RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)							DATE February 2007	
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development			R-1 ITEM NOMENCLATURE Command, Control and Communications Systems PE 0603760E					
COST (In Millions)	FY 2006	FY 2007	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
Total Program Element (PE) Cost	207.852	227.626	256.868	267.786	275.154	268.154	270.154	270.154
Command & Control Information Systems CCC-01	47.285	50.732	68.396	78.961	87.200	86.200	86.200	86.200
Information Integration Systems CCC-02	100.255	100.275	85.123	83.825	83.495	88.495	90.495	90.495
Classified CCC-CLS	60.312	76.619	103.349	105.000	104.459	93.459	93.459	93.459

(U) Mission Description:

(U) This program element is budgeted in the Advanced Technology Development Budget Activity because its purpose is to demonstrate and evaluate advanced information systems research and development concepts.

(U) The goals of the Command and Control Information Systems project are to develop and test innovative, secure architectures and tools to enhance information processing, dissemination and presentation capabilities for the commander. This will give the commander insight into the disposition of enemy and friendly forces, a joint situational awareness picture that will improve planning, decision-making and execution support capability and provide secure multimedia information interfaces and assured software to "on the move" users. Integration of collection management, planning and battlefield awareness programs is an essential element for achieving battlefield dominance through assured information systems.

(U) The goals of the Information Integration Systems project are to take diverse data inputs from a variety of sources, efficiently disseminate the information, and perform distributed and dynamic all-source correlation and fusion to produce an integrated, geo-spatially referenced, battlefield database and knowledge-base. The principal element of this project is assured communications using standard and non-traditional means.

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(U) **Program Change Summary:** *(In Millions)*	FY 2006	FY 2007	FY 2008	FY 2009
Previous President's Budget	213.316	232.489	238.395	245.796
Current Budget	207.852	227.626	256.868	267.786
Total Adjustments	-5.464	-4.863	18.473	21.990
Congressional program reductions	0.000	-4.863		
Congressional increases	0.000			
Reprogrammings	0.000			
SBIR/STTR Transfer	-5.464			

(U) Change Summary Explanation:

FY 2006	The decrease reflects the SBIR/STTR transfer.
FY 2007	The decrease reflects congressional program reductions to PANDA, XG and WNaN and a decrease for Section 8106 Economic Assumptions.
FY 2008/2009	The increases reflect additional funding in Project CCC-01 to transition cognitive systems technologies to operational Command, Control and Intelligence (C2I) systems and minor repricing of classified efforts, offset by a decrease in Project CCC-02 following transition of several communications efforts in FY 2007.

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COST (In Millions)	FY 2006	FY 2007	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
Command & Control Information Systems CCC-01	47.285	50.732	68.396	78.961	87.200	86.200	86.200	86.200

(U) Mission Description:

(U) Military operations since the end of the Cold War illustrate that current theater-level command, control, communications, and intelligence/information systems lack the ability to fully support operations in complex, time-critical environments. Warfighters must be prepared for operations ranging from conflict and peacekeeping in urban centers to heavy battle actions in remote areas. Current capabilities do not provide the commander with real-time, secure, situational awareness or the ability to orchestrate high-tempo planning, rehearsal, and execution. The programs in this project are developing and testing innovative, secure architectures and tools to enhance information processing, dissemination, and presentation capabilities. The programs provide the commander insight into the disposition of enemy and friendly forces, a joint situational awareness picture that will improve planning, decision-making, and execution support capability, as well as secure multimedia information interfaces and software assurance to the warfighter "on the move." Integration of collection management, planning, and battlefield awareness are essential elements for achieving battlefield dominance through assured information systems.

(U) Program Accomplishments/Planned Programs:

	FY 2006	FY 2007	FY 2008	FY 2009
Joint Air/Ground Operations: Unified, Adaptive Replanning (JAGUAR)	9.178	10.178	12.532	8.761

(U) The Joint Air/Ground Operations: Unified, Adaptive Replanning (JAGUAR) program will improve battle management for complex air campaigns that employ new air platforms featuring precision sensors, weapons and communications relays. The JAGUAR system is driven by: 1) targeting information, both for sensor targets and strikes, expressed as point and area targets (i.e., search, combat air patrol); 2) rules of engagement and procedural constraints, such as airspace restrictions; and 3) availability of platforms, weapons, sensors, and communications equipment. From this information JAGUAR produces ingress routes, flight schedules and patrol zones, while assuring airspace and electronic deconfliction. The technology provides pilots and commanders the option to choose conventional tactics or conceive unconventional operations.

