Systems

HOBBS, Col Randy
Air Combat Command/DRP
204 Dodd Blvd, Ste 226
Langley AFB, VA 23665
(757) 764-4446; DSN: 574-4446
Fax: (757) 764-5124
Hobbsjr@hqaccdr.langley.af.mil
Air Platforms

HOBBS, COL Robert
USA Infantry Center, ATZB
Ft. Benning, GA 31905
(706) 545-1515; DSN: 835-1515
Fax: (706) 545-2517
hobbsr@benning-emh2.army.mil
MOUT; Weapons

HOFF, Ms. Sandra
Aviation Applied Technology
Directorate, Aviation & Missile
Command
Ft. Eustis, VA 23604
(757) 878-4130; DSN: 927-4130
Fax (757) 878-0007
shoff@eustis-aatdf1.army.mil
Air Platforms

HOKE, Jr., COL Charles
USA Medical Research and Materiel
Command
505 Scott St
Ft. Detrick, Frederick, MD 21702
(301) 619-7567; DSN: 343-7567
Fax: (301) 619-2416
col_charles_hoke@ftdetrck-
ccmail.army.mil
Biomedical

HOMER, Mr. James H.
Foreign C^3 Systems Analyst
National Air Intelligence Center/TACN
Wright-Patterson AFB, OH 45433
(937) 257-3556; DSN: 787-3556
Fax: (937) 257-9888
jhh33@niac.wpafb.af.mil
Human Systems

HORN, Mr. George
Head, Undersea Mp and Train
Submarine Warfare Div
2000 Navy Pentagon
Washington, DC 20305-2600
(703) 604-7823; DSN: 664-7823
Fax: (703) 604-7858
horn.george@hq.navy.mil
Human Systems

HORN, Dr. Stuart
Army Night Vision & Electronic
Sensors Directorate
(703) 704-2025
Sensors, Elec & BS Environment

HOUSE, Mr. Thomas L.
Executive Director, USA Aviation
Research, Development and Engineering
Center
Bldg 5581
Redstone Arsenal, AL 35898
(205) 313-1725; DSN: 897-1725
Fax: (205) 313-1740
house-TL@redstone.army.mil
Air Platforms

HOWELL COL Michael
SFAE-UAV, Joint Tactical Unmanned
Aerial Vehicle Office
4901 University Square, Ste 1
Huntsville Al 35816
(205) 895-4449; DSN: 788-4449
Fax: (205) 895-5862
howell-uav@redstone.army.mil
Info Superiority

HOWSE, Maj Douglas
50th SW/XPSV
300 O'Malley Ave, Ste 74
Falcon AFB, CO 80912
(719) 567-2617; DSN: 560-2617
Fax: (719) 567-2655
howsedj@fafb.af.mil
Space Platforms

HUCHTING, RADM George A.
Aegis Program, Naval Sea Systems
Command/PMS 400
2531 Jefferson Davis Hwy, Ste 10N18
Arlington, VA 22242
(703) 602-7397; DSN: 332-7397
Fax: (703) 602-0941
huchting_george_RADM@hq.navsea.
navy.mil
Human Systems

HULCHER, Mr. Greg
Undersecretary of Defense, Advanced Technology, Pentagon, Rm BE130
Washington, DC 20301
(703) 693-6398; Fax: (703) 693-7039
hulchegd@acq.osd.mil
CB Defense & Nuclear

HUMMEL, Dr. R.
Defense Advanced Research Projects Agency
3701 N. Fairfax Dr
Arlington, VA 22203
Sensors, Elec & BS Environment

HUNDLEY, Mr. Ted
USA Aviation Center
Ft. Rucker, AL 36362
(334) 255-2704; Fax: (334) 255-1998
Air Platforms

HUNT, Mr. Ron
Air Force Research Laboratory/MNS
Eglin AFB, FL 32542
(850) 882-2200; DSN: 872-2200
Weapons

HUNTZINGER, CDR M.
CO ACB 1
(619) 437-5143
Materials/Processes

HUSS, CDR
PMS-325J
2611 Jefferson Davis Hwy, Rm 2010
Arlington, VA 22242
(703) 602-9024; DSN: 332-0870
Fax: (703) 602-5847
J_Huss@hq.NAVSEA.navy.mil
MOUT

HUTSON, Ms. Patrice
Textile Technologist
Human Systems Center, Systems Program Office, AF Clothing Div
2555 Monahan Way, Bldg 55
Wright-Patterson AFB, OH 45433
(937) 255-2382; DSN: 785-2382
Fax: (937) 656-4318
phutson@falcon.al.wpafb.af.mil
Human Systems

HYNES, Ms. Rosanne
OSD/C^{3}I
Precision Force

I

INFOSINO, Dr. Charles
Ballistic Missile Defense Organization/TOD
1725 Jefferson Davis Hwy, #809
Arlington, VA 22202
(703) 604-3505; Fax: (703) 604-3923
Weapons

IRWIN, Mr. Raymond A.
Chief Engineer, USA Communications-Electronics Command, Night Vision & Electronic Sensors
SEACOM AMSEL-RD-NV-SR-OD
Fort Monmouth, NJ 07703
(732) 427-4589; DSN: 987-4589
Fax: (732) 427-2493
rirwin@nvl.army.mil
Elec Combat

IZZO, COL Leonard A.
USA Chemical School
Ft. McClellan, AL 36205
(205) 848-6476; Fax: (205) 848-6607
izzol@mcclellan-cwls.army.mil
CB Defense & Nuclear

J

JACKSON, Mr. Chris
US Atlantic Command
Info Superiority

JACKSON, Mr. Dave
Joint Strike Fighter, Naval Air Weapon s Center
Bldg 2187, Ste 1280
48110 Shaw Rd, Unit #5
Patuxent River, MD 20670
(301) 342-3468; DSN: 342-8468
Fax: (301) 342-8503
jackson_dave%pax5@mr.nawcad.navy.mil
Human Systems

JACKSON, Mr. Mel
PEO Aviation, Commanche
Bldg 5681
Redstone Arsenal, AL 35898
(205) 313-4480; Fax: (205) 313-4548
Precision Force; Sensors, Elec & BS Environment

JACQUES, Maj David R.
LOCASS Program Manager
Air Force Research Laboratory/MNAV
Eglin AFB, FL 32542
(850) 882-8876 x3369; DSN: 872-8876
Fax: (850) 882-2201
jacques@eglin.af.mil
Precision Force

JAMIL, Mr. Iftikhar
Director Defense Research and Engineering/Information Technology
Pentagon, Rm 3D367
Washington, DC 20301
(703) 614-0207; DSN: 225-0207
Fax: (703) 693-2981
jamili@acq.osd.mil
Combat ID; Info Superiority; Info Systems Tech

JEFFREY, Dr. Bill
DARO
Sensors, Elec & BS Environment

JENNINGS, Mr. Michael J.
Branch Chief, Joint Countermine ACTD
Army Night Vision & Electronic Sensors Directorate
10221 Burbeck Rd
Ft. Belvoir, VA 22060
(703) 704-1032; DSN: 654-1032
Fax: (703) 704-1041
mjenning@nvl.army.mil
Force Projection/Dominant Maneuver

JENSEN, Mr. Jens A.
Headquarters, US Pacific Command
Box 64013
Capt. H.M. Smith, HI 96861
(808) 477-4650; DSN: 315-4650
Fax: (808) 477-7402
jjensen@nosc.mil
Info Superiority; Info Systems Tech

JOHNSON, CAPT Burt
Naval Air Systems Command/PMA-201
1421 Jefferson Davis Hwy
Arlington, VA 22202
(703) 604-2860, DSN: 664-2860
Weapons

JOHNSON, Brig Gen Charles
ASC/YC (C-17)
(937) 255-1545; Fax: (937) 255-9411
Materials/Processes

JOHNSON, Dr. Dave
Office of Naval Research
800 N. Quincy St
Arlington, VA 22217
DSN: 226-0807
Sensors, Elec & BS Environment

JOHNSON, Don
Office of the Secretary of Defense (R&T)
Pentagon, Rm 1C757
Washington, DC 20301
(703) 693-9550; DSN: 227-9550
Fax: (703) 693-7382
johnsond@pr.osd.mil
Human Systems

JOHNSON, CAPT Gary
PMA-280
(703) 604-0905
Precision Force

JOHNSON-WINEGAR, Dr. Anna
Director Defense Research and Engineering, Director for Environmental & Life Science
3080 Defense Pentagon, Rm 3D129
Washington, DC 20301
(703) 697-8714; DSN: 227-8714
Fax: (703) 693-7042
johnsoad@acq.osd.mil
Biomedical; Human Systems;JR&L/SSS

JOHNSTON, CAPT Burt
PMA-201
Weapons

JONES, Mr. Jon
Lab Project Manager
Air Force Research Laboratory/IFEA
32 Hangar Road
Rome, NY 13441
(315) 330-1665; Fax: (315) 330-2728
jonesj@rl.af.mil
Force Projection/Dominant Maneuver

JONES, Mr. Joseph
USA Infantry School
Ft. Benning, GA 31905
(706) 545-6406; DSN: 835-6406
Fax: (706) 853-2517
jonesj@benning-emh2.army.mil
Human Systems

JONES, Dr. Richard
Director, Naval Facilities Engineering
Service Center/Code ESC66
110 23rd Ave
Port Hueneme, CA 93043
(805) 982-1563; Fax: (805) 982-1553
Combating Terrorism

JONES, CDR Shaun
Defense Advanced Research Projects
Agency /Defense Sciences Office
3701 N. Fairfax Dr
Arlington, VA 22203
(703) 696-4427; DSN: 426-4427
Fax: (703) 696-3999
sjones@darpa.mil
Biomedical

JONES, Mr. Tim
Air Force Research Lab/MNA
Eglin AFB, FL 32542
(904) 882-3344 x2336; DSN: 872-3344
Precision Force

JONES, Ms. Traci A.
Systems Engineer, Simulation Training
& Instrumentation Command
12350 Research Parkway
Orlando, FL 32826
(407) 384-3927; DSN: 970-3927
Fax: (407) 384-3830
jonest@stricom.army.mil
Info Systems Tech

JONES, Dr. Walter F.
Deputy for Research Sciences, Secretary
of the Air Force, Assistant Secretary for
Acquisition, Research
1919 South Eads St, Ste 100
Arlington, VA 22202
(703) 602-9200 x26; DSN: 332-9200
Fax: (703) 602-9199
joneswf@af.pentagon.mil
JR&L/SSS; Space Platforms

JONES, Mr. William J.
Air Force Research Lab/MNAV
Eglin AFB, FL 32542
(850) 882-2220; DSN: 872-2220
Weapons

JONKOFF, Viktor
Joint Strike Fighter
1745 Jefferson Davis Highway
Crystal Square 4
Arlington, VA 22202
(703) 602-7390 x6663
Sensors, Elec & BS Environment

JUDGE, Lt Col Carol Lynn
Chief, Info & Tech Branch, Air Force
Agency for Modeling and Simulation
12350 Research Parkway
Orlando, FL 32826
(407) 208-5734; DSN: 970-5734
Fax: (407) 208-5988
judge.carol.Lynn@afams.af.mil
Info Systems Tech

K

KALB, COL John
Director, Force Development
USA Armor Center, ATZK-FD
Ft. Knox, KY 40121
(502) 624-5050; DSN 464-5050
Fax: (502) 624-7126
kalb@ftknoxdfd-emh13.army.mil
Precision Force; Weapons

KAM, LTC Vincent W.
Senior Requirements Officer, JCS/J34,
The Pentagon
Washington, DC 20318
(703) 696-7551; DSN: 223-7551
Fax: (703) 693 7539
kamvw@js.pentagon.mil
Combating Terrorism

KAMINSKI, Mr. Robert
Air Force Research Laboratory
Code IFGA, 525 Brooks Rd
Rome, NY 13441
(315) 330-7751; DSN: 587-7751
Fax: (315) 330-7137
kaminskir@rl.af.mil
Info Systems Tech

KASPAR, Lt Col Beth
Defense Advanced Research Projects
Agency/Sensor Technology Office
3701 N. Fairfax Dr
Arlington, VA 22203
(703) 696-2369
Materials/Processes

KAZNOFF, Dr. Alex
Naval Sea Systems Command/03M
Materials/Processes

KEARNS, Mr. Chris
USA Dismounted Battlespace Battle Lab
Bldg 4, Rm 343
Ft. Benning, GA 31906
(912) 545-3096; DSN: 835-3096
Fax: (912) 545-6391/-4799
kearn@benning-ddbl.army.mil
Biomedical

KEFFER, Mr. Les
USAF/ILEV
(703) 696-2797
Materials/Processes

KELLER, COL Brian
PM-Soldier
AMSSC-PM
Natick, MA 01760
(508) 233-5312; DSN: 256-5312
Fax: (508) 233-5554
bkeller@natick-emh2.army.mil
Human Systems

KELLY, Maj Frank
Naval Air Systems Command
(AIR 4.5.4)
1421 Jefferson Davis Hwy
Arlington, VA 22202
(703) 604-6240 x2818; DSN: 664-6240
Weapons

KELLY, Mr. James
Office of Naval Research
800 N. Quincy St
Arlington, VA 22217
Materials/Processes

KEMERER, Lt Col Mike
Chief, Systems Branch
HQ Air Force Special Operations
Command
100 Bartley St
Eglin AFB, FL 32542
(904) 884-5041; DSN: 579-5041
Fax: (904) 884-2549
kemererm@hurlburt.af.mil
Elec Combat; Weapons

KEMERLEY, Mr. Tim
Air Force Research Laboratory/EL
2241 Avionics Circle, Ste 29
Wright-Patterson AFB, OH 45433
(937) 255-2911 x4193, DSN: 755-2911
Fax: (937) 255-6942
Sensors, Elec & BS Environment

KENNEDY, Mr. Robert V.
USA Aviation and Missile Command
Redstone Arsenal, AL 35898
(205) 313-1725; Fax: (205) 313-1740
KENNEDY-RV@ccsmtp.redstone.
army.mil
Air Platforms

KESELOWSKY, Mr. Nicholas
PEO Command, Control,
Communications Systems
SFAE PEO C3S/HT1
Rm 3C129, Myer Center
Ft. Monmouth, NJ 07703
(732) 427-3263; DSN: 987-3263
Fax: (732) 542-1364
KESELOWS@doim6.monmouth.
army.mil
Info Superiority

KHINE-LATT, Ms.
Office of Naval Research
800 N. Quincy St
Arlington, VA 22217
Weapons

KIFER, CPT William
USA Maneuver Support Battle Lab
Engineer School
Ft. Leonard Wood, MO 65473
(573) 596-0131 x37917
DSN: 676-7917; Fax: 676-4089
kiferw@wood.army.mil
Human Systems

KILPATRICK, Dr. Michael
OSA(GWI)
5113 Leesburg Pike, Ste 901
Falls Church, VA 22041
(703) 578-8510; Fax: (703) 578-8510
mkilpatrick@gwillness.osd.mil
Biomedical

KIM, COL Myung
J-4, Medical Readiness Division,
Pentagon, Rm 2D828
Washington, DC 20318
(703) 697-4421; DSN: 227-4421
Fax: 703-697-0510
kimhm@js.pentagon.mil
Biomedical

KIMKER, Mr. Chris
USA Armament Research, Development
and Engineering Center, PM-TMAS
Picatinny Arsenal, NJ 07806
(973) 724-5307; DSN: 880-5307
Weapons

KING, LtCol Mark
USMC CNO-N853F
Director, Warfare Requirements
(Expeditionary Warfare Division)
Pentagon, Rm 5E613
Washington, DC 20350
(703) 697-1466; DSN: 227-1466
Fax: (703) 697-3808
king.mark@hq.navy.mil
Info Superiority

KING, Mr. William
Office of Naval Research
800 N. Quincy St
Arlington, VA 22217
(703) 696-4109; DSN: 426-4109
Fax: (703) 696-4274
kingw@onr.navy.mil
Human Systems; Sensors, Elec & BS Environment; Air Platforms

KINNISON, Col Henry L. (Hank)
System Manager-Soldier
USA Training and Doctrine Command
Ft. Benning, GA 31905
(706) 545-1189; DSN: 835-1189
Fax: (706) 545-1377
kinnisonh@benning-emh2.army.mil
Human Systems

KIRBY, COL Robert
Director, US Army Topographic
Engineering Center
7701 Telegraph Rd
Alexandria, VA 22315
(703) 428-6602; Fax: (703) 428-8154
rkirby@tec.army.mil
Sensors, Elec & BS Environment

KIRK, Mr. Jack
PM-AEC, Attn: SFAE-AV-AEC
Redstone Arsenal, AL 35807
(205) 842-6385
Electronic Combat, Weapons

KIRKLAND, Maj C. L.
USMC Deputy Director
Pentagon
Washington, DC 20310
(703) 614-1950; 246-1950
Weapons

KISTLER, CAPT Jay R.
Director, Navy Modeling & Simulation
Office (N6M)
2511 Jefferson Davis Hwy
Arlington, VA 22202
(703) 601-1482; DSN: 329-1482
Fax: (703) 601-1337
kistler.jay@hq.navy.mil
Info Systems Tech; JR&L/SSS

KITCHENS, JR., Dr. C. Wes
Director for Weapons Technologies,
Director Defense Research and
Engineering/Weapons Technologies
3080 Defense Pentagon, Rm 3D1089
Washington, DC 20301
(703) 695-9602; DSN: 225-9602
Fax: (703) 695-4885
kitchecw@osd.acq.mil
Elec Combat; Force Projection/ Dominant Maneuver; Joint TMD; MOUT; Precision Force; Weapons

KNARR, COL William
TRADOC Systems Manager for
Unmanned Aerial Vehicles
USA Intelligence Center
Ft. Huachuca, AZ 85613
(520) 533-1804; DSN: 821-1804
Fax: (520) 533-1588
knarrw@huachuca-emh1.army.mil
Air Platforms; Info Superiority

KOCH, Col Fred
HQ US European Command J5-D
Unit 30400, Box 1000
APO AE 09128
49711 680-5277; Fax: 49711 680-7338
CB Warfare/Counter WMD

KOLLMORGEM, CAPT R.
PMA-299
(703) 604-2500 x8847
Sensors, Elec & BS Environment

KORRELL, Maj Randy
AFSPC/XPX
Materials/Processes

KRESS, Mr. Bruce
B-2 SPO/YSDA
B-2 IPT Leader, Avionics and Software
Wright-Patterson AFB, OH 45433
(937) 255-9555; DSN: 787-9555
Fax: (937) 255-9450
kress.bruce@b2.wpafb.af.mil
Info Systems Tech

KRETZER, Mr. Michael
USAF Information Warfare Center
102 Hall Blvd., Ste 310
Kelly AFB, TX 78243
(210) 977-2567; DSN: 969-2567
Fax: (210) 977-3285
jmkretz@worldnet.att.net
Info Superiority

KROTKOV, Dr. Eric
Defense Advanced Research Projects
Agency /Tactical Technology Office
3701 N. Fairfax Dr
Arlington, VA 22203
(703) 696-4464; Fax: (703) 696-2204
ekrotkov@darpa.mil
Ground & Sea Vehicles

KUEHL, Mr. A.
USA Space & Missle Defense
Command SMDC-TC-50
PO Box 1500
Huntsville, AL 35807
205) 955-3772; Fax: (205) 955-2125
kuehla@smdc.army.mil
CB Defense & Nuclear

KUNEC, Mr. Daniel
Propulsion PM
Joint Strike Fighter Program Office
1745 Jefferson Davis Hwy, Ste 307
Arlington, VA 22202
(703) 602-7390 x6617
Fax: &030) 602-0593
Air Platforms; Materials/Processes

L

LABATAILLE, Mr. Roger
PEO-Ground Systems Integration
Warren, MI 48397
(810) 574-6721; DSN: 786-6721
Fax: (810) 786-7569
labatair@cc.tacom.army.mil
CB Defense & Nuclear