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In the latter case, the system captures the innovation and retains the strategic maneuver for future mission plans. JAGUAR monitors actual plan execution against expected results and alerts commanders to significant differences. The technology captures statistical descriptions of small differences to help assess the robustness of future plans. There is a Memorandum of Understanding in place with the U.S. Air Force and technology transition is planned to occur in FY 2009.

(U) Program Plans:

- Equip a training facility with software tools and human observers to capture plans as constructed, executed, and modified.
- Conduct exercises and capture a large set (several hundred) of mission plans as example cases.
- Decompose each plan into plan fragments.
- Assemble groups of related plan fragments into plan templates.
- Develop a large-scale integration algorithm to assemble plan fragments into a synchronized operational plan.
- Build optimization tools to tailor routes, schedule events, and deconflict airspace and radio frequencies.
- Compile standard mission plan products from the optimized operational plan.
- Demonstrate tools to correlate actual field events to planned events.
- Evaluate these techniques in periodic training events.

	FY 2006	FY 2007	FY 2008	FY 2009
Advanced Ground Tactical Battle Manager	7.605	6.133	8.000	10.000

(U) The Advanced Ground Tactical Battle Manager program is developing automated decision support tools for Army and Marine tactical commanders at the division level and below. The program also provides support for combined operations employing dismounted soldiers, manned platforms, and autonomous vehicles. The tool will elicit skeletal courses of action through a graphical interface with unit commanders and extend plans by applying adversarial reasoning techniques to identify vulnerabilities and opportunities in the predicted enemy course of action. Finally, modifications or counteractions will be developed to reduce vulnerabilities. Products will transition to the Army.

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- The Know What Is to Know Subsystem (KWIKS) will develop a support tool that autonomously and continually, during the execution of a military operation, tracks the state of what is known about the environment (and how well), and what are the forms and priorities of additional collection needs. This tool will provide substantially automated assistance to the current (laborious and non-real-time) process of collections planning, which currently includes manual steps such as analysis of external context, enemy and neutral goals and capabilities, and assessment of known threats. The overall benefit would be more effective, rapid, complete identification of enemy state, resulting in achieving mission objectives with fewer friendly casualties and lower collateral damage.

- The Deep Green subsystem combines anticipatory planning with adaptive execution, providing military decision makers with capabilities on the battlefield that the IBM computer 'Deep Blue' brings to the chessboard. This effort will explore closed-loop simulation to integrate planning, execution, and will incorporate continuous learning. The technology will also employ software agents to monitor the execution of the current operation against the plan, identify variations as the scenario unfolds and consistently explore the possible future states of the battlefield. This technology will allow a proactive rather than reactive stance in the command of the battlefield giving the U.S. warfighter the advantage.

(U) Program Plans:

– KWIKS
  -- Extend and develop emerging computational techniques for analysis of information state under conditions of adversarial concealment and deception and partial observability.
  -- Design and develop a system compatible with needs of service users and leveraging existing and emerging data sources.
  -- Design and execute a series of realistic wargame-based experiments to enhance and validate the capabilities of the system.
  -- Adapt and validate the system for transition requirements.
  -- Integrate into existing information infrastructures.

– Deep Green
  -- Extend prediction horizon further into the future.
  -- Include concealment and deception behaviors in predictions.
  -- Build interfaces to existing and future Army intelligence and command and control systems.
  -- Continue to conduct experiments to ascertain the value of the tools.

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-- Construct an architecture that allows interleaving anticipatory planning and adaptive execution.
-- Develop and enhance a state-space representation and new algorithms to identify courses of action.
-- Create and enhance planning agents to develop and assess enemy and friendly courses of action and execution monitoring agents to help identify when the plan is going awry.
-- Develop technologies that enable systems to learn how the enemy fights and to update both predictive analysis tools and behavior modeling in simulation (to include models of aggressive and timid enemy behaviors as well as hypothesized potentially deceptive behaviors).

	FY 2006	FY 2007	FY 2008	FY 2009
Predictive Battlespace Awareness	3.046	2.258	5.000	6.000

(U) The Predictive Battlespace Awareness program develops tools to interactively draw upon a distributed network of human experts, allowing them to collaboratively anticipate an opponent's future actions. The program will enable commanders to pre-position sensors, weapons, and information to counter the opponent's actions. The program will develop model- and knowledge-based techniques to predict areas of operation and tactical objectives. The technology will support the modeling of courses of action ranging over time horizons from hours to days. Program techniques permit "on-the-fly" tailoring of models and contextual knowledge, and leverage knowledge of sensor effectiveness, mobility factors, tactical templates, and target characteristics. Techniques to be developed include variable-fidelity prediction, such as the ability to determine both target locations over minutes and force zones of influence over hours. The tools anticipate enemy operations in time to thwart them with effects-based targeting, enabling use of sensors and other resources in proactive modes. The program will both enable commanders to avoid canned responses and support rapid incorporation of insights about new enemy strategies, capabilities, and tactics from peacetime to the heat of battle. The program will significantly enhance today's mostly manual, slow planning, and analysis processes. Technologies are planned to be transitioned to the Air Force Distributed Common Ground Station.

(U) Program Plans:
- Develop new algorithms for locating and tasking distributed human experts with portions of a problem to be solved.
- Construct sophisticated monitoring and assimilation algorithms that ensure the distributed human experts are making progress, re-task as necessary, and assimilate results to form a cohesive report for the requesting party.

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- Define a set of realistic challenge problems, including scenarios and a simulation facility to illustrate the context and value of predictive battlespace awareness.
- Develop approaches to prediction that combine physics-based modeling (e.g., for mobility and observability) with knowledge-based techniques (e.g., plan generation or recognition).
- Evaluate alternative approaches against the challenge problems.
- Define a system architecture that combines the best approaches into a consistent, mutually supporting toolkit.
- Integrate selected technologies into the toolkit.

	FY 2006	FY 2007	FY 2008	FY 2009
Comprehensive Force Protection	3.943	0.000	0.000	0.000

(U) The Comprehensive Force Protection program developed a rapidly deployable system to provide assured protection of permanent or temporary U.S. base camps in hostile territory. The system included wide-area sensors and platforms to maintain continuous surveillance of the camp area to detect potential intruders and weapon launches. The program also included a suite of airborne sensor platforms that can be tasked rapidly to investigate potential threats or "lock on" to personnel or weapons involved in an attack. Data collected from sensors is automatically analyzed, correlated, and provided to commanders to confirm threats and authorize precision weapons to engage. The system maintains continuous perimeter surveillance, allows rapid investigation, and, when authorized, attacks threats.

(U) Program Plans:
- Collected data on realistic intrusions in a variety of weather conditions.
- Characterized the performance of candidate signal processing, target recognition and localization, and environment monitoring algorithms on the test data.
- Selected a set of algorithms for a baseline system build.
- Constructed and calibrated a system performance model for the selected algorithms.

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	FY 2006	FY 2007	FY 2008	FY 2009
Urban Commander	13.025	11.727	13.998	12.146

(U) The Urban Commander thrust develops automated tools to help ground commanders construct detailed, realistic operational plans, particularly in nontraditional and urban environments. Partial plans are represented in hierarchical task networks and visualized through synchronization matrices, icon overlays, or tactical sketch animations. Commanders and staff modify, refine, and extend a plan through voice, sketching, and semi-structured input. The system links fragments constructed at different sites, transfers information among related parts, and discovers and recommends solutions for inconsistencies. The system continuously compiles a set of plan cases and employs analogical matching to propose extensions to current plans suggested by past experience. Plan elements are communicated through an integrated set of protocols from the unit commander down to dismount commanders equipped with advanced heads-up displays and helmet-worn sensors. Finally, the program continuously assesses progress against the operational plan and alerts users to significant deviations.

- The Multi-spectral Adaptive Networked Tactical Imaging System (MANTIS) program develops, integrates, and demonstrates a soldier-worn visualization system. Both helmet-mounted and handheld versions will be built during Phase 3 of the program. The system consists of five elements: 1) multi-spectral sensor suite; 2) high resolution digital display; 3) inertial measurement unit (IMU); 4) high-speed processor; and 5) power supply. MANTIS provides the warfighter with digitally-fused imagery in real time from the multi-spectral sensor suite, exploiting three distinct spectral bands: 1) the Visible/Near Infrared (VNIR, .4 - .9 microns); 2) the Short Wave Infrared (SWIR, 1 - 2 microns); and 3) the Long Wave Infrared (LWIR, 8 - 12 microns). The fused imagery is shown on two displays; one has a wide field-of view and the other a narrow field-of-view. When viewed together the system furnishes a larger field-of-view image with simultaneous high resolution and stereo capability. The system also allows the warfighters to record and "play back" the video while on the battlefield. The record/playback feature includes: electronic zoom, scroll, pan and panoramic image stitching. MANTIS provides a vision-aided inertial navigation system (INS) and will interface with the future soldier's global positioning system (GPS). When combined with precise pose estimation from the helmet-mounted IMU, MANTIS allows battlefield information to be overlaid on the display to provide increased situational awareness. MANTIS interfaces with the future soldier's advanced communications and networking systems, allowing the warfighter to send/receive video images and position information with fellow soldiers and commanders in real time. The coupling of the imaging system with INS/GPS will provide the individual warfighter a "point-click-kill" capability for real-time target hand-off capability to networked smart weapons fired from remote locations, thereby significantly increasing the lethality of the individual

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warfighter. There is a Memorandum of Agreement in place with the Program Executive Officer Soldier, and Night Vision & Electronics Sensor Directorate for transition at the conclusion of Phase III anticipated to be completed early in FY 2008.