LANDRY, LTC Robert
Army Medical Department Center and School, HQ, USA Medical Command, Rm 115
Ft. Sam, Houston, TX 78234
(210) 221-7943; DSN: 471-7943
Fax: (210) 471-6673
ltc_robert_landry@smtplink.medcom.amedd.army.mil
Biomedical

LANGSTON, MAJ Thomas F.
Chief, Deployable Systems Requirements, HQ Air Combat Command/SGXO
Office of the Command Surgeon
162 Dodd Blvd, Ste 100
Langley AFB, VA 23665
(757) 764-1284; DSN: 574-1284
Fax: (757) 764-4631
Thomas.Langston@langley.af.mil
Human Systems

LANPHERE, LTC Mike
Joint Service Integration Group
Bldg 1081, Rm 122, Faith Wing
Ft. McClellan, AL 36205
(205) 848-6533; DSN: 865-6533
Fax: (205) 848-6687
lanpherem@mcclellan-cmls-army.mil
CB Defense & Nuclear

LASSWELL, Col James A.
Deputy Director, Experimental Operations/ USMC Warfighting Lab
2042 Broadway St, Ste 201
Quantico, VA 22134
(703) 784-5169; DSN: 278-5169
Fax: (703) 784-5025
lasswellj@quantico.usmc.mil
MOUT

LASTER, Mr. Paul E.
Acquisition Manager, Multifunction Staring Sensor Suite
Army Night Vision & Electronic Sensors Directorate
Ft. Belvoir, VA 22060
(703) 704-3492; DSN: 354-3492
Fax: (703) 704-111
plaster@nvl.army.mil
Precision Force

LAVIN, Mr. John
AF/ILSP
1030 Air Force Pentagon, Rm 4A276
Washington, DC 20330
(703) 697-6613; DSN: 227-6613
Fax: (703) 694-7570
lavinj@af.pentagon.mil
Air Platforms

LAW, Dr. Graham
Assistant Deputy Undersecretary of Defense for Technology Systems Integration, Office of the Undersecretary of Defense for Advanced Technology
Pentagon, Rm 3D148
Washington, DC 20301
(703) 693-0462; DSN: 223-0462
Fax: (703) 892-8061
lawg@acq.osd.mil
Info Superiority; Info Systems Tech; JR&L/SSS

LAWRENCE, Mr. James
Program Manager
Office of Special Technology
Technical Support Working Group
10530 Riverview Rd, Bldg 3
Ft. Washington, MD 20744
(301) 203-2634; Fax: (301) 203-2641
lawrence@specialtech.com
Combating Terrorism

LEAHY, Lt Col Mike
USAF Material Command/STE
2640 Loop Rd West
Wright-Patterson AFB, OH 45433
(937) 255-7764; DSN: 785-7764
Fax: (937) 656-4054
leahymb@rasg.wpafb.af.mil
Human Systems

LEE, Mr. Jim
Advanced Amphibious Assault Vehicle
(703) 492-3402
Materials/Processes

LEE, Mr. Robert
Air Force Research Laboratory/MES
Materials/Processes

LEEDOM, Dr. Dennis
Army Research Laboratory
AMSRL-HR-S
Aberdeen Proving Ground, MD 21005
(410) 278-5919; DSN: 298-5919
Fax: (410) 278-8830
dleedom@arl.army.mil
Human Systems

LE FEVRE, MAJ Graham R.
UKA (British Army) Standards and Interroperability Division, Office of the Director, Information Systems for C^4I
HQ Department of the Army
107 Army Pentagon
Washington, DC 20310
(703) 695-4555; DSN: 225-4555
Fax: (703) 695-5213
lefevr@hgda.army
Info Superiority

LEVAN, Dr. Paul
Air Force Research Laboratory/VSSS
3550 Aberdeen Ave, SE
Kirtland AFB, NM 87117
(505) 846-9959; Fax: (505) 846-9666
levan@plk.af.mil
Joint TMD

LEVINE, Mr. Stan
PEO C^3S, HTI
Info Superiority

LEWIS, Mr. Charles Lynn
USA Aviation and Missile Command
Redstone Arsenal, AL 35898
(205) 876-7663; DSN: 746-7663
Fax: (205) 876-8471
Lewis-CH@redstone.army.mil
Precision Force

LEWIS, Lt Col David
Office of Science, Technology, and Engineering Directorate
1900 South Eads St, Ste 100
Arlington, VA 22202
(703) 602-9870 x32; DSN: 332-9870
Fax: (703) 602-9199
DLewis@af.pentagon.mil
Space Platforms

LILLIE, Lt Col Tom
HQ USAF/XOOA
(703) 697-1702; DSN: 227-1702
Materials/Processes

LINDER, Mr. Steve
Office of Naval Research
800 N. Quincy St
Arlington, VA 22217
(703) 696-8482
Materials/Processes

LINK, Dr. Lewis E.
USA Corps of Engineers, CERD-ZA
20 Massachusetts Ave, NW
Washington, DC 20314
(202) 761-1839; Fax: (202) 761-0907
Materials/Processes

LITAVEC, LTC Douglas
Director, Fire Power Division
USA Infantry Center, ATZB-CDG
Rm 311
Ft. Benning, GA 31905
(706) 545-1016; DSN: 835-1016
Force Projection/Dominant Maneuver

LITTLE, Maj Kirk
US Atlantic Command
Advanced Technology Division
1562 Mitscher Ave, Ste 200
Norfolk, VA 23551
(757) 836-5351; DSN: 836-5351
Fax: (757) 836-7609
littlek@acom.mil
Info Superiority

LITTLEFIELD, Mr. Scott
Office of Naval Research
800 N. Quincy St
Arlington, VA 22217
(703) 696-2496; DSN: 426-2496
Sensors, Elec & BS Environment

LONDON, Dr. Gil
NAWC
Materials/Processes

LONG, Capt Michael C
Joint Intelligence Center, Central, Operational Intelligence Collection Management
7115 South Boundary Blvd
MacDill AFB, FL 33621
(813) 828-6319; DSN: 968-6319
Fax: (813) 828-6369
mlong558@digital.net
Info Superiority

LOOMIS, LTC Steve
AFZF-ENL
(817) 287-4232
Materials/Processes

LOPEZ, Dr. Carlos
SPP
Materials/Processes

LORTIE, Maj Joseph P.
Space & Missle Center/User Equipment Division/GPS JPO
2435 Vella Way, Ste 1613
Los Angeles AFB
El Sequndo, CA 90245
(310) 363-3454; DSN: 833-3454
Fax: (310) 363-3844
lortiejp@gps1.laafb.af.mil
Info Superiority

LOTT, MAJ Damien
HQ USMC (APW-61)
Aviation Weapons Dept
1155 Defense Pentagon, Rm 5D773
Washington, DC 20310
(703) 614-1729; DSN: 224-1729
Fax: (703) 614-2318
lottd@hqi.usmc.mil
Info Superiority

LOVERRO, Col Douglas
Office of the Deputy Undersecretary of Defense/AD
Pentagon, Rm 1E760
Washington, DC 20301
(703) 693-0254
Weapons

LOVETT, LTC Greg
PM-AEC St Louis
SFAE-AV-AEC
Elec Combat

LUKSIK, CDR John F. (Ret)
USN, PMS340
2531 Jefferson Davis Highway
Arlington, VA 22241
(703) 602-9024; DSN: 332-9024
Fax: (703) 602-5847
luksik_john_f_cdr@hq.navsea.navy.mil
Weapons

LUNCEFORD, Mr. W. H. (Dell)
Program Manager for ASTT and COAA, Defense Advanced Research Projects Agency /Information Systems Office
3701 N. Fairfax Dr
Arlington, VA 22203
(703) 696-2238; DSN: 426-2238
Fax: (703) 696-2203
dlunceford@darpa.mil
Info Systems Tech

LUNDIE, Maj Don
Chief, SEAD Requirements
HQ Air Combat Command/DRAS
204 Dodd Blvd, Ste 226
Langley AFB, VA 23665
(757) 764-6220; DSN: 574-6220
Fax: (757) 764-3596
acc.dras@langley.af.mil
Elec Combat

LUPO, Dr. Jasper C.
Director for Sensors and Electronics
Defense Research and Engineering (Sensors, Electronics & Battlespace Environment)
3080 Defense Pentagon, Rm 3D375
Washington, DC 20310
(703) 614-0206; DSN: 224-206
Fax: (703) 697-3762
lupojc@acq.osd.mil
Force Projection/Dominant Maneuver; Precision Force; Sensors, Elec & BS Environment; Weapons

LUZWICK, Lt Col Perry
DISA Global Operations and Security Center
Info Superiority

LYON, Mr. J. Michele
USA Missile Command
Redstone Arsenal, AL 35898
(205) 876-8119; DSN: 746-8119
Fax: (205) 876-4356
jlyon@redstone.army.mil
Weapons

LYONS, CAPT James
Director for Advanced Submarine Research & Development Office
Commander, C92R
Naval Systems Command
2531 Jefferson Davis Hwy
Arlington, VA 22242
(703) 602-3618; Fax: (703) 602-0820
lyons_james_capt@hq.navy.mil
Ground & Sea Vehicles

M

MACGREGOR, COL Douglas A.
USA Battle Command Battle Lab
415 Sherman Ave
Ft. Leavenworth, KS 66027
(913) 684-8052; DSN: 552-8052
Fax: (913) 684-2842
macgregord@LEAV-emh.army.mil
Info Systems Tech

MACK, Dr. Ingham
Office of Naval Research
800 N. Quincy St
Arlington, VA 22217
(703) 696-4825; DSN: 426-4825
Sensors, Elec & BS Environment

MACYS, CAPT David
USN Environmental Health Center
2510 Walmer Ave
Norfolk, VA 23513
(757) 363-5402; DSN: 864-5402
Fax: (757) 445-7885
macysd@ehc50.med.navy.mil
Biomedical

MADDEN, Col Patrick
Air and Space Command and Control Agency/C2CG
130 Andrews St, Ste 213
Langley AFB, VA 23665
DSN: 574-2269
Sensors, Elec & BS Environment

MAILLOUX, Bob
Air Force Research Laboratory
Sensors, Elec & BS Environment

MAKRAKIS, Greg
PMA-209
Materials/Processes; Weapons

MANFRA, LTC Ken
Headquarters, US Pacific Command (STA)
Box 64028
Camp H.P. Smith, HI 96861
(808) 477-0795; Fax: (808) 477-0797
manfrakl@nosc.mil
CB Warfare/Counter WMD; Precision Force

MARKEY, Mr. Bill
Army Night Vision & Electronic Sensors Directorate
Sensors, Elec & BS Environment

MARLIN, MAJ Evan
USAF Aeronautical Systems Command/XRSS
2275 D St, Ste 10
Wright-Patterson AFB, OH 45433
(937) 255-5035; DSN: 785-5035
Fax: (937) 656-7889
marlinen@xr_smtp_gw.wpafb.af.mil
Human Systems

MARTIN, Lt Col Douglas D.
USAF Joint Warfighting Center
Fenwick Rd, Bldg 96
Ft. Monroe, VA 23651
(757) 726-6432; DSN: 680-6432
Fax: (757) 726-6433
martind@jwfc.js.mil
JR&L/SSS

MARTIN, Mr. Gary E.
Theater Missile Defense IPT Leader
ASC/FBXT
2275 D St, Bldg 16
Wright-Patterson AFB, OH 45433
(937) 255-1230; DSN: 785-1230
Fax: (937) 785-4183
gary.martin@ascfb.wpafb.af.mil
Human Systems

MARTZ, Mr. Ken
Infantry for Combat Development
USA Infantry Center
Ft. Benning, GA 31905
(706) 545-4810, DSN: 835-4810
Weapons

MASSARO, Col James C.
Air Force Information Warfare Center
102 Hall Blvd., Ste 345
San Antonio, TX 78243
(210) 977-2091; DSN: 696-2091
Fax: (210) 977-3552
jcmassa@afiwc.osis.gov
Biomedical

MATHIS, CAPT Michael
Naval Sea Systems Command/PMS-422
2531 Jefferson Davis Hwy
Arlington, VA 22242
(703) 602-0202, DSN: 332-0202
Fax: (703) 602-6235
Weapons; Combat ID

MATLOCK, Mr. Richard
Ballistic Missile Defense
Organization/TRC-529
Pentagon
Washington, DC 20301
(703) 604-3132; DSN: 664-3132
Weapons

MATZELEVICH, CAPT Bill
N872E
Sensors, Elec & BS Environment

MAUGHAN, Mr. Phil
XVIII Airborne Corps
Ft. Bragg, NC 28307
(910) 396-8862; DSN: 236-8862
Fax: (910) 396-8215
Force Projection/Dominant Maneuver

MAZZARA, Col A. F.
Director, Joint Nonlethal Weapons
Directorate
3097 Range Rd
Quantico, VA 22134
(703) 784-1977; DSN: 278-1977
Fax: (703) 784-3178
mazzaraa@quantico.usmc.mil
MOUT

MCAULIFFE, Mr. Daniel J.
Air Force Research Laboratory/IFG
525 Brooks Rd
Rome, NY 13441
(315) 330-2165; DSN: 587-2165
Fax: (315) 330-1894
mcauliffed@rl.af.mil
Info Systems Technology; Info Superiority

MCCARTNEY, Mr. Pat
Attack Battle Lab
(405) 442-5028
Precision Force

MCCLELLAND, Dr. Richard
USA Tank-Automotive & Armaments
Command, Tank Automotive Research,
Development & Engineering Center
AMSTA-TR-R-MS # 202
Warren, MI 48397
(810) 574-5494; DSN: 786-5494
Fax: (810) 574-6013
mcclollr@cc.tacom.army.mil
Ground & Sea Vehicles

MCCOY, LCDR Tim
Naval Sea Systems Command/03Z
(703) 602-0450
Sensors, Elec & BS Environment

MCCRABB, Col Maris (Buster)
Air Force Space & Control Agency/2CE
130 Andrews St, Ste 216
Langley AFB, VA 23665
(757) 764-3501; DSN: 574-3501
Fax: (757) 764-7688
mccrabbm@hqaccdr.langley.af.mil
Info Systems Tech; Precision Force

MCHENRY, Dr. Mark
Defense Advanced Research Projects
Agency/Tactical Technology Office
3701 N. Fairfax Dr
Arlington, VA 22203
(703) 696-7495; DSN: 426-7495
Fax: (703) 696-2204
mchenry@darpa.mil
MOUT

MCMICHAEL, Dr. James
Defense Advanced Research Projects
Agency /Tactical Technology Office
3701 N. Fairfax Dr
Arlington, VA 22203
(703) 696-2377
jmcmichael@darpa.mil
Air Platforms

MCWILLIAMS, Dr. Robert
Defense Advanced Research Projects
Agency /DISA/JPO
4601 N. Fairfax Dr
Arlington, VA 22203
(703) 284-875; Fax: (703) 577-5042
rmcwilliams@jpo.org
JR&L/SSS

MEANS, Maj Joseph
J6K, Joint Staff (Information Assurance
Division)
Pentagon, Rm 1C826
Washington, DC 20350
(703) 614-7815; DSN: 224-7815
Fax: (703) 614-7814
meansj@js.pentagon.mil
Info Superiority

MEARS, Lt Col Christopher C.
Chief, Requirements & Integration Div
USAF Reserve
Pentagon, Rm 5C1075
Washington, DC 20330
(703) 697-4740; DSN: 227-4740
Fax: (703) 697-2083
chris.mears@re.hq.af.mil
Info Systems Tech

MEDLEY, Mr. David
USMC Training Center
Parris Island, SC
(803) 525-2142
Materials/Processes

MEEKER, Mr. James
Air Force Research Laboratory/MLS
Materials/Processes

MEFFORD, Maj Mitch
SMC/XRT
2430 El Segundo Blvd, Ste 1340
Los Angeles AFB
El Segundo, CA 90245
(310) 363-0844; DSN: 833-0844
Fax: (310) 363-6442
dwight.mefford@losangeles.af.mil
Space Platforms

MELENDEZ, Mr. Gerardo J.
PM Combat Identification
USA Communications-Electronics
Command, Intelligence and Electronic
Warfare & Sensors Division
Bldg 563
Ft. Monmouth, NJ 07703
(732) 427-5970; DSN: 427-5970
Fax: (732) 427-5962
melendez@doim6.monmouth.army.mil
Combat ID

MENZ, LCDR Keith
HQ US Central Command/J3-PI
7115 South Boundary Blvd
McDill AFB, FL 33621
(813) 828-5162; DSN: 968-5162
Fax: (813) 828-5829
menzkb@centcom.mil
Info Superiority

METZGER, Dr. Jim J.
Director, Joint Warfare System Office
1555 Wilson Blvd, Ste 619
Arlington, VA 22209
(703) 696-9492; DSN: 426-9492
Fax: 703-696-9563
metzgerj@paesmtp.pac.osd.mil
Info Systems Tech

MEYER, LTC Hal
Strategic Command, J55
901 SAC Boulevard, Ste 2E7
Offutt AFB, NE 68113
(420) 294-1132; DSN: 271-1132
Fax: (420) 294-1154
CB Defense & Nuclear; Weapons

MEYERS, Mr. Lee
Edwards AFB, Attn: PL/RK
Edwards AFB, CA 93523
(805) 275-5620; DSN: 350-5620
Fax: (805) 275-5086
meyerl@lablink.ple.af.mil
Weapons

MEYER, Lt Col Marty
Deputy Undersecretary of Defense for
Advanced Technology
3700 Defense Pentagon
Washington, DC 20301
(703) 614-0193; DSN 224-0193
Fax: (703) 695-8208
meyermg@acq.osd.mil
Combat ID; Elec Combat; Info Superiority

MICELI, Mr. William
Office of Naval Research
800 N. Quincy St
Arlington, VA 22217
(703) 696-0560; DSN: 426-0560
Fax: (703) 696-1331
miceli@nosc.mil
Combat ID; Sensors, Elec & BS Environment

MILLAR, COL Roy D.
PM Enhanced Fiber-Optic Guided
Missile, USA Missile Command
Redstone Arsenal, AL 35898
(205) 876-7725; DSN: 746-7725
Fax: (205) 842-8864
millarr@redstone.army.mil
Force Projection/Dominant Maneuver; Info Superiority, Info Systems Tech;Weapon

MILLER, Dr. Ann
Director, Information Technologies
Director Defense Research and
Engineering
Pentagon, Rm 3D367
Washington, DC 20301
(703) 695-0208; DSN: 225-0208
Fax: (703) 693-2981
millerak@acq.osd.mil
Info Superiority; Info Systems Tech

MILLER, Mr. Jack
Air Force Space Command,
MILSATCOM Systems Div/SCZ
150 Vandenberg St, Ste 1105
Peterson AFB, CO 80914
(719) 554-3898; DSN 692-3898
Fax: (719) 554-3571
millerj@spacecom.af.mil
Info Superiority

MILLER, Mr. Keith
Defense Advanced Research Projects
Agency /Defense Sciences Office
3701 N. Fairfax Dr
Arlington, VA 22203
Materials/Processes

MILLER, Maj Rick
Air Force Space Command/XPXT
150 Vandenberg St, Ste 1105
Peterson AFB, CO 80914
(719) 554-5233; DSN: 692-5233
Fax: (719) 554-5119
Space Platforms; Weapons

MILLS, Capt Mike
Air Intelligence Agency/XRRT
2 Hall Blvd, Ste 210
San Antonio, TX 78243
(210) 977-5269; DSN: 969-5269
Fax: (210) 977-4775
msmills@aia.af.mil
Info Systems Tech

MINER, Col Dennis
US Air Force, XORBP
1480 Air Force Pentagon
Washington, DC 20330
(703) 614-0760; DSN: 224-0760
Fax: (703) 695-1264
minerd@af.pentagon.mil
MOUT

MOLLOY, CAPT William D.
Chief, Advanced Simulation Division
Joint Warfighting Center
Fenwick Rd, Bldg 96
Ft. Monroe, VA 23651
(757) 727-6428; DSN: 680-6428
Fax: (757) 727-6433
molloyb@jwfc.js.mil
Info Systems Tech

MONROE, Col George
HQ Air Combat Command,
Requirements Directorate/DRM
(757) 764-4325; Fax: (757) 764-2338
monroe@hqaccdr.langley.af.mil
Air Platforms; Materials/Processes

MONTGOMERY, Mr. John
Naval Research Laboratory
4555 Overlook Ave, SW
Washington, DC 20375
(202) 767-6278
Sensors, Elec & BS Environment

MOOK, Mr. Rick
Air Force Research Laboratory/MNA
Bldg 13
Precision Force

MOORE, Mr. Dale
NAWCAD 4.3.4
Materials/Processes

MOORE, Mr. James
Air Force Research Laboratory/ AGTFT
Eglin AFB, FL 32542
(850) 882-5489 x3362; DSN: 872-5489
Weapons

MOORE, Lt Col Larry
HQ Air Combat Command/DRSP
204 Dodd Blvd
Langley AFB, VA 23655
(757) 764-7490; DSN: 574-7490
Fax: (757) 764-6211
Weapons

MOORE, Ms. Patricia
US Atlantic Command, J-2
1562 Mitschner Ave, Ste 299
Norfolk VA 23551
(757) 836-5018; DSN 836-5018
Fax: (757) 445-9951
patty@vo.com.inter.net
Info Superiority

MORFORD, CDR Peter
USN
Force Projection/Dominant Maneuver

MORGAN, CAPT John
N84
Sensors, Elec & BS Environment

MORGAN, Ms. Sara
USA, Enhanced Soldier System Team
PM-Soldier
10401 Totten Rd, Ste 121
Ft. Belvoir, VA 22060
(703) 704-3826; Fax: (703) 704-3820
smorgan@pm-soldier.us.net
Materials/Processes

MORRAL, CAPT Dennis
Navy Sea Systems Command/PMS 429
2531 Jefferson Davis Hwy
Arlington, VA 22242
(703) 602-7396; DSN: 332-7396
Weapons

MORRISH, Dr. Art
Defense Advanced Research Projects
Agency /Tactical Technology Office
3701 N. Fairfax Dr
Arlington, VA 22203
(703) 696-7502; Fax: (703) 696-2204
amorrish@darpa.mil
Ground & Sea Vehicles

MORRISON, Dr. Jeffrey G.
Space & Naval Warfare Systems Center
53560 Hull St, Bldg A-33, Rm 1405
San Diego, CA 92152
(619) 553-9070; DSN: 553-9070
Fax: (619) 553-9072
jmorriso@nosc.mil
Human Systems

MORSE, Dr. Steven
Defense Advanced Research Projects Agency /Defense Sciences Office
3701 N. Fairfax Dr
Arlington, VA 22203
(703) 696-7489; DSN: 426-7489
Fax: (703) 696-3999
smorse@darpa.mil
Biomedical

MOSCOSO, Mr. Chris
Joint Precision Strike Demonstration Project Office
10401 Totten Rd, Bldg 399, Ste 325
Ft. Belvoir, VA 22060
(703) 704-1966; DSN 654-1966
Fax: (703-704-2138
cmoscoso@nvl.army.mil
Info Superiority

MUELLER , Dr. George
Naval Research Laboratory
4555 Overlook Ave, SW
Washington, DC 20375
(202) 767-6977; Fax: (202) 767-6980
Materials/Processes

MUKAI, Mr. Dennis
Air Force Research Laboratory
Wright Laboratory
2241 Avionics Circle
Wright Patterson AFB, OH 45433
(937) 255-6427 x4351; DSN 785-6427
Fax: (937) 255-8086
Mukaidm@aa.wpafb.af.mil
Info Superiority; Sensors, Elec & BS Environment

MULDOON, LCDR R.
H-53
Materials/Processes

MURRAY, Maj Skip
US Strategic Command
910 SAC Blvd
Offutt AFB, NE 68113
(402) 294-5026: DSN: 271-5026
Fax: (402) 294-4985
j541@j5.stratcom.af.mil
CB Defense & Nuclear

MYRICK, Mr. Erwin
Ballistic Missile Defense Organization/TRS
Sensors, Elec & BS Environment

N

NAUDAIN, LTC Craig
PEO-GCSS, Attn: SFAE-GCSS-W-BV
Warren, MI 48397
(810) 574-7644
Materials/Processes; Weapons

NAUMANN, Maj Mark
USA Material Command/DCG
5001 Eisenhower Ave
Alexandria, VA 22333
(703) 617-9709
Weapons

NEIGHBOR, Mr. Terry
Air Force Research Laboratory/VA
2130 Eighth St, Ste 1
Wright-Patterson AFB, OH 45433
(937) 255-2532; DSN: 785-2532
Fax: (937) 656-4448
neighbtl@bo45mail.wpafb.af.mil
Air Platforms

NEIGHBORS, Mr. Robert H.
PEO Tactical Missiles
USA Missiles Command
Redstone Arsenal, AL 35898
(205) 876-6141; DSN: 746-6141
Fax: (205) 876-7849
rneigh@redstone.army.mil
Force Projection/Dominant Maneuver

NEUMANN, LTC Robert C.
US European Command
Box 451
APO AE 09128
011-49-711-680-8234
DSN: 430-8262
neumannr@eucom.mil
CB Defense & Nuclear; CB Warfare/Counter WMD

NEWBERRY, LTC Tom
PM Stinger
USA Missiles Command
Redstone Arsenal, AL 35898
(205) 876-4927; DSN: 746-4927
Weapons

NEWMAN, Mr. E.
PEO
(703) 602-1986 x207
Sensors, Elec & BS Environment

NG, Dr. Kam
Office of Naval Research
800 N. Quincy St
Arlington, VA 22217
(703) 696-0812; DSN: 426-0812
ngk@onr.navy.mil
Weapons

NICKELL, Mr. Stan
DAIM-FDF-B
(703) 428-6175; Fax: (703) 428-6197
Materials/Processes

NIFONTOFF, Capt. J.
SPAWAR PD18
(619) 524-7625
Sensors, Elec & BS Environment

NORTON, Col Randy
PEO-MIW M
2531 Jefferson Davis Hwy
Alexandria, VA 22242
(703) 602-9807; DSN: 332-9807
Fax: (703) 602-2906
Force Projection/Dominant Maneuver

NUMRICH, Dr. Susan K.
JCOS Program Manager, Joint Countermine Operational Simulation
Naval Research Lab (Code 5580)
4500 Overlook Ave, SW
WasHington, DC 20375
(202) 767-3567; DSN: 297-3567
Fax: (202) 404-1191
numrich@ait.nrl.navy.mil
Info Systems Tech

NUNZIATO, Mr. John
Project Manager, Warfighter Information Network–Terrestrial
SFAE-C3S-WIN-CMS
Ft. Monmouth, NJ 07703
(732) 532-1253; DSN: 992-1253
Fax: (732) 427-3494
nunziato@doim6.monmouth.army.mil
Info Systems Tech

NYCZ, Mr. Tom
USA Communications-Electronics Command
(732) 532-8982
Sensors, Elec & BS Environment

O

O'CONNOR, Maj Ed
US Special Operations Command
PO Box 70660
Ft. Bragg, NC 28307
(910) 396-0657; DSN: 239-0657
Fax: (910) 239-6873
oconnore@soc.mil
Human Systems

O'DWYER, Maj Jim
USMC Warfighting Laboratory
Barrett Hall, 2042 Broadway, Ste 201
Quantico, VA 22134
(703) 784-1083; Fax: (703) 784-1378
odwyerj@quantico.usmc.mil
Human Systems

OGG, Mr. Jon
F-22 SPO
(513) 255-4167
Materials/Processes

OGRODNIK, Robert
Air Force Research Laboratory/OCSM
(315) 330-3903
Sensors, Elec & BS Environment

OLDHAM, Mr. Jim
ICBM SPO
Materials/Processes

OLSON, Maj Craig
Joint STARS/SPO (ESC/JSIH)
Radar Technology Insertion PM
75 Vandenberg Dr
Hanscom AFB, MA 01731
(617) 377-6304; DSN: 478-6304
Fax: (617) 377-5792
olsonc@hanscom.af.mil
Info Systems Tech

OLSON, CPT John
USA Intelligence Center
Bldg 4, Rm 319
Ft. Benning, GA 31905
(706) 545-6399; DSN: 835-6399
Fax: (706) 545-2517
olsonj@benning-emh2.army.mil
Biomedical

OPEKA, Dr. Mark
NSWCCD
(301) 394-3513; Fax: (301) 394-2958
Materials/Processes

O'PRAY, COL John E.
Director, Defense Research and Engineering, Systems Analysis
3080 Defense, Pentagon, Rm 3E1045
Washington, DC 20301
(703) 695-0598; Fax: (703) 614-6829
oprayje@acq.osd.mil
Joint TMD; Sensors, Elec & BS Environment

OSWALD, LTC Paul
HQ US Pacific Command, J-54K
Box 60145
Camp H.M. Smith, HI 96861
(808) 477-3152; Fax: (808) 477-0242
oswaldpa@hq.pacom.smk.mil
CB Defense & Nuclear

OWEN, Col Rick L.
Director for Ground Weapons, Marine Corps Systems Command/Ground Weapons (G136)
2033 Barnett Ave, Ste 315
Quantico, VA 22134
(703) 784-2006 x2703; DSN: 278-2006
Fax: (703) 784-5842
owenr@mqg-smtp3.usmc.mil
MOUT; Weapons

OXFORD, Mr. Vayl
Defense Special Weapons Agency/PMC
6801 Telegraph Rd
Alexandria VA 22310
(703) 325-2403; Fax: (703) 325-2961
oxford@hq.dswa.mil
CB Warfare/Counter WMD

P

PADGETT, COL Thomas
Office of the Undersecretary of Defense (FMP) (PSFE)
4000 Defense Pentagon, Rm 1B700
Washington, DC 20301
(703) 695-3629; DSN: 225-3629
Fax: (703) 697-2519
padgettj@pr.osd.mil
Biomedical

PAGE, COL Thomas F.
Hq USA Training and Doctrine Command, ATCD-Q
(804) 727-3160; DSN: 680-3160
Fax: (804) 727-2588
paget@emhio.monroe.army.mil
Combat ID

PALADINO, Mr. Richard
PM Tactical Missiles, CCAWS
Redstone Arsenal, AL 35898
(205) 842-0851
rpaladino@ccaws.redstone.army.mil
Force Projection/Dominant Maneuver

PAPINEAU, LT James C.
Program Manager, USN Joint Special Operations Command
PO Box 70239
Ft Bragg, NC 28307
(910) 396-9084; DSN 236-9084
Fax: (910) 396-0573
CB Defense & Nuclear

PARKER, COL Gerald
Air Combat Command, USA Medical Research, Materiel Command
505 Scott St, Ft. Detrick
Frederick, MD 21702
(301) 619-7439; DSN: 343-7439
Fax: (301) 619-2416
col_gerald_parker@ftdetrck-ccmail.army.mil
Biomedical

PARMER, Maj Tim
Chief of Tactical Standoff Systems
HQ Air Combat Command/DRPW
204 Dodd Blvd, Ste 226
Langley AFB, VA 23655
(757) 764-7068; DSN: 574-7068
Fax: (757) 764-5124
Weapons

PATTEN, Dr. Frank
Defense Advanced Research Projects Agency/Defense Sciences Office
3701 N. Fairfax Dr
Arlington, VA 22203
(703) 696-2285; Fax: (703) 696-3999
Materials/Processes

PAUL, Mr. Jeffrey
Director, Defense Research and Engineering (Sensors, Electronics & Battlespace Environment)
Combating Terrorism

PAULK, Mr. Michael
MLS-OL/SA-ALC
Materials/Processes

PAWLICKI, COL R.
USA Research, Development and Engineering Center
Bldg 65, North
Attn: PM TMAS
Picatinny Arsenal, NJ 07806
(973) 724-5307; DSN: 880-5307
Fax: (973) 724-6959
Weapons

PEARL, Mr. Jeff
Naval Sea Systems Command/PMS-422
2531 Jefferson Davis Hwy
Arlington, VA 22242
(703) 602-0663; DSN: 332-0663
Weapons

PEEL, Maj Mike
USAF Space Command, XPX
150 Vanderberg St, Ste 1105
Peterson AFB, CO 80914
(719) 554-5842; DSN: 692-5842
Fax: (719) 554-5119
mpeel@spacecom.af.mil
Info Systems Tech

PENTACOST, COL Brian M
Director Operations and Training, Headquarters, USA Infantry School
Ft. Benning, GA 31905
(706) 545-5717; DSN: 838-5717
Fax: (706) 545-8818
pentacostb@benning-emh2.army.mil
Info Systems Tech

PERDUE, Mr. Tom
Assistant, Deputy Undersecretary of Defense for Advanced Technology
3700 Defense Pentagon, Rm 3E1045
Washington, DC 20301
(703) 697-8045; DSN: 227-8045
Fax: (703) 697-3585
Perduet@acq.osd.mil
Info Superiority; Force Projection/ Dominant Maneuver

PEREZ, LTC Steve
US European Command
Box 451, APO AE 09128
011-49-711-680 7160
CB Defense & Nuclear; Weapons

PERKINS, Dr. Charles
Assistant Deputy Undersecretary of Defense for Special Projects
Pentagon, Rm 3E1065
Washington, DC 20301
(703) 697-3568; DSN: 227-3568
Fax: (703) 695-8208
perkincw@acq.osd.mil
Elec Combat; Info Superiority; Info Systems Tech; Force Projection/ Dominant Maneuver; Precision Force

PETITO, Mr. Fred
Army Night Vision & Electronic Sensors Directorate
Sensors, Elec & BS Environment

PHULL, LTC Kotu
USA Center, Health Promotion and Preventive Medicine
Aberdeen Proving Ground, MD 21010
(410) 671-2306; DSN: 284-2306
Fax: (410) 671-4784
ltckotophull@chppm5-apgea.army.mil
Biomedical

PIERRE, Dr. Les
Ballistic Missile Defense Organization/JNB
Pentagon
Washington, DC 20301
(703) 604-3128; DSN: 664-3128
Fax: (703) 604-3106
leslie.pierre@bmdo.osd.mil
CB Defense & Nuclear

PILCHER, CAPT Ray
Head, Land Attack Warfare
Department of the Navy, N864
2000 Navy Pentagon
Washington, DC 20350
(703) 697-1465
Precision Force

PIROG, Mr. John
Air Force Research Laboratory
Info Superiority

PISANO, Dr. A. P.
Defense Advanced Research Projects Agency/Electronic Technology Office
3701 N. Fairfax Dr
Arlington, VA 22203
Sensors, Elec & BS Environment

PLEBANEK, Col Robert
Defense Advanced Research Projects Agency /Information Systems Office
3701 N. Fairfax Dr
Arlington, VA 22203
(703) 696-2375; DSN: 426-2375
Fax: (703) 696-2203
rplebanek@darpa.mil
Info Systems Tech

POHANKA, Dr. R.
Office of Naval Research
800 N. Quincy St
Arlington, VA 22217
(703) 696-4309; DSN: 426-4309
Fax: (703) 696-8343
Materials/Processes

PORTER, Mr. Jon
Air Force Research Laboratory/MLQC
(850) 283-3073; DSN: 523-3073
Fax: (850) 283-4932
Materials/Processes

POTTER, Mr. Marshall R.
Director Defense Research & Engineering/Information Technology
Pentagon, Room 3D367
Washington, DC 20301
(703) 614-0207; DSN: 224-0207
Fax: (703) 693-2981
pottermr@acq.osd.mil
Info Systems Tech

POWELL, COL William
USA Training and Doctrine Command
Ft. Rucker, AL 36362
(334) 255-3320; DSN: 558-3320
Human Systems

PRICE, Mr. John
ASAF Aeronautical Systems Center/RAE
2640 Loop Rd, West
Wright-Patterson AFB, OH 45433
(937) 255-6747; Fax: (937) 656-4293
pricejw@rasg.wpafb.af.mil
Human Systems

PRICE, Lt Col Walter R.
Defense Advanced Research Projects Agency/Tactical Technology Office
3701 N. Fairfax Dr
Arlington, VA 22203
(703) 696-7500; DSN: 426-7500
Fax: (703) 696-8401
Elec Combat

PUTZ, COL Neil L
Joint Staff (J6T)
Pentagon, Rm 1D826
Washington, D.C. 20351
(703) 697-1934; DSN: 227-1934
Fax: (703) 614-9364
neil.putz@js.pentagon.mil
Info Superiority

Q

QUIGLEY, Mr. Richard
Air Force Research Laboratory/PR
1950 Fifth St
Wright-Patterson AFB, OH 45433
(937) 255-5334; DSN: 785-2520
Fax: (937) 656-4657
quiglere@wl.wpafb.af.mil
Air Platforms

R

RADICH, CAPT Thomas F.
Military Deputy to the Deputy Undersecretary of Defense for Advanced Technology
3700 Pentagon, Rm 3E1044
Washington, DC 20301
(703) 695-5036; DSN: 225-5306
Fax: (703) 614-6829
radicht@acq.osd.mil
Force Projection/Dominant Maneuver; JR&L/SSS

RAMBERG, Dr. Steven
Office of Naval Research
800 N. Quincy St
Arlington, VA 22217
(703) 696-4358
Sensors, Elec & BS Environment

RANELLI, Mr. Pete
CNMOC
DSN: 485-4500
Sensors, Elec & BS Environment

READY, Mr. Tom
DD-21
(703) 602-6453 x176
Materials/Processes

REDDY, Col Robert P.
Director, Warfighting, USA Training and Doctrine Command
DCST, Bldg 161
Ft. Monroe, VA 23651
(757) 728-5726; DSN: 680-5726
Fax: (757) 728-5743
reddyr@emh12.monroe.army.mil
JR&L/SSS

REEPS, Ms. Suzanne
NCTRF
PO Box 59, Code N2
Natick, MA 01760
(508) 233-4189; DSN: 256-4189
Fax: (508) 233-4653
sreeps@natick-amed02.army.mil
Human Systems

REEVES, COL Stephen V.
PM-NBC Defense Systems
5232 Fleming Rd
Aberdeen Proving Ground, MD 21010
(410) 671-4056; Fax: (410) 671-1383
svreeves@cbdcom.apgea.army.mil
CB Defense & Nuclear

REGIAN, Dr. W.
Air Force Research Laboratory/HEJT
7909 Lindbergh Dr, Bldg 578, Rm 106E
Brooks AFB, TX 78235
(210) 536-2034; DSN: 240-2034
Fax: (210) 536-2902
regian@alhrt.brooks.af.mil
Human Systems

REICHLEN, Mrs. Gladys
Defense Advanced Research Projects Agency, DISA AITS-JPO
3701 N. Fairfax Dr
Arlington, VA 22217
(703) 284-8890; Fax: (703) 527-5042
greichlen@darpa.mil
Info Systems Tech

REID, LTC Jerry
Human Systems Program Office
Human Systems Center/YACA
485 Quenton Roosevelt Rd., Ste 7
Kelly AFB, TX 78241
(210) 925-3756; DSN: 945-3756
Fax: (210) 945-0189
JeReid@ldgate1.kelly.af.mil
Human Systems

REINGRUBER, Mr. John K
Assistant for Science & Technology
Office of the Secretary of Defense (Special Operations/Low-Intensity Conflict), Forces & Resources
Pentagon, Rm 1A674B
Washington, DC 20301
(703) 693-5222; DSN: 223-5222
Fax: (703) 693-3039
solicaq@policyl.policy.osd.mil
Combating Terrorism

RESIO, Dr. Donald T.
Senior Scientist, Joint Logistics Over the Shore Program
USA Engineering Waterways Experiment Station Coastal & Hydraulics Lab
3909 Halls Ferry Rd (CHL-CV-CS)
Vicksburg, MS 39180
(601) 634-2018; Fax: (601) 634-2055
d.resio@cerc.wes.army.mil
Info Systems Tech

REYMAN, Mr. Chris
NACW-AC
JR&L/SSS

REYNOLDS, Mr. John
Multiple Launch Rocket System Project Office, USA Missile Command
Redstone Arsenal, AL 35898
(205) 842-7217; DSN: 788-7217
Fax: (205) 955-0136
Precision Force

RICH , Capt Ben
Air & Space Command and Control Agency, HQ Air Combat Command
130 Andrews St, Ste 213
Langley AFB, VA 23665
(757) 764-5708; DSN: 574-5708
Fax: (757)764-4101
ben.rich@langley.af.mil
Combat ID

RICHARDSON, Capt Andrew
USAF Space and Missile Systems Center
2430 East El Segundo Blvd, Ste 1340
El Segundo, CA 90245
(310) 363-2508; DSN: 833-2508
Fax: (310) 363-2332
andrew.richardson@losangeles.af.mil
CB Defense & Nuclear

RICHARDSON, CAPT Dana
Office of the Assistant Secretary of the Navy for Research, Development and Acquisition
Pentagon
Washington, DC 20301
(703) 695-7949; DSN: 225-7949
Fax: (703) 614-4608
Weapons

RICHBURGH, Mr. Dennis
AIA/CA
2 Hall Blvd., Ste 201
San Antonio, TX 78243
(210) 977-2005; DSN: 969-2005
Fax: (210) 977-3539
dbr@mail.aia.af.mil
Human Systems

RIEVE, CAPT Robert
Chief of Naval Operations/N851
(703) 695-1444
MOUT

RIGGINS, Capt David
Demonstration Manager
C-MRL ACTD
Joint Precision Strike Office
10401Totten Rd, Ste 312
Ft. Belvoir, VA 22060
(703) 704-1527; DSN: 654-1527
Fax: (703) 704-2138
wriggins@nvl.army.mil
Precision Force/Dominant Maneuver

RITHMIRE, Mr. Michael
Office of the Assistant Secretary of the Army for Research, Development & Acquisition, Attn: SARD-TT
Pentagon
Washington, DC 20310
(703) 697-8434
Force Projection/Dominant Maneuver; Weapons

ROBERTS, COL Kathy
USAF Space and Missile Center
SBIRS–Low Program
185 Discovery Blvd, Ste 1315
Los Angeles, CA 90245
(310) 363-1985; DSN: 833-1985
Fax: (310) 363-6882
roberts@laafb.af.mil
Space Platforms

RODRIGUEZ, Mr. Gume
AMSRL-WM-MA
Materials/Processes

ROWELL, LtCol Mike
Demonstration Manager, Joint Command and Control Warfare Center
2 Hall Blvd., Ste 217
San Antonio, TX 78243
(210) 977-2483; DSN: 969-2483
Fax: (210) 977-4166
Elec Combat

RUCKY, Mr. Frank
B04 Dahlgren Naval Surface Warfare Center
17320 Dahlgren Rd
Dahlgren, VA 22448
(703) 418-8216; Fax: (703) 418-8347
rucky_frank@hq.navsea.navy.mil
Sensors, Elec & BS Environment

RUSSELL, Mr. William
MCHB-DC-EEN
Materials/Processes

RUTH, COL Henry C. III
Director, Army Modeling & Simulation Office, Office of the Direction Director
Chief of Staff for Operations & Plans
1111 Jefferson Davis Hwy
(CG North, Ste 503E)
Arlington, VA 22202
(703) 601-0006, x11; DSN: 329-0006
Fax: (703) 601-0018
ruthhec@dcsopspo3.army.mil
JR&L/SSS; Info Systems Tech

RUTH, Robert J.
Defense Advanced Research Projects Agency /Information Technology Office
3701 N. Fairfax Dr
Arlington, VA 22203
(703) 696-2260; DSN: 426-2260
Fax: (703) 696-2202
rruth@darpa.mil
Info Systems Tech

RYAN, Col Owen (Dan)
J6, Joint Staff, Chief, Information Superiority Office
Pentagon, Rm 1D777
Washington, DC 20301
(703) 614-3577; DSN: 224-3577
Fax: (703) 697-7058
owen.ryan@js.pentagon.mil
Info Superiority

S

SALAS, Mr. Raul
USAF Info Warfare Battle Lab
102 Hall Blvd, Ste 214
San Antonio, TX 78243
(210) 977-4410; DSN: 969-4410
Fax: (210) 977-2122
rcsalas@afiwc.osis.gov
Info Systems Tech

SANDERS, Maj Hank
Air Force Special Operations
100 Bartley St, Bldg 1
Hurlburt Field, FL 32544
(904) 884-5986; DSN: 579-5986
Fax: (904) 579-2130
sandersh@hqafsoc.hurlburt.af.mil
Human Systems

SANDGATHE, Dr. Scott
Office of Naval Research
800 N. Quincy St
Arlington, VA 22217
Sensors, Elec & BS Environment

SANTI, Mr. Victor P.
ASAF Aeronautical Systems
Center/YFAIC
2130 Fifth St
Wright-Patterson AFB, OH 45433
(937) 255-1558 x 2426; DSN: 785-0949
Victor.Santi@acs-yf.wpafb.af.mil
Human Systems

SASHIN, CDR Michael
J4 (MRD)
Joint Staff, The Pentagon, Rm 2D828
Washington, DC 20716
(703) 697-4421; DSN: 227-4421
Fax: (703) 697-0510
msashin@js.pentagon.mil
Biomedical

SASS, Mr. Paul
USA Communications-Electronics
Command, Space & Terrestrial
Communications Directorate
AMSEL-RD-ST-C
Ft. Monmouth, NJ 07703
(732) 427-2306; DSN: 987-2306
Fax: (732) 427-2822
sass@doim6.monmouth.army.mil
Info Systems Tech

SAUNDERS, Mr. Rob
Office of the Assistant Secretary of the
Army for Research, Development &
Acquisition, Attn: SARD-TT
103 Army Pentagon, Rm 3480
Washington, DC 20310
(703) 697-8433; DSN: 227-8433
Fax: (703) 695-3600
saunderr@sarda.army.mil
Force Projection/Dominant Maneuver; Precision Force; Sensors, Elec & BS Environment; Weapons

SAVAGE, Col Richard T.
Project Manager, Air-to-Ground
Missiles System
USA Missiles Command
Redstone Arsenal, AL 35898
(205) 876-1365; DSN: 645-8532
Fax: (205) 955-8532
Precision Force; Weapons

SAWYER, Maj Buzz
Hq USAF/XOR
1480 Air Force Pentagon
Washington, DC 20330
(703) 614-0760; DSN: 225-0760
Fax: (703) 695-1624
sawyers@af.pentagon,mil
CB Defense & Nuclear

SCHAEFER, Ms. Pamela
Air Force Research Laboratory/MLPJ
Wright-Patterson AFB, OH 45433
(937) 255-3808 x3150; DSN: 785-3808
Fax: (937) 255-1128
Materials/Processes

SCHAFFRAN, Mr. Robert
Program Manager for MARITECH
Defense Advance Research Project
Agency/Tactical Technology Office
MARITECH Program Office
4301 N. Fairfax Dr
Arlington, VA 22203
(703) 696-2354; Fax: (703) 696-2980
bschaffra@bs1.prc.com
JR&L/SSS

SCHANCHE, Mr. Gary
CERL
(217) 373-7275
Materials/Processes

SCHATTLE, LtCol Duane
Naval Sea Systems Command, J8/LLD
Pentagon, Rm 3D940
Washington, DC 20130
(703) 695-4657; Fax: (703) 695-8031
shatldr@js.pentagon.mil
MOUT

SCHEUREN, Dr. Bill
Joint Strike Fighter
(703) 696-2321
Materials/Processes

SCHINDLER, LtCol James W.
Logistics Integration Officer, Marine
Corps Combat Development Center
330 Russell Rd, Ste 200
Quantico, VA 22134
(703) 784-6287; DSN: 278-6287
Fax: (703) 784-3265
schindlerj@quantico.usmc.mil
JR&L/SSS

SCHMIDT, Dr. Edward M.
Army Research Laboratory
Attn: AMSRL-WM-B
Aberdeen Proving Ground, MD 21005
(410) 278-3786; DSN: 298-3786
Weapons

SCHNEIDER, Mr. Paul A.
Exective Director of Naval Sea Systems
Command
2531 Jefferson Davis Hwy
Arlington, VA 22242
(703) 602-2366; DSN: 332-2366
Fax: (703) 602-1454
schneider_paul_a@hq.navsea.navy.mil
JR&L/SSS

SCHNEIDER, Mr. Phillip
PMS 377
(703) 602-8515
Materials/Processes

SCHROEDER, COL James
TSM Tactical Radio, USA Signal Center
Ft. Gordon, GA 30905
(706) 791-2981; DSN: 780-2981
Fax: (706) 790-3352
schroedj@emh1.gordon.army.
Info Systems Tech

SCHROEDER, Mr. Steve
Arnold Engineering Development
Center
1090 Avenue C., Ste E205
Arnold AFB, TN 37389
(931) 454-6653; DSN: 340-6653
Fax: (931) 454-3559
schroeder@hap.arnold.af.mil
Info Systems Tech

SCHROLL, Dennis W.
Personal Systems Specialist
USAF Aeronautical Systems
Center/ENFC, Crew Systems Branch
2530 Loop Rd West
Wright-Patterson AFB, OH 45433
(937) 255-7953; DSN: 785-7593
Fax: (937) 255-8063
schroldw@asc-en.wpafb.af.mil
Human Systems

SCHULTE, Mr. Harry E.
AF PEO Tactical Systems
1050 Air Force Pentagon, Rm 4C328
Washington, DC 20330
(703) 695-8343; Fax: (703) 614-0693
Materials/Processes

SCHURMEIER, Mr. Dennis
NPRDC Code 11
53335 Ryne Rd
San Diego, CA 92152
(619) 553-8034; Fax: (619) 553-0453
dennis@nprdc.navy.mil
Human Systems

SCHWARTZ, Mr. Fred
SSF
(703) 602-7390 x6637
Air Platforms

SEBASTO, Mr. Anthony
USA Armament Research, Development
and Engineering Center
Picatinny Arsenal, NJ 07806
(973) 724-6192; DSN: 880-6192
Fax: (973) 724-6353
Weapons

SEDRIKS, Dr. John
Office of Naval Research
800 N. Quincy St
Arlington, VA 22217
Materials/Processes

SEIDEL, Dr. Robert J.
Chief, Advanced Training Methods
Research Unit, Army Research Institute
5001 Eisenhower Ave
Alexandria, VA 22333
(703) 617-8838: DSN: 767-8838
Fax: (703) 617-3268
seidel@ari.fed.us
JR&L/SSS

SELIX, LTC George
ASAF Air Education and Training
Command/XPRT
244 F St, East, Ste 2
Randolph AFB, TX 78150
(210) 652-7840; DSN: 487-7840
Fax: (210) 652-2537
selixg@rndgate1.aetc.af.mil
Human Systems

SENGUPTA, Dr. Somnath
Army Research Laboratory
(302) 892-6545; Fax: (302) 892-6504
Materials/Processes

SHAFFER, Col Alan
Director Defense Research and
Engineering (Sensors, Electronics &
Battlespace Environment)
Pentagon, Rm 3D375
Washington, DC 20301
(703) 614-0206; DSN: 224-0206
Fax: (703) 697-3762
Info Superiority; Sensors, Elec & BS Environment

SHANABROOK, Dr. Ben
Naval Research Laboratory
4555 Overlook Ave, SW
Washington, DC 20375
Sensors, Elec & BS Environment

SHANNON, CAPT William
Chief of Naval Operations/N88
2000 Navy Pentagon
Washington, DC 20350
(703) 695-2688; DSN: 225-2688
Fax: (703) 695-2919
Force Projection/Dominant Maneuver; Weapons

SHARKEY, Mr. J. Brian
Defense Advanced Research Projects
Agency/Information Systems Office
3701 N. Fairfax Dr
Arlington, VA 22203
(703) 526-6601; DSN: 426-6601
Fax: (703) 522-8916
bsharkey@darpa.mil
Info Systems Tech; JR&L/SSS

SHARP, Mr. Scott
AFSPC
(702) 532-9767 x4002
Sensors, Elec & BS Environment

SHEIBLEY, Mr. Robert
PM ALSE
(314) 263-8199
Materials/Processes

SHEIL, MAJ Martin C., USA
US Atlantic Command (J2P3B)
1562 Mitscher Ave, Ste 200
Norfolk, VA 23551
(757) 836-0282; DSN: 836-0282
Fax: (757) 836-0260
shiel@acom.mil
Info Superiority

SHEN, Mr. Chyau N.
NAWCAD 4.5.5.6
48110 Shaw Rd, Unit 5
Patuxent River, MD 20670
(301) 342-0093; Fax: (301) 342-0129
Shen_Chyau%PAX5A@mr.nawcad.
navy.mil
Combat ID

SHEPARD, CAPT
PMA-231
(703) 604-2282
Sensors, Elec & BS Environment

SHIPLEY, Maj Buford
Ballistic Missile Defense
Organization/TOS
1725 Jefferson Davis Hwy, Ste 809
Arlington, VA 22202
(703) 604-3163; Fax: (703) 604-3926
buford.shipley@bmdo.osd.mil
Joint TMD

SHISLER, Mr. Vernon E.
USA Armament Research, Development
and Engineering Center
Picatinny Arsenal, NJ 07806
(973) 724-6009; DSN: 880-6009
Fax: (973) 724-6930
Weapons

SHKOR, RADM J. E.
JIATFE
Combat ID

SICHINA, Mr. Jeff
Army Research Laboratory
2800 Powder Mill Rd
Adelphi, MD 20783
(301) 394-2530; Fax: (301) 394-4690
jsichina@arl.mil
Sensors, Elec & BS Environment

SIEGEL, Mr. David S.
Office of Naval Research
800 N. Quincy St
Arlington, VA 22217
(703) 696-0554; DSN: 426-0554
Precision Force; Weapons

SILVA, COL John
Defense Advanced Research Projects
Agency /Defense Sciences Office
3701 N. Fairfax Dr
Arlington, VA 22203
(703) 696-2221; DSN: 426-2221
Fax: 703-696-3999
jsilva@darpa.mil
Biomedical

SILVER, Col Dayton L.
Deputy for ICBM Systems, Strategic &
Tactical Systems/Missile Warfare
3090 Defense Pentagon, Rm 3D136
Washington, DC 20301
(703) 695-7328; DSN: 225-7328
Fax: (703) 697-2457
silverdl@acq.osd.mil
JR&L/SSS

SIMMONS, LTC P. K.
US Strategic Command
901 SAC Boulevard
Offutt AFB, NE 68113
(402) 294-7001; DSN: 271-5784
Fax: (402) 294-6913
simmonsp@hq.dswa.mil
CB Defense & Nuclear

SINGARAJU, Dr. B.
VSS Technical Advisor
Air Force Research Laboratory
Phillips Laboratory/VSS
3550 Aberdeen Ave SE
Kirtland AFB, NM 87117
(505) 846-0484; Fax: (505) 696-2290
Sensors, Elec & BS Environment

SINGLETON, Col T. J.
Office of Naval Research
800 N. Quincy St
Arlington, VA 22217
(703) 696-1299; DSN: 426-1299
Force Projection/Dominant Maneuver

SISSON, Mr. Olen
APEO (T)
(703) 604-3900 x5929
Air Platforms; Materials/Processes

SLOTER, Dr. Lewis
Director Defense Research and
Engineering for Advanced Technology
(703) 695-0005; Fax: (508) 233-4700
Materials/Processes

SMITH, Ms. Janice
Space and Missile Systems Center,
MILSATCOM Joint Program Office,
Advanced Program Directorate
2420 Vela Way, Ste 1467
Los Angeles AFB
El Segundo, CA 90245
(310) 336-4844; DSN: 833-4844
Fax: (310) 336-4905
SmithJ@mc.laafb.af.mil
Space Platforms

SMITH, Mr. Jeffrey
Defense Advanced Research Projects Agency /Tactical Technology Office
3701 N. Fairfax Dr
Arlington, VA 22203
(703) 696-2305
Air Platforms

SNEDECOR, Maj Michael
Det 1, Human Systems Center
Preventive Services Directorate
2602 Doolittle Rd
Brooks AFB, TX 78235
(210) 536-6518; DSN: 240-6518
Fax: (210) 536-6290
snedecor@ophsa1.brooks.af.mil
Biomedical

SNIDER, Mr. Gary
Naval Air Systems Command
DSN: 664-6240 x2863
Sensors, Elec & BS Environment

SNIDER, MG James
Program Executive Office, Aviation
Bldg 5681
Redstone Arsenal, AL 35898
(205) 313-4000; DSN 897-4000
Fax: (205) 313-4013
sniderj@peoavn.redstone.army.mil
Air Platforms

SNOW, Mr. Patrick R.
Director Defense Research and Engineering (E&LS)
USA Natick RD&E Center, Kansas St,
Natick, MA 01760
(508) 233-5436; DSN: 256-5436
Fax: (508) 233-4483
panow@natick-emh2.army.mil
Human Systems

SNYDER, Mr. George W.
USA Missile Command
Redstone Arsenal, AL 35898
(205) 876-3483; DSN: 746-3483
Fax: (205) 876-9861
Weapons

SOBELEWSKI, Ms. Elisa
Defense Advanced Research Projects Agency/Electronic Technology Office
3701 N. Fairfax Dr
Arlington, VA 22203
(703) 696-2254; Fax: (703)696-2206
esobelewski@darpa.mil
Sensors, Elec & BS Environment

SOLHAN, Mr. George W.
Deputy Director for Amphibious Warfare & Technology Directorate,
Marine Corps Systems Command
2033 Barnett Ave, Ste 315
Quantico, VA 22134
(703) 640-2220; DSN: 278-2761
Fax: (703) 640-2764
solhan@mqg-smtp3.usmc.mil
Info Systems Tech; Space Platforms

SORENSEN, CDR Dennis
Office of Naval Research
800 N. Quincy St
Arlington, VA 22217
Precision Force

SORRELL, LtCol Dennis
Marine Corps Combat Development Center, C^4I Requirement
JR&L/SSS

SPECTOR, Mr. Phillip H.
Deptuty for Plans & Programs
Strategic Systems Program 2020
1931 Jefferson Davis Hwy
Arlington, VA 22202
(703) 607-3444; Fax: (703) 607-2233
JR&L/SSS

SPINK, Mr. Brian
Air Force Research Laboratory
Information Directorate
525 Brooks Rd
Rome, NY 13441
(315) 330-7596; DSN: 587-7596
Fax: (315) 330-4390
spinkb@rl.af.mil
Info Superiority

SPRACKLIN, LCDR David B.
Project Engineer, Naval Air Command
41.1.2/PMA 299
Bldg 2272, Ste 156
47123 Busea Rd Unit IPT
Patuxent River, MD 20670
(301) 757-5335; DSN: 757-5335
Fax: (301) 757-5276
JR&L/SSS; Materials/Processes

STANLEY, Mr. Jeff
Air Force Research Laboratory/SNZ
Joint Strike Fighter Mission Systems IPT
2241 Avionics Circle, Bldg 620, Ste 1
Wright-Patterson AFB, OH 45433
(937) 255-4794 x4318; DSN: 785-4794
Fax: (937) 255-9539
stanlejh@aa.wpafb.af.mil
Elec Combat

STEED, LCDR Michael
US European Command
Precision Force

STEELE, CDR Timothy P.
Deputy Director, Cognitive & Neural Science & Technology Div
Office of Naval Research
800 N. Quincy St
Arlington, VA 22217
(703) 696-0364; DSN: 426-0364
Fax: (703) 696-1212
steelet@onr.navy.mil
Human Systems

STEIGER, Mr. Daniel
Office of Naval Research
800 N. Quincy St
Arlington, VA 22217
(703) 696-0988; DSN: 426-0988
Fax: (703) 696-0308
steiged@onr.navy.mil
Ground & Sea Vehicles

STIEGLER, Mr. Robert
Naval Surface Warfare Center Dahlgren Division
17320 Dahlgren Rd
Dahlgren, VA 22448
(540) 653-8141; DSN: 249-8141
Fax: (540) 653-8870
rstiegl@nswc.navy.mil
MOUT

STILTNER, CDR Deborah R.
Aegis Program Office, PMS-400
2531 Jefferson Davis Highway
Arlington, VA 22242
(703) 602-7090; Fax: (703) 602-0058
stiltner_deb_cdr@hq.navsea.navy.mil
Human Systems

STOKOWSKI, CAPT Dennis
Head, Land Attack Warfare
Chief of Naval Operations/N864F
2000 Navy Pentagon
Washington, DC 20350
(703) 604-7667; DSN: 664-7667
Fax: (703) 604-1917
Precision Force

STONE, Dr. Frank
Chief of Naval Operations N45G
(703) 604-1424
Materials/Processes

STONELAKE, SMSgt Gregory
Air Combat Command/LGMS
Materials/Processes

STOTT, Mr. Duane
USA Space and Missile Defense Command (SMDC-TC-SR)
PO Box 1500
Huntsville, AL 35807
(205) 955-4570; Fax: (205) 955-4572
stottd@smdc.army.mil
Joint TMD

STRINI, LTC Robert
Joint Training Analysis & Simulation Center, US Atlantic Command J7
Norfolk, VA
(757) 626-7525; Fax: (757) 686-7501
strini@acom.mil
JR&L/SSS

STROPKI, Mr. Michael
Air Force Research Laboratory/MLI
Materials/Processes

STUART, COL Paul
USFK
Precision Force

STUBSTAD, Dr. John
Ballistic Missile Defense Organization
Surveillance & Interceptor Technology Directorate
(703) 604-3133; Fax: (703) 604-3121
Materials/Processes

SUMMA, Mr. Bill
Defense Special Weapons Agency/ES
6801 Telegraph Rd
Alexandria, VA 22310
(703) 325-7087; DSN: 271-7087
Fax: (703) 325-2951
summa@hq.dswa.mil
CB Defense & Nuclear

SUMMERS, Mr. Tim
Army PEO-TM
Materials/Processes; Weapons

SUNSHINE, Douglas
Defense Special Weapons Agency
6801 Telegraph Rd
Alexandria, VA 22310
(703) 325-1477; Fax: (703) 325-6206
sunshine@hq.dswa.mil
Combating Terrorism

SVITAK, COL Richard A.
Chief, Topographic Research Division
USA Topographic Engineering Center
7701 Telegraph Rd
Alexandria, VA 22315
(703) 428-6663; Fax: (703) 428-6425
Force Projection/Dominant Maneuver; Precision Force

SWINSON, Col Mark
UAV Joint Project Office
Info Superiority

SWISTAK, Mr. Joseph E.
USA Topographic Engineering Center, CETEC-TD-T
7701 Telegraph Road
Alexandria, VA 22315
Sensors, Elec & BS Environment

SZKRYBALO, Ms. Irena D.
Office of the Assistant Secretary of the Army for Research, Development & Acquisition, SARD-TT
Pentagon, Rm 3E479
Washington, DC 20310
(703) 697-8432; DSN: 227-8432
Fax: (703) 695-3600
szkrybi@sarda.army.mil
Force Projection/Dominant Maneuver; Precision Force; Weapons

T

TABER, Mr. Michael
B2 SPO/YSSW, Avionics and Software Lead
Tinker AFB, OK 73145
(405) 739-4258; DSN: 339-4258
Fax: (405) 739-2547
mtaber@gate.tinker.af.mil
Info Systems Tech

TANSEY, Mr. J.
AATRD-AMSAT-R-TL
(703) 604-3900 x5949
JR&L/SSS

TARGOSCZ, Mr. Leo, Jr .
Naval Criminal Investigative Service
Chief of Naval Operations/N09N3
Code 24B
901 M St., SE
Washington, DC 20388
(202) 433-9138: Fax: (202) 433-9147
ltargosz@cs27.frodo.org
Combating Terrorism

TATTELMAN, Mr. Paul
Air Force Research Laboratory/VSBE
29 Randolph Rd
Hanscom AFB, MA 01731
(781) 377-5956; DSN: 478-5956
Fax: (781) 377-2984
tattelman@plh.af.mil
Sensors, Elec & BS Environment

TAYLOR, CAPT Robert
Chief of Naval Operations/N88
2000 Navy Pentagon, Rm 5B666
Washington, DC 20350
(703) 695-1634; DSN: 225-1634
Fax: (703) 695-2919
Weapons

TEMPEL, Maj Kurt
USAF Air Education and Training Command/SAS
151 J. St E., Ste 2
Randolph AFB, TX 78150
(210) 652-6893; DSN: 487-6893
Fax: (210) 487-6895
tempelk!pop3.rnd.aetc.af.mil
Human Systems

TENNENHOUSE, Dr. David L.
Defense Advanced Research Projects Agency /Information Technology Office
3701 Fairfax Ave
Arlington, VA 22203
(703) 696-2228; DSN: 426-2228
Fax: (703) 696-0564
dtennenhouse@darpa.mil
Info Systems Tech

TENPENNY, MAJ Thomas
Headquarters, Air Combat Command
Aerospace Controls Weapons Branch
204 Dodd Blvd, Ste 226
Langley AFB, VA 23665
(804) 764-5915; DSN: 764-5915
Fax: (804) 764-3596
tenpennt@relay2.langley.af.mil
Human Systems

TEWKSBURY, Al
Air Force Research Laboratory
Wright Laboratory, WL/AADI
2241 Avionics Circle
Wright-Patterson AFB, OH 05433
(937) 255-4557 x3371
Fax: (937) 255-8656
tewksbar@aa.wpafb.af.mil
Sensors, Elec & BS Environment

THACKER, Dave
Project Director, Combat Terrain Information Systems
Director, USA Topographic Engineering Center
7701 Telegraph Rd
Alexandria, VA 22315
(703) 428-6876; Fax: (703) 428-6302
dthacker@tec.army.mil
Sensors, Elec & BS Environment

THOMPSON, CDR Carol
Defense Advanced Research Projects Agency /Information Systems Office
3701 N. Fairfax Dr
Arlington, VA 22203
(703) 696-2302; DSN: 426-2302
Fax: (703) 696-2203
cthompson@darpa.mil
Info Systems Tech

THOMPSON, Dr. James
AMSTA-TR-R
(810) 574-5780; Fax: (810) 574-6674
Materials/Processes

THOMPSON, Mr. Jim
PEO-USW ASTO
(703) 604-6011
Sensors, Elec & BS Environment

THORTON, Mr. C.
USA Dismounted Battlespace Battle Lab
DSN: 835-3082
Sensors, Elec & BS Environment

TIERNAN, COL Helen S.
USA Medical Department Center and School
1400 East Grayson St
Ft. Sam, Houston, TX 78234
(210) 221-0617; DSN: 471-0617
Fax: (210) 221-0067
col_helen_tiernan@smtplink.medcom.amedd.army.mil
Biomedical

TINNEY, M. T.
USAF/AIA
DSN: 969-4588
Sensors, Elec & BS Environment

TITLEY, CDR Dave
NAVOCEANO
DSN: 485-5152
Sensors, Elec & BS Environment

TODOROFF, Dr. Doug
Office of Naval Research
800 N. Quincy St
Arlington, VA 22217
(703) 696-2485; DSN: 426-2485
Fax: (703) 696-2007
Force Projection/Dominant Maneuver; Weapons

TRENCK, Mr. Rich
APEO (A)
(703) 604-3910 x6026
Air Platforms

TURNBACH, Dr. Susan
Director Defense Research and Engineering (Sensors, Electronics & Battlespace Environment)
(703) 614-0206; Fax: (703) 697-3762
turnbase@acq.osd.mil
Sensors, Elec & BS Environment

TURNER, Ms. Glenda
Office of the Undersecretary of Defense (Policy), Deputy Director for Infrastructure Analysis
5109 Leesburg Pike, Ste 304
Falls Church, VA 22041
(703) 681-5650; DSN: 761-5650
Fax: (703) 681-5733
glenda.turner@osd.pentagon.mil
Info Systems Tech

U

UHLE, Lt Col B.
85 TES/CC
Eglin AFB, FL
(904) 882-2400; DSN: 872-2400
Fax: (904) 882-2186
uhleb@wg53.eglin.af.mil
Human Systems

UHLER, Dr. Dale
Office of the Chief of Naval Operations
N6H, Space, Information Warfare, Command & Control Directorate
2000 Navy Pentagon
Washington, D.C. 20350
(703) 601-1202; DSN: 329-1202
Fax: (703) 601-1320
uhler.dale@hq.navy.mil
Info Superiority

ULRICH, Mr. Paul
PM C2SIP and Deputy PM Maneuver Control System
PEO C3S, Bldg 455
Ft. Monmouth, NJ 07703
(732) 532-4676; DSN: 992-4676
Fax: (732) 532-6388
ulrich@doim6.monmouth.army.mil
Info Superiority

UPMAL, Mr. Don
USA Communications-Electronics Command
Ft. Monmouth, NJ 07703
(732) 532-0440; DSN: 992-0440
Fax: (732) 532-0456
upmal@doim6.monmouth.army.mil
Info Systems Tech

URBAN, LTC Michael G.
J3, Chemical Officer
US Central Command
71155 Boundary Blvd
MacDill AFB, FL 33621
(813) 828-6229; DSN: 968-6229
Fax: (813) 828-6218
CB Warfare/Counter WMD

V

VADEN, LTC David W.
USA Training and Doctrine Command
Deputy Chief of Staff for Simulation & Analysis
Ft. Monroe, VA 23651
(757) 728-5954; DSN: 680-5954
Fax: (757) 727-4394
vadend@monroe.army.mil
Info Systems Tech

VAN DERLASKE, Mr. Dennis
Director of Countermine
USA Communications-Electronics Command, Night Vision & Electronic Sensors Directorate
10221 Burbeck Rd, Ste 430
Ft. Belvoir, VA 22060
(703) 704-1258; DSN: 654-1258
Fax: (703) 704-1041
dvanderl@nvl.army.mil
Force Projection/Dominant Maneuver

VAN DIVER, Ms. Emily H.
USA Aviation and Missile Command
Redstone Arsenal, AL 35898
(205) 876-4857; DSN: 746-4857
Fax: (205) 876-4033
Force Projection/Dominant Maneuver

VAN KIRK, Mr. Jack
PM Aviation Electronics Combat
Redstone Arsenal, AL 35898
(205) 313-4422; DSN: 897-4422
Fax: (205) 313-4540
vankirkj@peoavn.redstone.army.mil
Weapons

VAN VECHTEN, Dr. Deborah
Office of Naval Research
800 N. Quincy St
Arlington, VA 22217
Materials/Processes

VAUGHAN, Dr. Willard S.
Office of Naval Research
800 N. Quincy St
Arlington, VA 22217
(703) 696-4505; DSN: 426-4505
Fax: (703) 696-1212
vaughaw@onr.navy.mil
Human Systems

VECCHIOLLA, CAPT Tom
Office of the Assistant Secretary of the Navy for Research, Development and Acquisition
1000 Navy, Pentagon
Washington, DC 20350
(703) 695-7949; DSN: 225-2905
Fax: 703) 614-4608
vecchiollathomas@hq.navy.mil
Force Projection/Dominant Maneuver

VERDERAME, MAJ Ken
Air Force Research Laboratory/VT-X
3550 Aberdeen Ave, SE
Kirtland AFB, NM 87117
(505) 846-8927 x150
Fax: (505) 846-8930
verderak@plk.af.mil
Human Systems

VILLALBA, Mr. Rafael
Aeronautical Systems Center/LPZ
Air Force Materiel Command
(937) 255-4056 x3326
Materials/Processes

VINSON, CAPT John, USN
Deputy Program Manager, PD 133A, Space & Naval Warfare Systems Center
4301 Pacific Highway
San Diego, CA 92110-3124
(619) 537-0143; DSN: 557-0143
Fax: (619) 537-0155
vinsonj@spawar.navy.mil
Info Superiority

VOGEL, Ms. Catherine
Air Force Research Laboratory/MLQE
139 Barnes Dr, Ste 2
Tyndall AFB, FL 32403
(904) 283-6208; DSN: 523-6208
Fax: (904) 283-6064
cathy _vogel@ccmail.aleq.tyndall.af.mil
Materials/Processes

VOGELSONG, Dr. Richard
Office of Naval Research
800 N. Quincy St
Arlington, VA 22217
(703) 696-0816; DSN: 426-0816
Fax: (703) 696-0308
vogelsr@onr.navy.mil
Ground & Sea Vehicles

VOLEK, Maj Michael
HQ AF Space Command/XPX
150 Vandenberg St. Ste. 1105
Peterson AFB, CO 80914
(719) 554-9137; DSN: 692-9137
Fax: (719) 554-5119
mvolek@spacecom.af.mil
Info Superiority; Sensors, Elec & BS Environment

VOORHEES, Col D.
US Special Operations Command
7701 Tampa Point Blvd
MacDill AFB, FL 33621
(813) 840-5247; DSN: 968-5247
Fax: (813) 828-9404
voorhees@soac.hqsocom.mil
MOUT; Weapons

W

WACHE, Maj Robert
Human Systems Program Office/YACP
8107 13th St
Brooks AFB, TX 78235
(210) 536-6897; Fax: (210) 536-2993
wache@hermes.brooks.af.mil
Materials/Processes

WALBERT, Mr. James
USA Research Laboratory
AMSRL-SL-BA
Aberdeen Proving Ground, MD 21005
(410) 278-2608; DSN: 298-2608
Fax: (410) 278-7266
Materials/Processes

WALKER, Mr. Gregory
NAVFAC
JR&L/SSS

WARD, COL Barry M.
PM Multiple Launch Rocket System
USA Missile Command
SFAE-MSL-ML
Redstone Arsenal, AL 35898
(205) 876-1195; DSN: 746-1195
Fax: (205) 955-7958
Weapons

WARD, Ms. Janet E.
USA Natick RD&E Center
CDR, USARSSC
Natick, MA 01760
(508) 233-5462; DSN: 256-5462
Fax: (508) 233-4795
jward@nataick-emh2.army.mil
Human Systems

WARNER, LtCol Gary
Headquarters, US Marine Corps
Info Superiority

WASILAUSKY, Mr. Robert
Space & Naval Warfare Systems Center
53560 Hull St
San Diego, CA 92152
(619) 553-4066; DSN: 553-4066
Fax: (619) 553-4153
wasilaus@spawar.navy.mil
Info Systems Tech

WATSON, Mr. Edward
Air Force Research Laboratory
DSN: 785-9614
Sensors, Elec & BS Environment

WATTENBARGER, Mr. J. Frank
US Special Operations Command
Advanced Concepts and Engineering Division
7701 Tampa Point Rd
MacDill AFB, FL 33621
(813) 828-9361; DSN: 968-9361
Fax: (813) 828-9382
wattenbf@soac.hqsocom.mil
Info Systems Tech

WATTS, Mr. Timothy
USA Communications-Electronics Command, Night Vision & Electronic Sensors Directorate
10221 Burbeck Rd, Ste 430
Ft. Belvoir, VA 22060
(703) 704-1356; DSN: 654-1356
twatts@nvl.army.mil
Precision Force

WAX, Dr. Steve
Defense Advanced Research Projects Agency/Defense Sciences Office
3701 N. Fairfax Dr
Arlington, VA 22203
(703) 696-2281
Materials/Processes; Weapons

WEAVER, Mr. Patrick
Program Manager AIR 260C
Naval Systems Command
47123 Unit #IPT, Code PMA 260 C-24
Patuxent River, MD 20670
(301) 757-6846; DSN: 757-6846
Fax: (301) 757-6862
weaverps.nimtz@navair.navy.mil
JR&L/SSS

WEBB, Mr. R. C.
Defense Special Weapons Agency/ESE
6801 Telegraph Rd
Alexandria, VA 22310
(703) 325-7016; DSN: 221-7016
Fax: (703) 325-2951
webb@hq.dswa.mil
CB Defense & Nuclear; Sensors, Elec & BS Environment

WEBER, Dr. Edward J.
Global Positioning Sysstem/Lonospheric Effects Branch/GPSI
29 Randolph Rd
Hanscom AFB, MA 01731
(617) 377-3121; DSN: 478-312
Fax: (617) 377-2770
Webere@plh.af.mil
Info Superiority

WEHLING, Mr. Martin F.
Air Force Research Laboratory/MNG
101 West Eglin Blvd
Eglin AFB, FL 32542
(850) 882-4033; DSN: 872-4033
Fax: (850) 882-4034
wehling@eglin.af.mil
Weapons

WEHLING, Mr. Rick
Air Force Research Laboratory/MNG
Sensors, Elec & BS Environment

WEHRING, Mr. Douglas
CEMRO-ED-ST
Combating Terrorism

WEINER, Lt Col Allan
Air Force Research Laboratory/MLQE
(904) 283-6308
Materials/Processes

WELBY, Mr. Stephen
Defense Advanced Research Projects Agency /Information Systems Office
3701 N. Fairfax Dr
Arlington, VA 22203
(703) 696-2374; DSN: 426-2374
Fax: (703) 696-2203
swelby@darpa.mil
Info Superiority

WELCH, LtCol Steven
PM Wind Corrected Munitions Dispenser
USAF Aeronautical Systems Center/YHW
102 West D. Ave, Ste 168
Eglin AFB, FL 32542
(850) 882-8002; DSN: 872-8002
Weapons

WELLMAN , LtCol John
US Atlantic Command J-RC/J-33
1562 Mitscher Ave, Ste 200
Norfolk VA 23551
(757) 836-7613; DSN: 836-7613
Fax: (757) 836-6591
usacomjrc@aol.com
Info Superiority

WETZEL-SMITH, Ms. Sandra
Space & Naval Warfare Systems Center/Code D301
53560 Hull St, Bldg BK 328, Rm 212A
San Diego, CA 92152
(619) 553-7693; Fax: (619) 553-0477
skw@spawar.navy.mil
Human Systems

WHITE, MAJ Larry
Chief of Information Operations
US European Command
Unit 30400, Box 1000, ECJ35
APO AE 09138
011-49-711680-4294
DSN: (314) 430-4294
Fax: 011-49-711680-8451
Elec Combat

WIECK, MAJ Timothy
Air Force Research Laboratory/HESA
Human Systems

WIESE, MAJ Tom
160th SOAR(A)
Commander 160th SOAR
Ft. Campbell, KY 42223
(502) 798-1869; DSN: 635-1869
Fax: (502) 635-1844
wieset@soar.net
Human Systems

WIGHTMAN, Dr. Dennis
Army Research Institute/RWARU
Bldg 5100
Ft. Rucker, AL 36362
(334) 255-2834; DSN: 558-2834
Fax: (334) 255-9025
Human Systems

WILHOITE, Maj Brian
Engineering/Mine-Countermine
Requirements Officer
Marine Corps Combat Development
Command, Code 443
3300 Russell Road
Quantico, VA 22314
(703) 784-6212; DSN: 278-6212
Fax: (703) 784-2532
wilhoiteb@quantico.usmc.mil
Force Projection/Dominant Maneuver

WILLEY, Mr. Kirk
USA Communications-Electronics
Command, Night Vision & Electronic
Sensors Directorate
Ft. Monmouth, NJ 07703
(732) 427-2663: DSN: 987-2663
Fax: (732) 532-0705
kwilley@nvl.army.mil
Info Superiority

WILLIAMS, CAPT Rick
Space & Naval Systems Command
PD-13A/X
4301 Pacific Highway
San Diego, CA 92110
(619) 553-0656; DSN: 553-0656
Fax: (619) 553-9297
rwilliam@nosc.mil
Info Systems Tech

WILLIAMS, Mr. Ron
ASC/LPP
Materials/Processes

WILSON, Mr. Tom
Office of the Deputy Undersecretary of
Defense (Space)
Sensors, Elec & BS Environment

WILSON, CDR Ward
Staff, Commander Third Fleet
APO AP 96601
(619) 545-3213; Fax: (619) 545-2798
u31c3f@corondao.navy.mil
Human Systems

WINEGRAD, Mr. Daniel
Naval Surface Force
US Atlantic Fleet, Code N02X
1430 Mitscner Ave
Norfolk, VA 23511
(804) 444-5691: Fax: (804) 445-8930
nsaplnsl@nemo.nosc.mil
JR&L/SSS

WINKENHOFER, Mr. Alan
USA Armor Center
Directorate for Force Development
Ft. Knox, KY 40121
(502) 624-8064; DSN: 464-8064
Fax: (502) 624-8057
winkenha@ftknoxDFD-MH13.army.mil
Ground & Sea Vehicles; Weapons

WINTERHALTER, Ms. Carole A.
USA Natick RD&E Center, SSCOM
Natick, MA 01760
(508) 233-5460; DSN: 256-5460
Fax: (508) 233-5223
cwinterh@natick-amed02.army.mil
Human Systems

WISE, Mr. Pete
Air Force Research Laboratory/MNAG
Eglin AFB, FL 32542
(850) 882-5489; DSN: 872-5489
Weapons

WITTE, CAPT Mike
PEOCU-TCS
47123 Buse Rd., Unit IPT
Patuxent River, MD 20670
(301) 757-5879; Fax: (301) 757-5885
witte@lan-email.peocu.navy.mil
Human Systems

WITTE, Mr. Terry
Naval Air Systems Command/PMA 202
1421 Jefferson Davis Hwy
Arlington, VA 22202
(703) 664-4480 x7343
Fax: (703) 604-4442
wittetl.nimitz@navair.navy.mil
Human Systems

WITTWER, Dr. Leon
Defense Special Weapons Agency/WEL
6801 Telegraph Rd
Alexandria, VA 22310
(703) 325-7143; Fax: (703) 325-1327
wittwer@hq.dswa.mil
CB Defense & Nuclear

WOLF, Dr. Stuart
Defense Advanced Research Projects
Agency/Defense Sciences Office
3701 N. Fairfax Dr
Arlington, VA 22203
(703) 696-4440; Fax: (703) 696-3999
Materials/Processes

WOLFF, CAPT W. Steven
USN Bureau of Personnel (PERS-22)
Navy Department, 2 Arlington Annex
Washington, DC 20370
(703) 695-3936; DSN: 224-3936
Fax: (703) 614-6502
p22@bupers.navy.mil
Human Systems

WOLFGRAM, COL Paul
Director, Joint Precision Strike
Demonstration Project Office
10401 Totten Rd, Ste 325
Ft. Belvoir, VA 22060
(703) 704-1940; DSN: 654-1940
Fax: (703) 704-2138
pwolfgram@nvl.army.mil
Precision Force

WOOD, Col Anthony A.
Director, Marine Corps Warfighting Lab
2042 Broadway St, Ste 201
Quantico, VA 22134
(703) 784-5096; DSN: 278-5096
Fax: (703) 784-5025
wooda@quantico.usmc.mil
Air Platforms; Info Systems Tech

WOODY, Mr. William
Air Force Research Laboratory/MLP
(513) 255-4588 x3201
Fax: (513) 255-4913
Materials/Processes

WORRELL, Dr. Joseph
Det-2, 645th MATS
Sensors, Elec & BS Environment

WRIGHT, Mr. Richard A.
USA Communications-Electronics
Command, Research, Development and
Engineering Center, Night Vision &
Electronic Sensors Directorate
10221 Burbeck Rd., Ste 430
Ft. Belvoir, VA 22060
(703) 704-1329; DSN 654-1329
Fax: (703) 704-1387
wright@nvl.army.mil
Precision Force

WULFECK, Dr. Wally
Space & Naval Warfare Systems Center
Code D301
53560 Hull St, Bldg BK 328, Rm 206B
San Diego, CA 92152
(619) 553-9269; DSN: 553-9269
Fax: (619) 553-0477
wulfeck@spawar.navy.mil
Human Systems

WYATT, LTC Earl
Joint Strike Fighter Program Office
(703) 602-7390
Materials/Processes

Y

YANKER, Mr. Jerry
OC-ALC/CD
(405) 739-2202
Materials/Processes

YERACE, Mr. Gary
Chief of Staff, Defense Modeling & Simulation Office
1901 N. Beauregard St, Ste 504
Alexandria, VA 22311
(703) 998-0660; Fax: (703) 998-0667
gyerace@dmso.mil
Info Systems Tech

YFF, Col Philip N.
Chief, Logistics Information Systems Division, Joint Staff/J4
J4 Logistics Systems Divison
Pentagon, Rm 2E825
Washington, DC 20318
(703) 695-0967; DSN: 225-0967
Fax: (703) 697-2024
yffpn@js.pentagon.mil
Info Systems Tech; JR&L/SSS

YOUNG, Ms. Shiela D.
Navy Strategic Systems Program Office
(703) 607-0518
JR&L/SSS

Z

ZAHNER, COL Richard P.
525 Military Intelligence Brigade (Corps) (Airborne)
Ft. Bragg, NC 28307
(910) 396-3209; DSN: 236-3209
Fax: (910) 396-8264
zahnerr@bragg.army.mil
Info Superiority

ZARABA, JR., LTC Charles
USFK
Precision Force

ZEMAN, Dr. Allen
Deputy Director Navy Training N-7B
2000 Navy Pentagon
Washington, DC 20350
(703) 697-1098; DSN: 223-1098
Fax: (703) 693-6480
zeman@allen@hq.navy.mil
Human Systems

ZIMMERMAN, Mr. Bruce
Office of the Assistant Secretary of the Army for Research, Development & Acquisition
Pentagon, Rm 3E480
Washington D.C. 20351
(703) 697-8434; DSN: 227-8434
Fax: (703) 695-3600
zimmermb@sarda.army.mil
Combat ID; Info Superiority; Force Projection/Dominant Maneuver; MOUT; Precision Force

ZIMMERMAN, Mr. Mathew
USA TACOM, Armament Research, Development and Engineering Center
Joint Services Small Arms Program
Picatinny Arsenal, NJ 07806
(973) 724-7993; DSN: 880-7993
zimmerman@pica.army.mil
MOUT

ZIMMERS, Mr. Walter H.
Team Chief, Modeling & Simulation
Defense Special Weapons Agengy
Code WELM
6801 Telegraph Rd
Alexandria, VA 22310
(703) 325-1135; DSN: 221-1135
Fax: 703-325-0398
zimmersw@hq.dswa.mil
Info Systems Tech

APPENDIX B

IDENTIFICATION OF PROGRAM ELEMENTS AND PROJECTS

APPENDIX B

IDENTIFICATION OF PROGRAM ELEMENTS AND PROJECTS

0602102F MATERIALS
- 4347 Materials for Struc, Prop, & Subsys
- 4348 Matls for Elect, Optics & Surv
- 4349 Materials Techn for Sustainment

0602105A MATERIALS TECH
- H84 Materials

0602111N SURFACE AEROSPACE SURVEILLANCE & WEAPONS TECH

0602120A SENSORS & ELECTRONIC SURVIVABILITY
- 140 Hi-Power Microwave Tech
- H15 Ground Combat ID Tech
- H16 S^3I Technology

0602121N SURFACE SHIP & SUB HM&E TECH

0602122N AIRCRAFT TECH

0602131M MARINE CORPS LANDING FORCE TECH

0602173C SPT TECH EXP DEV
- 1651 Innovative S&T
- 1660 Statutory and Mandated Programs

0602201F AEROSPACE FLIGHT DYNAMICS
- 2401 Structures
- 2402 Vehicle Equipment
- 2403 Flt Control/Vehicle-Pilot Interface
- 2404 Aeromechanics
- 4397 Airbase Technology

0602202F ARMSTRONG LAB EXPLORATORY DEV
- 1123 Manpower, Personnel, and Training
- 1900 Environmental Quality Technology
- 7184 Crew Technology
- 7757 Toxicology/Radiation/Noise Haz

0602203F AEROSPACE PROPULSION
- 3048 Fuels and Lubrication
- 3066 Turbine Engine Technology
- 3145 Aerospace Power Technology

0602204F AEROSPACE AVIONICS
- 2000 Electronic Countermeasures Tech
- 2001 Electro-Optical Technology
- 2002 Microwave Technology
- 2003 Avionics Sys Design Technology
- 6095 Information Fusion Technology
- 6096 Microelectronics Technology

0602211A AVIATION TECH
- 47A Aeron & Acft Wpns Tech
- 47B Veh Prop & Structure Tech

0602232N SPACE & ELECTR WARFARE (SEW) TECH

0602233N READINESS/TRNG/ENVIR QUAL TECH

0602234N MATERIALS ELECT & COMPUT TECH

0602269F HYPERSONIC TECHNOLOGY PROGRAM
- 1025 Hypersonic Technology

0602270A EW TECH
- 442 Tactical EW Technology
- 906 TAC EW Techniques

0602270N ELECTRONIC WARFARE TECH

0602301E COMP SYST & COMM TECH
- ST-11 Intelligent Sys & Software
- ST-19 High Performance Computing
- ST-22 Software Engineering Tech
- ST-24 Information Survivability

0602303A MISSILE TECH
- 214 Missile Technology

0602308A MODELING AND SIMULATION
- C90 DIS Technology

0602314N UNDERSEA WARFARE SURVEIL TECH

0602315N MCM, MINING & SPECIAL WARFARE TECH

0602383E BIOLOGICAL WARFARE DEFENSE
- BW-01 Biological Warfare Defense

0602384BP CHEM & BIO DEF PROGRAM
- CB2 Chem Bio Def
- TB2 Med Bio Def
- TC2 Med Chem Def

0602435N OCEAN & ATMOSPHERIC TECH

0602601A COMBAT VEHICLE & AUTO TECH
- C05 Armor Exploratory Dev
- H91 Tank & Automotive Tech

0602601F PHILLIPS LAB EXPLORATORY DEVELOPMENT
- 1010 Geophysics and Weather Technology
- 1011 Rocket Propulsion Technology
- 3326 Lasers & Imaging Technology
- 5797 Adv Weapons & Survivability Tech
- 8809 Space and Missiles Technology

0602602F CONVENTIONAL MUNITIONS
- 2068 Advanced Guidance Technology
- 2502 Ordnance Technology

0602618A BALLISTICS TECH
- H75 Electric Gun Technology
- H80 Ballistics Technology
- H81 Armor/Antiarmor Tech

0602623A JOINT SERVICE SMALL ARMS PROGRAM
- H21 JT SVC SA Prog (JSSAP)

0602624A WEAPONS AND MUNITIONS TECH
- H18 Arty & CBT SPT Tech
- H19 Close Combat Weaponry

0602633N UNDERSEA WARFARE WPN TECH

0602702E TACTICAL TECH
- TT-03 Naval Warfare Tech
- TT-04 Advanced Land Sys Tech
- TT-06 Advanced Tactical Tech
- TT-07 Aeronautics Tech
- TT-10 Advanced Logistics Tech
- TT-11 Joint Logistics ACTD

0602702F COMMAND/CONTROL/COMMUNICATION
- 4506 Surveillance Technology
- 4519 Communications Technology
- 4594 Information Technology
- 4600 Electromagnetic Tech
- 5581 Command and Control Technology

0602705A ELECTRONICS AND ELECTRONIC DEVICES
- H11 Battery/Ind Power Tech
- H94 Elec & Electronic Dev

0602709A NIGHT VISION TECH
- H95 Night Vision & EO Tech

0602712A COUNTERMINE SYS
- H24 Countermine Sys

0602712E MAT & ELECTRONIC TECH
- MPT-01 Materials Processing Tech
- MPT-02 Microelectronic Device Technologies
- MPT-07 Military Medical/Trauma Care Tech

0602715H TEST AND SIMULATION TECH
- AB, AC, AE, AF, AI, AL Test and Simulation Tech

0602716A HUMAN FACTORS ENGINEERING TECH
- H70 Human Fact Eng Sys Dev

0602720A ENVIRONMENTAL QUALITY TECH
- 048 Ind Ope Poll Ctrl Tech
- 835 Mil Med Environ Crit
- 896 Base Fac Environ Qual
- F25 Mil Env Restor Tech

0602782A COMMAND, CONTROL, COMM TECH
- 779 C^2 & Plat Elec Tech
- H92 Communications Tech

0602784A MILITARY ENGINEERING TECH
- 855 Top, Image Intel & Space
- H71 Atmospheric Investigation
- T40 MOB/WPNS Eff Tech
- T42 Cold Regions Engr Tech

0602785A MANPOWER/PERS/TRAINING TECH
- 790 Personnel Sys/Perf Tech

0602786A WARFIGHTER TECHNOLOGY
- H99 Joint Service Food System Technology
- H98 Clothing & Equipm Tech

0602787A MEDICAL TECH
- 869 T-Med/Advanced Technology
- 870 DoD Med Def Ag Inf Dis
- 874 CBT Casualty Care Tech
- 878 Hlth Haz Mil Materiel
- 879 Med Fact Enh Sold Eff

0602787D MEDICAL TECHNOLOGY
P505 Medical Technology

0603001A WARFIGHTER ADVANCED TECHNOLOGY
242 Airdrop Equipment
393 Mil Ops in Urban Terrain (MOUT)
C07 Joint Service Food Tech Demo
J50 Force XXI Land Warrior

0603002A MEDICAL ADV TECH
810 Ind Base ID Vacc & Drug
840 Combat Injury Mgmt

0603002D MEDICAL ADVANCED TECHNOLOGY
P506 Risk Assessment & Biomed Applications

0603003A AVIATION ADV TECH
313 Adv Rotarywing Mep Integ
436 Rotarywing Mep Integ
447 ACFT Demo Engines
B97 A/C Avionics Equipment

0603004A WEAPONS & MUNITIONS ADV TECH
43A Adv Weaponry Tech Demo
232 Adv Munitions

0603005A COMBAT VEHICLE & AUTO ADV TECH
221 Combat Veh Survivability
440 Adv CBT Vehicle Tech
441 Combat Vehicle Mobility
497 Combat Vehicle Electro

0603006A C^3 ADV TECH
247 TAC C^4 Technology INT
257 Digital Battlefld Comm

0603007A MANPOWER, PERS, & TRNING ADV TECH
792 Manpower and Personnel

0603106A LOGISTICS SYSTEMS TECHNOLOGY
2745 Logistics Perf and Support Tech

0603112F ADV MATERIALS FOR WEAPON SYS
2100 Laser Hardened Materials
3153 Non-Destructive Inspection Dev
3945 Materials Transition

0603122D COUNTERTERROR TECHNICAL SUPPORT
P484

0603160D COUNTERPROLIFERATION SUPPORT
P539

0603173C SPT TECH ATD
1161 Adv Sensor Tech
1270 Applied Intert Mats & Sys Tech Proj
1360 Directed Energy Prog

0603202F AEROSPACE PROP SUBSYS INTEGRATION
668A Aircraft Propulsion Subsys Int

0603203F ADV AVIONICS FOR AEROSPACE VEHICLES
665A Airborne Sensor Technology
69CK Advanced Electronics
69DF TGT Attack & Recognition Tech

0603205F FLIGHT VEHICLE TECHNOLOGY
2978 Flight Vehicle Technologies
4398 Airbase Technology

0603211F AEROSPACE STRUCTURES
486U Advanced Aerospace Structures

0603216F AEROSPACE PROP AND POWER TECHNOLOGY
2480 Aerospace Fuels & Atmospheric Prop
3035 Aerospace Power Technology
681B Adv Turbine Engine Gas Generator

0603217N AIR SYST & WPN ADV TECH
R0446 Maritime Avionics Subsystem Tech
R0447 Weapons Advanced Tech
R2264 Air Systems Affordability
W2014 Integ HP Turbine Engine Tech (IHPTET)

0603227F PERSONNEL, TRNG AND SIMULATION TECH
2743 Advanced Training/Force Management

0603231F CREW SYSTEMS AND PERS PROTECT TECH
2830 Crew Workstations Life, Support & Escape
3257 Helmet-Mounted Devices Technologies

0603232D AUTO TARGET RECOG
P232 Auto Target Recog

0603238A GLBL SURV/AIR DEF/PREC/STRIKE TECH DEMO
177 JT ALS PS Demo

0603238N PRECISION STRIKE AND AIR DEFENSE TECH
R2145 Global Surv/Prec Strike/Air Def Tech Demo

0603245F FLIGHT VEHICLE TECH INTEGRATION
2568 Flight Vehicle Tech Integration

0603253F ADVANCED AVIONICS INTEGRATION
666A Reference & Info Transmission Tech

0603270A EW TECH
K15 Advanced Comm ECM Demo
K16 Non-Commo ECM Tech Demo

0603270F ELECTRONIC COMBAT TECHNOLOGY
2432 Defensive Syst Fusion Technology
431G RF Warning & Countermeasures
691X EO/IR Warning & Countermeasures

0603270N ADV ELECTRONIC WARFARE TECH
R2090 Functional Recognition and Response
E2194 Electronic Warfare Advanced Tech

0603302F SPACE & MSL ROCKET PROPULSION
0003 Launch Vehicle Technology
4373 Launch & Orbit Transfer Prop Tech
6339 Tactical Propulsion Technology
6340 SAT Control & Maneuvering Prop Tech

0603313A MISSILE & ROCKET ADV TECH
263 Future Msl Tech Integr (FMTI)
380 Multi Platform Launchr
486 Rapid Force Proj SIM
493 Rapid Force Proj Demo
496 Enhanced FOG-M
550
567 LCPK for 2.75-inch Rockets

0603384BP CHEM & BIO DEF PROGRAM
CB3 Chem Bio Def (AVD Tech)
CP3 Counterprolif SPT
TB3 Med Bio Def (Industrial)
TC3 Med Chem Def (Life SPT)

0603401F ADVANCED SPACECRAFT TECH
1026 Space Structures & Controls Tech
2181 Space Electronics & Software Tech
3784 Space Sensors & SAT Comm Tech
3834 Space Tech Integ & Demo
4400 Satellite Survivability
682J Space Power & Thermal Mgmt Tech

0603410F SPACE SYS ENVIRON INTERACTIONS TECH
2822 Space Environmental Impact Tests

0603508N SHIP & SUB HM&E ADV TECH
R2224 Ship & Sub HM&E Adv Tech
R2328 Project M

0603601F CONVENTIONAL WEAPONS
670A Ordnance Technology
670B Guidance Technology

0603605F ADVANCED WEAPONS TECHNOLOGY
3151 Hi Power Semiconductor Laser Tech
3152 Hi Pwr Microwave Tech
3647 Hi Energy Laser Technology

0603606A LANDMINE WARFARE & BARRIER ADV TECH
608 Countermine & Bar Dev

0603607A JOINT SERVICE SMALL ARMS PROGRAM
627 JT SVC SA Prog (JSSAP)

0603640M MARINE CORP ATD
C2223 Marine Corps ATD
C2362 Modeling & Simulation Efforts; Extended Littoral in the Battlefield (ELB)

0603654A LINE-OF-SIGHT, ANTITANK (LOSAT)

0603706N MEDICAL DEVELOPMENT
R0095 Fleet Health Tech
R0096 Fleet Health Standards

0603707F WEATHER SYSTEMS – ADV DEV
2688 Weather Support Tech

0603707N MANPOWES, PERS, TRNG AT
R1770 Manpower and Personnel Development
R1771 Ship Human Factors Engineering
R1772 Education and Training Dev
R1773 Simulation & Training Devices

0603710A NIGHT VISION ADV TECH
K70 Night Vision Adv Tech
K86 Night Vision, ABN Sys
K87 Night Vision, CBT Veh

0603712N ENVIRON QUALITY & LOG ADVANCED TECHNOLOGY
R1910 Logistics Eng Adv Demo (Lead)
R2206 Environ Requirements Advanced Technology

0603712S GENERIC LOG R&D TECH DEMO

0603716D SERDP

0603723F ENVIRONMENTAL ENGINEERING TECHNOLOGY
2103 Environmental Quality Adv Tech

0603726F C3I SUBSYSTEM INTEGRATION
2810 Adv Image/Info Applications
2863 Integrated Photonics
3192 Adv Optical Memory Tech

0603727D JOINT WARFIGHTING

0603728F ADVANCED COMPUTER TECHNOLOGY
2527 Software Life Cycle Cost
2530 Distributed System Reliability/Surv
2532 Knowledge-Based Systems

0603734A MILITARY ENGINEERING ADV TECH
T08 Combat Eng Systems
T12 Rapid Battlefield Visualization ATD

0603739E ADV ELECTRONICS TECH
MT-03 Infrared Focal Plane Array
MT-04 Electronic Module Tech
MT-06 Microwave & Analog Front End Tech
MT-08 Manufac Tech Applications
MT-12 MEMS

0603746E MARITIME TECH
MR-01 MARITIME Tech

0603747N UNDERSEA WARFARE ADV TECH
R2142 Undersea Warfare Concepts
R2267 USW Weapons Advance Tech

0603750D ACTD
P523 ACTD

0603760E CMD, CONTROL & COMMS SYS
CCC-01 Command & Control Information Sys
CCC-02 Information Integration Sys

0603761E COMM & SIM TECH
CST-01 Advanced Simulation
CST-02 Global Grid Communications

0603762E SENSOR & GUIDANCE TECH
SGT-01 Guidance Tech
SGT-02 Aerospace Surveillance Tech
SGT-04 Sensors & Exploitation Syst

0603763E MARINE TECH
MRN-02 Advanced Ship/Sensor System

0603764E LAND WARFARE
LNW-01 Combat Hybrid Power System
LNW-02 Small-Unit Operations

0603772A ADV TAC COMPUTER SCI & SENSOR TECH
101 Tactical Automation
243 Sensors & Signals Proc
281 Ground Combat ID Demos

0603782N MINE AND EXPEDITIONARY WARFARE ADV TECH
R2226 Mine & Expeditionary Warfare Adv Tech

0603789F C3I TECHNOLOGY DEVELOPMENT
2335 Advanced C^3 Technology
4072 Correlation & Fusing
4216 Warftr Info Use, Mgmnt & Intg Tech

0603792N ADV TECH TRANSITION
R1889 Adv Tech Demonstration

0603794N C^3 ADVANCED TECH
R2239 Advanced Targeting (C^3I)
X2091 Sew Advance Tech

0603832D JOINT WARGAMING SIMULATION MANAGEMENT OFFICE
P476 Joint Wargaming Simulation Management Office

APPENDIX C

ADVANCED CONCEPT TECHNOLOGY DEMONSTRATIONS

APPENDIX C

INDEX OF APPROVED ADVANCED CONCEPT TECHNOLOGY DEMONSTRATIONS

ACTD Title	*DTO*	*Page*
FY 1995		
Advanced Joint Planning	F.02	I-82
High-Altitude Endurance Unmanned Aerial Vehicle	A.10	I-11
Joint Countermine	G.04	I-110
Precision Rapid Counter Multiple Rocket Launcher	B.01	I-34
Precision Signals Intelligence Target Systems	B.03	I-35
Rapid Force Projection Initiative	M.05	I-128
Synthetic Theater of War	F.01	I-80
FY 1996		
Airbase/Port Biological Detection	I.03	I-150
Battlefield Awareness and Data Dissemination	A.07	I-7
Combat Identification	C.02	I-55
Combat Vehicle Survivability	None	
Counterproliferation I	J.03	I-153
Joint Readiness Extension to Advanced Joint Planning	F.10	I-87
Miniature Air-Launched Decoy Program	H.04	I-137
Navigation Warfare	A.16	I-19
Semiautomated Imagery Intelligence Processing	A.09	I-9
Tactical Unmanned Aerial Vehicle	A.14	I-18
FY 1997		
Chemical Enhancement to Airbase/Port Biological Detection	I.05	I-152
Counterproliferation II	J.04	I-154
Extending the Littoral Battlespace	M.02	I-124
Information Operations Planning Tool	A.25	I-30
Integrated Collection Management	A.05	I-4
Joint Advanced Health and Usage Monitoring System	F.18	I-92
Military Operations in Urban Terrain	E.02	I-74
Rapid Terrain Visualization	A.06	I-5

ACTD Title	*DTO*	*Page*
FY 1998		
Adaptive Course of Action	None	
C^{4}I for Coalition Warfare	A.23	I-27
High-Powered Microwave	H.11	I-145
Information Assurance: Automated Intrusion Detection System	A.26	I-31
Joint Biological Remote Early Warning System	I.02	I-148
Joint Continuous Strike Environment	B.07	I-38
Joint Modular Lighterage System	F.20	I-96
Line-of-Sight Antitank System	M.04	I-126
Link–16	C.07	I-59
Migration Defense Intelligence Threat Data System	None	
Precision Targeting Identification	C.05	I-58
Space-Based Space Surveillance Operations	None	
Theater Precision Strike Operations	B.25	I-50
Unattended Ground Sensors	A.24	I-29

APPENDIX D

GLOSSARY OF ABBREVIATIONS AND ACRONYMS

APPENDIX D

GLOSSARY OF ABBREVIATION AND ACRONYMS

µm	micrometer
1D	one dimensional
2D	two dimensional
3D	three dimensional
4D	four dimensional (three dimensional plus time)

A

A	ampere
A/C	aircraft
A/D	analog to digital
AABFS	Amphibious Assault Bulk Fuel System
AAM	air-to-air missile
AAN	Army After Next
AAW	active aeroelastic wing
ABCS	Army Battle Command System
ABIS	Advanced Battlespace Information System
ABL	airborne laser
ABMS	Automated Battlefield Management System
ac	alternating current
ACBL	amphibious cargo beaching lighter
ACC	Air Combat Command
ACCM	advanced cooperative collection management
ACES	Advanced Concept Ejection Seat
ACN	Airborne Communications Node
ACPT	Air Campaign Planning Toolkit
ACR	advanced concepts and requirements
ACTD	Advanced Concept Technology Demonstration
ADCAP	advanced capability
ADS	authoritative data sources
AEW	airborne early warning
AFATDS	Advanced Field Artillery Tactical Data System
AFFTC	Air Force Flight Test Center
AFRL	Air Force Research Laboratory
AFSCN	Air Force Satellite Control Network
AGE	aerospace ground equipment
AGRI	Air-to-Ground Radar Imaging
Ahr	ampere-hour
AHOS-A	Advanced Hybrid Oxygen System–Aircraft
AI	artificial intelligence
AIEWS	Advanced Integrated Electronic Warfare System
AIM	Advanced INFOSEC Module
AIN	Army Interoperability Network
AIT	Atmospheric Interceptor Technology
AJ	antijam
AJMRR	Automated Joint Monthly Readiness Review
AJP	Advanced Joint Planning
Al	aluminum
ALC	air logistics center
ALCM	air-launched cruise missile
ALERT	air/land enhanced reconnaissance and targeting
ALI	Alpha/LAMP Integration
ALISS	Advanced Lightweight Influence Sweep System
ALMDS	Airborne Laser Mine Detection System
ALP	Advanced Logistics Program
AMC	U.S. Army Materiel Command
AMDS	Advanced Mine Detector Sensor
AMP	Antimine Projectile
AMRAAM	Advanced Medium-Range Air-to-Air Missile
AMTEC	alkali metal thermal electric conversion
AMW	amphibious warfare
ANL	Armstrong National Laboratory (now AFRL)
ANSI	American National Standards Institute
AoA	analyses of alternatives
AOC	air operations center
API	American Petroleum Institute
APKWS	Advanced Precision Kill Weapon System
APPEX	Advanced Power Projection and Execution
APS	active protection system
ARDEC	Armament Research, Development and Engineering Center
ARFF	aircraft rescue and firefighting
ARG	Amphibious Ready Group
ARM	antiradiation missile
ART	Advanced Rotorcraft Transmission
As	arsenic
ASA	altered states of awareness
ASARS	Advanced Synthetic Aperture Radar System
ASAS	All-Source Analysis System
ASAT	antisatellite
ASCAT	Advanced Space Computing Analysis Technology
ASCM	antiship cruise missile
ASM	air-to-surface missile
ASMT	Air Superiority Missile Technology
ASSDC	Army Space and Strategic Defense Command
AST	advanced SEAD targeting
ASTAMIDS	Airborne Standoff Minefield Detection System
ASTE	advanced strategic and tactical expendable
ASTT	Advanced Simulation Technology Thrust
ASUW	antisurface ship warfare
ASW	antisubmarine warfare
AT	antitank
ATACMS	Army Tactical Missile System
ATAD	Air Target Algorithm Development

ATTCIS	Army Tactical Command and Control Information System
ATD	Advanced Technology Demonstration
ATGW	antitank guided weapon
ATIMS	Airborne Tactical Information Management System
ATIR	Advanced Threat Infrared
ATM	asynchronous transfer mode
ATR	automatic target recognition
ATSD(NBC)	Assistant to the Secretary of Defense (Nuclear/Biological/Chemical)
ATT	Antitorpedo Torpedo
AUFP	average unit flyaway price
AUP	advanced unitary penetrator
AWACS	Airborne Warning and Control System
AWE	advanced warfighting experiment

B

b	bit
B	byte
BADD	Battlefield Awareness and Data Dissemination
BAMB	bending annular missile body
BAT	Brilliant Antitank
BCIS	Battlefield Combat Identification System
BDA	battle damage assessment
BGP	Border Gateway Protocol
BIP	Battlefield Interoperability Program
BISAR	bistatic synthetic aperture radar
BISTAP	bistatic space-time adaptive processing
BMD	ballistic missile defense
BMDO	Ballistic Missile Defense Organization
BPI	boost-phase intercept
bps	bits per second
Btu	British thermal unit
BW	biological warfare

C

C/NOFS	Communications/Navigation Outage Forecasting System
C^2	command and control
C^2I	command, control, and intelligence
C^2V	command and control vehicle
C^2W	command and control warfare
C^3	command, control, and communications
C^3I	command, control, communications, and intelligence
C^4	command, control, communications and computers
C^4I	command, control, communications, computers, and intelligence
C^4ISR	command, control, communications, computers, intelligence, surveillance, and reconnaissance
CA	combat assessment
CAD	computer-aided design
CAE	computer-aided engineering
CAI	composites affordability initiative
CAIV	cost as an independent variable
cal/cm^2	calories per square centimeter
CALCM	conventional air-launched cruise missile
CAM	computer-aided manufacturing
CAPS	Counteractive Protection System
CAS	close air support
CASDAT	Conceptual Aircraft System Design and Analysis Toolkit
CASE	computer-aided software engineering
CB	chemical/biological
CBASS	Common Broadband Advanced Sonar System
CBM	condition-based maintenance
CC SART	Cognitive Compatibility–Situational Awareness Rating Technique
CC&D	camouflage, concealment, and deception
CCD	charged-coupled device
CCL	concentric canister launcher
CCM	counter-countermeasure
CCSD	C^4I Combat System Demonstration
CCTT	Close Combat Tactical Trainer
CCTV	closed circuit television
CDC	Centers for Disease Control and Prevention
CDMA	code division multiple access
CDR	critical design review
CDS	Combat Direction System
CEASE	Compact Environmental Anomaly Sensor
CECOM	U.S. Army Communications-Electronics Command
CENTCOM	Central Command
CEP	circular error probable
CFD	computational fluid dynamics
CFIT	controlled-flight-into-terrain
CFOR	command forces
CGF	computer-generated force
CHPS	Combat Hybrid Power System
CIC	combat information center
CICM	Communications Integration and Cancellation
CID	combat identification
CIDDS	Combat Identification for Dismounted Soldiers
CIGSS	common integrated ground/service system
CINC	commander in chief
CINCPAC	Commander-in-Chief Pacific Command
CIS	Combat Information System; chemical imaging sensor
CKEM	Compact Kinetic-Energy Missile
CLIRCM	close loop IRCM
cm	centimeter
CM	countermeasure; countermobility
CM/M	countermine/mine
CMC	ceramic matrix composite
CMD	cruise missile defense
CMIP	common management information protocol
CMM	Capability Maturity Model

CMMS	conceptual models of the mission space
CMOS	complementary metal oxide semiconductor
CMWS	Common Missile Warning System
CNI	communications navigation integration
CNO	Chief of Naval Operations
CO_2	carbon dioxide
COBRA	coastal battlefield reconnaissance and analysis
COE	common operating environment
COEA	cost and operational effectiveness analysis
COIL	chemical oxygen-iodine laser
COMINT	communications intelligence
COMSEC	communications security
CONOPS	concept of operations
CONUS	continental United States
COP	common operating picture
CORBA	Common Object Request Broker Architecture
COTS	commercial off the shelf
CP	counterproliferation
CPA	closest point of approach
CPL	capillary-pumped loops
CPoF	command post of the future
CPU	central processing unit
CRDA	cooperative research and development agreement
CRI	cochannel radio interference
CRT	cathode ray tube
CSA	Chief of Staff, Army
CSAR	combat search and rescue
CSD	computational structure dynamics
CSS	combat service support/common semantics and syntax
CSSOC	combat service support operations center
CT	counterterrorism
CTAPS	Contingency Tactical Automated Planning System
CTS	continuous transverse stub
CW	chemical warfare; continuous wave; conventional weapon

D

D^2	damage or destroy
D/A	digital to analog
DACS	divert and attitude control system
DAMA	demand assignment multiple access
DARPA	Defense Advanced Research Projects Agency
DASSL	Demonstration of Advanced Solid-State LADAR
dB	decibel
DBBL	Dismounted Battlespace Battle Lab
DBC	Digital Battlefield Communications
DBMS	database management system
dc	direct current
DCS	Deputy Chief of Staff
DDB	dynamic database
DDR&E	Director, Defense Research and Engineering
DEW	directed-energy weapon
DF	direction finding
DIA	Defense Intelligence Agency
DIAL	differential absorption LIDAR
DIF	data interchange format
DII	defense information infrastructure
DIL	Digital Integrated Laboratory
DISA	Defense Information Systems Agency
DISN	Defense Information Systems Network
DITP	Discriminating Inteceptor Technology Program
DLA	Defense Logistics Agency
DMA	Defense Mapping Agency
DNA	Defense Nuclear Agency; deoxyribonucleic acid
DNAPL	dense nonaqueous phase liquid
DNS	domain name server
DOE	Department of Energy
DOF	degrees of freedom
DRFM	digital radio frequency modulator/memory
DRTF	DECADE Radiation Test Facility
DSB	Defense Science Board
DSCS	Defense Satellite Communications System
DSEAT	demonstration of selected electronic attack techniques
DSI	Defense Simulation Internet
DSP	Defense Support Program; digital signal processor
DSPW	Digital Stereo Photogrammetric Workstation
DSS	Decision Support System
DSTAG	Defense Science and Technology Advisory Group
DSUP	defense system upgrade program
DSWA	Defense Special Weapons Agency
DT&E	development, test and evaluation
DTAP	*Defense Technology Area Plan*
DTED	digital terrain elevation data
DTO	Defense Technology Objective
DU	depleted uranium
DUSD	Deputy Under Secretary of Defense

E

EA	electronic attack
EC	electronic combat
ECCM	electronic counter-countermeasure
ECM	electronic countermeasure
EDCS	Evolutionary Design of Complex Software
EDOCC	enhanced deep operations coordination center
EEE	Eastern equine encephalitis
EFOG	enhanced fiber-optic guided
EFOGM	Enhanced Fiber-Optic Guided Missile
EHF	extremely high frequency
EKV	exoatmospheric kill vehicle

ELB	extended littoral battlespace
ELF	extremely low frequency
ELINT	electronic intelligence
ELV	expendable launch vehicle
EM	electromagnetic
EMC	electromagnetic compatibility
EMD	engineering and manufacturing development
EMI	electromagnetic interference
EMP	electromagnetic pulse
EN	Explosive Neutralization
EO	electro-optic(al)
EOCM	electro-optic countermeasure
EOD	explosive ordnance disposal
EOTDA	electro-optical tactical decision aid
EPLRS	Enhanced Position Location and Reporting System
ERA	explosive reactive armor
ERASER	Enhanced Recognition and Sensing LADAR Radar
ERD	extended-range demonstration
ERGM	Extended-Range Guided Missile; Extended-Range Gun Munition
ERP	effective radiated power
ES	electronic support
ESA	electronically scanned antenna; enhanced situation awareness
ESM	electronic support measure
ETB	earth-and-timber bunker
ETC	electrothermal-chemical
ETEC	Enterotoxigenic *Escherichia coli*
EUCOM	U.S. European Command
EUT	early user test
EW	electronic warfare
EXCOM	Executive Committee

F

FA	false alarm
FAAD	forward area air defense
FAR	false alarm rate
FATE	Future Aircraft Technology Enhancement
FBCB2	Force XXI Battlefield Command Brigade and Below
FC	fuel cell
FCS	Future Combat System
FDA	Food and Drug Administration
FDR	Future Digital Radio
FED	field emission device
FET	field effect transistor
fhr	flight hour
FHVT	fixed high-value target
FIV	Future Infantry Vehicle
FLIR	forward-looking infrared
FLOP	floating point operation
FMTI	Future Missile Technology Integration
FMTV	family of medium tactical vehicles
FO	fiber-optic(s)
FOC	future operational capability
FOG	fiber-optic guided
FOPEN	foliage-penetrating
FOV	field of view
FPA	focal plane array
FSCS	Future Scout and Calvary System
FSRS	Frequency Selective Receiver System
FSTP	full-spectrum threat protection
FSU	former Soviet Union
ft/s	feet per second
FWV	fixed-wing vehicle
FY	fiscal year
FYDP	Future Years Defense Plan

G

g	acceleration caused by gravity at Earth's surface
G&C	guidance and control
Ga	gallium
GaAs	gallium arsenide
GaN	gallium nitride
Gbps	gigabits per second
GBL	ground-based laser
GBR	ground-based radar
GBS	Global Broadcast Services/System
GCAS	Ground Collision Avoidance System
GCC	ground component commander
GCCS	Global Command and Control System
GCSS	Global Combat Support System
GCV	ground combat vehicle
GEO	geosynchronous Earth orbit
GFLOP	giga-floating point operations
GHz	gigahertz
G-LOC	g-induced loss of consciousness
GOPS	giga operations per second
GOTS	government off the shelf
GPS	Global Positioning System
GSD	ground sample distance
GVW	gross vehicle weight
GW	gross weight

H

HABE	High-Altitude Balloon Experiment
HACT	Helicopter Active Control Technology
HAE	high-altitude endurance
HARM	High-Speed Antiradiation Missile
HBT	heterojunction bipolar transistor
HCI	human–computer interface
HDI	high-definition imaging
HE	high explosive
HEL	high-energy laser
HEMP	high-altitude electromagnetic pulse
HEPA	high-efficiency particulate aerosol
HF	high frequency
HFE	heavy fuel engine
HFSWR	High-Frequency Surface-Wave Radar
HgCdTe	mercury-cadium-telluride
HHT	handheld terminal
HIL	hardware-in-the-loop
HIMARS	High-Mobility Artillery Rocket System
HIV	human immunodeficiency virus
HLA	high-level architecture
HMMWV	High-Mobility Multipurpose Wheeled Vehicle (Hummer)

HMSE	Helmet-Mounted Sensory Ensemble
HMT/D	helmet-mounted tracker/display
HOB	height of burst
hp	horsepower
HP	high power
HPAC	hazard prediction assessment capability
HPC	high-performance computer/ computing
HPM	high-power microwave
HPT	Hazard Prediction Tool
hr	hour
HRR	high-resolution radar
HS	hyperspectral
HSI	hyperspectral imaging
HSRIS	High-Speed Remote Influence Sweeping
HSOK	hunter/standoff killer
HTS	high-temperature superconductor/ superconducting
HTSF	hard-target smart fuse
HUMINT	human intelligence
HUMS	health and usage monitoring systems
HW	hardware
HWIL	hardware-in-the-loop
Hz	hertz

I

I^2	image intensifier
I/O	input/output
I^2R	imaging infrared
IADS	Integrated Air Defense System
IC	integrated circuit
ICAI	intelligent computer-aided instruction
ICBM	intercontinental ballistic missile
ICM	Integrated Collection Management
ICT	integrated concept team
ICWC	integrated comprehensive weaponeering capability
ID	identification
IDIP	intrusion, detection, and isolation protocol
IED	improvised explosive device
IEEE	Institute of Electrical and Electronic Engineers
IEW	intelligence electronic warfare
IEWCS	Intelligence Electronic Warfare Common Sensor
IFEM	Integrated Force and Execution Management
IFF	identification friend or foe
IFOG	interferometric fiber-optic gyroscope
IHPRPT	Integrated High-Payoff Rocket Propulsion Technology
IHPTET	Integrated High-Performance Turbine Engine Technology
IIR	imaging infrared
ILS	Integrated Logistics System
IM&D	information management and display
IMAT	interactive multisensor analysis training
IMEA	integrated munitions effects assessment
IMINT	imagery intelligence
IMIS	Integrated Maintenance Information System
IMU	inertial measurement unit
in	inch
IND	investigational new drug
INFOSEC	information security
InP	indium phosphorus
INS	inertial navigation system
IO	information operations
IOC	initial operating capability
IOPT	Information Operations Planning Tool
IOS	integrated ordnance suite
IP	Internet protocol
IPA	Image Product Archive
IPPD	integrated product and process development
IPT	integrated product team
IPU	integrated power unit
IR	infrared
IR&D	independent research and development
IRAM	intelligent random access memory
IRCCM	infrared counter-countermeasure
IRCM	infrared countermeasure
IRFPA	infrared focal plane array
IRST	infrared search and track
ISAR	inverse synthetic aperture radar
ISAT	Integrated Sensors and Targeting
ISDN	Integrated Services Digital Network
Isp	specific impulse (theoretical)
ISR	intelligence, surveillance, and reconnaissance
ISTEF	Innovative Science and Technology Evaluation Facility
ISX	information superiority experiment
IT	information technology
ITAG	Inertial Terrain-Aided Guidance
ITALD	Improved Tactical Air-Launched Decoy
ITPTS	Integrated Target Planning Tool Set
ITV	in-transit visibility
ITW/AA	Integrated Threat Warning and Attack Assessment
IW	information warfare

J

J/g	Joules per gram
J/S	jam-to-signal ratio
JASSM	Joint Air-to-Surface Standoff Missile
JCM	joint countermine
JCOS	Joint Countermine Operational Simulation
JCNPMS	Joint Communications Network Planning and Management System
JCS	Joint Chiefs of Staff
JCSE	joint continuous-strike environment
JDAM	Joint Direct Attack Munition
JDIICS–D	Joint DII Control System–Deployed
JFACC	Joint Force Air Component Command
JHMCS	Joint Helmet-Mounted Cueing System

JL	Joint Logistics
JLOTS	joint-logistics-over-the-shore
JMASS	Joint Modeling and Simulation System
JMCIS	Joint Military Command Information System
JMCOMS	Joint Maritime Communications Strategy
JMET	joint mission essential task
JMLS	Joint Modular Lighterage System
JMRR	Joint Monthly Readiness Report
JOT&E	joint operational test and evaluation
JPATS	Joint Primary Aircrew Training System
JPO	Joint Program Office
JPP	joint power projection
JPS	Joint Precision Strike; Joint Planning System
JROC	Joint Requirements Oversight Council
JRTC	Joint Readiness Training Center
JSA	Joint Strike Aircraft
JSAS	Joint Situation Awareness System
JSF	Joint Strike Fighter
JSGPM	Joint Service General-Purpose Mask
JSIMS	Joint Simulation System
JSLIST	Joint Service Lightweight Integrated Suit Technology
JSOW	Joint Standoff Weapon
JSTARS	Joint Surveillance Target Attack Radar System
JTF	Joint Task Force
JTIDS	Joint Tactical Information Distribution System
JTMD	joint theater missile defense
JTR	Joint Tactical Radio
JV 2010	*Joint Vision 2010*
JW	joint warfighting
JWARN	Joint Warning and Reporting Network
JWARS	Joint Warfare Simulation
JWCO	Joint Warfighting Capability Objective
JWE	joint warfighting experiment
JWSTP	*Joint Warfighting Science and Technology Plan*

K

K	(degree) kelvin
kb	kilobit
kbps	kilobits per second
KE	kinetic energy
KEAS	knots equivalent airspeed
kg	kilograms
kHz	kilohertz
KIA	killed in action
km	kilometer
km/s	kilometers per second
kn	knot
KR	knowledge representation
ksps	thousand samples per second
kW	kilowatt

L

L	liter
L/D	lift/drag
L/V	lethality/vulnerability
LADAR	laser radar
LAMIDS	Lightweight Airborne Multispectral Countermine Detection System
LAMP	Large Aperture Mirror Program
LAN	local area network
LB/TS	Large Blast/Thermal Simulator
lbf	foot-pound-force
LBVDS	Lightweight, Broadband, Variable-Depth Sonar
LCAC	landing craft air cushion
LCC	life-cycle cost
LCD	liquid crystal display
LCM	laser countermeasures
LCMS	Low-Cost Missile Systems
LCPK	low-cost precision kill
LDTOC	Light Digital Tactical Operations Center
LEO	low Earth orbit
LES	Leading Edge Services
LGW	laser-guided weapon
Li	lithium
LIDAR	light detection and ranging
LIFE	Laser IRCM Flyout Experiment
LLNL	Lawrence Livermore National Laboratory
LMVS	Lockheed-Martin Vought Systems
LO	low observable
LOAL	lock-on after launch
LOCAAS	low-cost antiarmor submunition; Low-Cost Autonomous Attack System
LODE	Large Optics Demonstration Experiment
LOS	line of sight
LOSAT	Line-of-Sight Antitank
LOTS	logistics-over-the-shore
LPC	launch pod container
LPD	low probability of detection
LPE	low probability of exploitation
LPI	low probability of intercept
lpm	liters per minute
LPT	low-pressure turbine
LRU	line replaceable unit
LSCD	laser standoff chemical detector
LSE	life-support equipment
LRIP	low rate initial production
LW	Land Warrior
LWIR	long wavelength infrared

M

m	meter; milli
M	Mach number; mega
M&S	modeling and simulation
m/s	meters per second
MADMEL	Management and Distribution for More Electric Aircraft
MAFET	microwave and analog front-end technology

MAJIC	monopulse angle jamming integrated countermeasure
MALD	Miniature Air-Launched Decoy
MASINT	measurement and signal intelligence
MASS	modular aircraft support system
MAT	Multimode Airframe Technology
MAV	micro air vehicle
Mbps	megabits per second
MCA	multichip assembly
MCM	mine countermeasure; multichip module
MCS	Maneuver Control System
MEA	More Electric Aircraft
MEADS	Medium Extended Air Defense System
MEMS	microelectromechanical systems
MERS	Multifunction Electromagnetic Radiating System
MESFET	metal semiconductor field-effect transistor
MEU	Marine Expeditionary Unit
MEV	million electron volts
MFLOP	mega-floating point operations
MFOM	MRLS family of missiles
MFS^3	Multifunction Staring Sensor Suite
MH/K	mine hunter/killer
MHz	megahertz
mi	mile
MICOM	U.S. Army Missile Command
MIDB	modernized integrated database
min	minute
MIS	management information system
MITL	man-in-the-loop
MIW	mine warfare
MJ	megajoule
MLRS	Multiple-Launch Rocket System
mm	millimeter
MMC	metal-matrix composite
MMI	man–machine interface
MMIC	monolithic microwave integrated circuit
MMPM	millimeter-wave power module
MMW	millimeter wave
MOA	memorandum of agreement
MOE	measure of effectiveness
MOP	measure of performance
MOPP	mission-oriented protective posture
MOUT	military operations in urban terrain
MPa	megapascal
mph	miles per hour
MPI	message passing interface
MPM	microwave power module
MRAM	magnetic random access memory
MRLS	Multiple Rocket Launcher System
MS&A	modeling, simulation, and analysis
MSD	multisite damage
MSE	Mobile Subscriber Equipment
MSI	multispectral imaging
MSMCM	mixed-signal multichip module
Msps	mega samples per second
MSRR	modeling and simulation resource repository
MSTAR	Moving and Stationary Target Acquisition and Recognition; MLRS Smart Tactical Rocket
MTBF	mean time between failure
MTBR	mean time between replacement; mean time between removal
MTI	moving target indicator
MTV	Mobile Test Vehicle
MW	megawatt
MWIR	mid-wavelength infrared

N

NACES	Navy Aircrew Common Ejection Seat
NaS	sodium sulfur
NASA	National Aeronautics and Space Administration
NATO	North Atlantic Treaty Organization
NAVAIR	Naval Air Command
NAVOCEANO	Naval Oceanographic Office
NAVSEA	Naval Sea Systems Command
NAVSOC	Naval Space Operations Center
NAVSPACECOM	Naval Space Command
NCB	nuclear/chemical/biological
NCTR	noncooperative target recognition
NDE	nondestructive evaluation
NDI	nondestructive inspection/item
NEDT	noise-equivalent delta temperature
Ni	nickel
NIR	near infrared
nm	nanometer
NMD	National Missile Defense
nmi	nautical mile
NOx	nitrous oxide
NPOESS	National Polar-Orbiting Environmental Satellite System
NRL	Naval Research Laboratory
Nrms	Newton root mean square
NRTC	National Rotorcraft Technology Center
NSA	National Security Agency
NSF	National Science Foundation
NSFS	Naval Surface Fire Support
NTM	national technical means
NVD	night vision device
NVESD	Night Vision and Electronic Sensors Directorate
NVG	night vision goggle

O

O&I	operational and intermediate
O&M	operations and maintenance
O&S	operations and support
OASD	Office of the Assistant Secretary of Defense
OBATS	off-board augmented theater surveillance
OBS	off-board source
OCONUS	outside continental United States
OCSW	Objective Crew-Served Weapon
ODDR&E	Office of the Director, Defense Research and Engineering
OICW	Objective Individual Combat Weapon
OIW	offensive information warfare

OMC	organic-matrix composite
ONR	Office of Naval Research
OOTW	operations other than war
OPDS	Offshore Petroleum Discharge System
OPSEC	operations security
ORB	Object Request Broker
OS	operating system
OSD	Office of the Secretary of Defense
OSPF	open shortest path first
OTH	over-the-horizon
OTH-T	over-the-horizon targeting
OTM	on the move
OTV	orbit transfer vehicle
OUSD	Office of the Under Secretary of Defense

P

P	phosphorus
P^3I	preplanned product improvement
PACM	Patriot Anti-Cruise Missile
PBCS	post-boost control system
PbMN	lead magnesium niobate
PBV	post-boost vehicle
PC	personal computer
PCS	personal communications system
P_d	probability of detection
PDM	program decision memorandum
PDR	preliminary design review
PE	program element
PEBB	power electronic building block
PEO	program executive office
PEP	propellants, explosives, and pyrotechnics
P_{fa}	probability of false alarm
PGM	precision-guided munition
PGMM	Precision-Guided Mortar Munitions
P_h	probability of hit
P_i	probability of incapacitation
PI	product improvement
PIOS	Programmable Integrated Ordnance Suite
PIP	product improvement program
P_k	probability of kill
PLAID	Position Location and Identification
PM	program manager; permanent magnet
PMAD	power management and distribution
PMO	program management office
PNGV	Partnership for New Generation Vehicle
PNVG	panoramic night vision goggle
POC	point of contact
POM	program objective memorandum
ppm	parts per million
PRCMRL	Precision Rapid Counter Multiple Rocket Launcher
psf	pounds per square foot
psi	pounds per square inch
PSTS	Precision SIGINT Targeting System
PTI	precision targeting identification

Q

QAM	quadriture amplitude modulation
QIP	Quadrilateral Interoperability Program
QWIP	quantum well infrared photodetection

R

R&D	research and development
R&S	reconnaissance and surveillance
rad	radiation
RAMICS	Rapid Airborne Mine Clearance System
RAP	radio access point
RASSP	Rapid Application-Specific Signal Processors/Processing
RBV	Rapid Battlefield Visualization
RCS	radar cross section
RDA	research, development, and acquisition
RDT&E	research, development, test and evaluation
RECO	remote control
RF	radio frequency
RFCM	radio frequency countermeasure
RFI	radio frequency interference
RFPI	Rapid Force Projection Initiative
RHETT	Russian Hall Effect thruster
RIBS	Rapidly Installed Breakwater System
RITA	Rotorcraft Industry Technology Association
RLV	reusable launch vehicle
RMC	resin matrix composite
rms	root mean square
RMS	Remote Minehunting System
RPA	Rotorcraft Pilot's Associate
rpm	revolutions per minute
RSAP	Reentry Systems Applications Program
RSTA	reconnaissance, surveillance, and target acquisition
RTIC	real-time information in the cockpit
RTM	resin transfer molding
RTOC	real-time information out of the cockpit
RTS	real-time support
RTSMP	real-time symmetric multiprocessing
RTV	rapid terrain visualization
RV	reentry vehicle
RVAP	Reentry Vehicle Applications Program

S

s	second
S&A	safe and arm
S&T	science and technology
SA	situation awareness
SAILSS	Smart Aircrew Integrated Life-Support System

SAIP	semiautomated image processing
SAM	surface-to-air missile
SAR	synthetic aperture radar
SAS	synthetic aperture sonar
SASO	stability and support operations
SATCOM	satellite communications
Sb	antimony
SBIRS	Space-Based Infrared System
SBL	space-based laser
SBR	space-based radar
SCINDA	Scintillation Network Decision Aid
SDTS	Self-Defense Test Ship
Se	selenium
SEAD	suppression of enemy air defense
SEB	staphylococcal enterotoxin B
SEI	specific emitter identification
SERAT	Structurally Embedded Reconfigurable Antenna Technology
SES	smart escape systems
SFC	specific fuel consumption
SFDR	Surrogate Future Digital Radio
SHF	super high frequency
SHPL	Scaleable High-Performance LAN
Si	silicon
SiC	silicon carbide
SiGe	silicon-germanium
SIGINT	signals intelligence
SIL	system integration laboratory
SIMD	single instruction/multiple data stream
SINCGARS	Single-Channel Ground and Airborne Radio System
SIPRnet	Secret-Level Internet Protocol Router Network
SIRE	synthesized immersion research environment
SIT	static induction transistor
SLAM	Standoff Land Attack Missile
SLBM	submarine-launched ballistic missile
SNMP	simple network management protocol
SNR	signal-to-noise ratio
SOBEDS	Small On-Board Environmental Diagnostic Sensors
SOF	Special Operations Forces
SOI	silicon-on-insulation
SOJ	standoff jamming
SORTS	Status of Resources and Training System
SOS	silicon-on-silicon; system of systems
SPAWAR-SYSCEN	Space and Naval Warfare System Center
SPRINT	shift, pan, register, and integrate
sps	samples per second
SRAM	static random access memory
SSB	Small Smart Bomb
SSCOM	Solider Systems Command
SSP	Strategic Systems Program (Office)
STAP	space-time adaptive processing
STEP	Standard for Exchange of Product
STI	stationary target indicator
STIL	Streak Tube Imaging LIDAR
STO	Science and Technology Objective (Army)
STOW	Synthetic Theater of War
STR	space-time reference
STRV	Space Technology Research Vehicle
STW	surveillance and threat warning
SUO	small unit operations
SWIR	short-wavelength infrared

T

T&E	test and evaluation
T/R	transmit/receive
T/W	thrust-to-weight ratio
TA	target acquisition; threat alert
TAC	tactical command center
TACLOG	tactical logistics
TAD	theater air defense
TALD	Tactical Air-Launched Decoy
TARA	Technology Area Review and Assessment
TARTS	Tactical Real-Time Targeting System
TASID	Tactical Advanced Situation Display
TAV	total asset visibility
TBD	to be determined
TBM	theater ballistic missile
TCA	thrust chamber assembly
TCS	Tactical Control Station
TD	technology demonstration
TDD	target detection device
TDDS	Tactical Data Dissemination System
TDOA	time difference of arrival
TDP	technical data package
TEMO	training exercises and military operations
TFLOP	tera-floating point operations
TFPM	tactical forward-looking infrared pod modification
TFXXI	(U.S. Army) Task Force Twenty-One
THAAD	Theater High-Altitude Air Defense
Ti	titanium
TI	Tactical Internet
TLX	task load index (NASA)
TMC	Ti matrix composite
TMD	theater missile defense
TO	theater of operation
TOA	time of arrival
TOC	tactical operations center
TOGW	takeoff gross weight
TOTA	thin-optical towed array
TOW	Tube-Launched Optically Guided Weapon
TPFDD	total package fielding delivery date
TPSO	theater precision strike operations
TPV	thermo-photovoltaic
TRADOC	U.S. Army Training and Doctrine Command
TRIT	turbine rotor inlet temperature
TRL	technology readiness level
TTCP	The Technical Cooperation Program
TTP	tactics, techniques, and procedures
TUAV	tactical unmanned aerial vehicle
TUGS	tactical unattended ground sensor
TVC	thrust vector control
TVSS	toroidal-volume search sonar
TWT	traveling wave tube

U

U.K.	United Kingdom
UAV	unmanned aerial vehicle
UCAV	unmanned combat air vehicle
UFP	unit flyaway price
UGS	unattended ground sensor
UGV	unattended ground vehicle
UHF	ultra high frequency
UPC	unit production cost
USSOCOM	U.S. Special Operations Command
USSPACECOM	U.S. Space Command
USW	undersea warfare
UUV	unmanned undersea vehicle
UV	ultraviolet
UWB	ultra wideband
UXO	unexploded ordnance

V

V	volt
V&V	verification and validation
VDL	virtual distributed laboratory
VEE	Venezuelan equine encephalitis
VFATE	Virtual Future Aircraft Technology Enhancement
VHF	very high frequency
VHSIC	very high speed integrated circuit
VLS	Vertical Launch System
VLSI	very large scale integrated
VLWIR	very long wavelength infrared
VMAS	Vehicle Management System
VMF	variable message format
VMMD	vehicle-mounted mine detector
VOC	volatile organic compound
VPN	virtual private networking
VSIL	Vetronics System Integration Laboratory
VTC	video teleconferencing
VV&A	verification, validation, and accreditation
VV&C	verification, validation, and certification

W

W	watt
WAN	wide area network
WDM	wavelength-division multiplexing
WEE	Western equine encephalitis
WFD	widespread fatigue damage
Whr	watthour
Whr/kg	watthours per kilogram
WI	Warfighter's Internet
WMD	weapons of mass destruction
WORM	write once–read many
WPAFB	Wright-Patterson Air Force Base
WSMR	White Sands Missile Range
WWW	Worldwide Web

X

X	times; factor of
XVIII ABC	18th Airborne Corps

Z

$ZnGeAs_2$	zinc germanium arsenide