- The ULTRA-VIS program will develop an integrated system to provide Army and Marine small unit leaders with the ability to conduct daytime operations in an urban environment. Key technologies will be developed to significantly improve the awareness, lethality and survivability for small units in urban combat. The system will include a conformal, see-through, optical waveguide visor that displays intra-squad commands, alerts, and even icons that are attached to the urban landscape. Network protocols will be developed for information management that allows the squad leader to hand-off actionable information and direct alerts to the squad /fire teams for real-time collaboration without overload. ULTRA-VIS will relay standard phrases and visual annotations that can be issued covertly, avoiding hand signals or shouting that may be recognized by the enemy. A robust, optically-assisted navigation technique will provide continuous geo-location and head tracking for each squad member while operating in GPS-denied environments. The ULTRA-VIS system will synthesize weapon fire observables across a networked moving squad to detect and locate hostile weapon fire using a helmet mounted IR sensor and small acoustic array for precise sniper location and real time designation within the warfighter's visor. ULTRA-VIS will empower the small unit leader with a clear tactical advantage through inter/intra squad collaboration, heightened awareness and the ability to take decisive action while on-the-move. The ULTRA-VIS technology is planned for transition to the Army.

- An urban warfare environment presents the warfighter with limited sightlines and mobility with insufficient knowledge of the disposition of enemy combatants, civilians, and occupied structures. As a result, the warfighter requires situational awareness information, presented in a manner that accounts for current operational context and personal strengths, limitations, and preferences. The Urban Commander program develops planning and control tools to support dismounted troops equipped with MANTIS and ULTRA-VIS sensors and displays. "On-the-ground" warfighters do not have time to constantly check an information rich visual display. Cognitive Impedance Matching (CIM) technology will develop a prototype system for presenting the information at the correct time and format to the affected individual. The system will ensure that situational awareness will be obtained and maintained across a range of echelons and battlefield conditions. Urban Commander forms a command and control substrate that enables ground forces, including vehicles and dismounts, to rapidly coordinate actions as the situation and commanders knowledge of the situation change. The program includes: 1) spatial analysis to determine lines of sight and fields of fire; 2) planning aids to assist in sensor placement and route planning; 3) visualization tools to allow commanders and soldiers to rapidly apprehend and address a situation; and 4) analysis tools to suggest locations and types of

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potential threats. Urban Commander Technologies are planned to transition to the Army Program Executive Office Command, Control, and Communications Tactical (PEO C3T).

(U) Program Plans:

– Multi-spectral Adaptive Networked Tactical Imaging System (MANTIS).
  -- Evaluated/demonstrated multi-sensor imagery and processing capability via MANTIS testbed.
  -- Completed functional prototype design.
  -- Fabricate three MANTIS functional prototypes (two helmet-mounted, one handheld) for evaluation.
  -- Conduct independent laboratory/field tests of MANTIS prototypes.
  -- Transition to the US Army (PEO Soldier).

– Ultra-VIS
  -- Develop see-thru display conformal visor using holographic waveguide.
  -- Develop optically-assisted navigation for continuous geo-location and pose estimation.
  -- Develop interface to actuate non-verbal commands and post icons onto a shared urban landscape.
  -- Create network protocols for alerts and information management for inter-squad collaboration.
  -- Develop fusion algorithms to precisely locate weapon fire using IR and acoustic signatures within a moving networked squad.
  -- Integrate technology components into an end-to-end system and demonstrate full system capabilities for military evaluations.

– Urban Commander
  -- Defined a common plan representation, based on service training material, for combined arms operations and constructed an initial collection of operational plans, for many scenarios and force structures.
  -- Developed multi-modal presentation of situation awareness data, utilizing visual, auditory, haptics, and other presentation modes.
  -- Develop new interfaces for presenting content rich information in a compact format and operational languages.
  -- Construct protocols to propagate changes generated at one location to affected locations, in accordance with defined policy and build flexible algorithms to match changes received from remote locations to the aspects of a plan retained locally.
  -- Demonstrate detection of plan inconsistencies and recommend corrections and conduct a series of laboratory evaluations with Army and Marine commanders to assess the quality and utility of program products.

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-- Develop an architecture based on the concept of a tactical global information grid (T-GIG), a service-oriented architecture that provides adaptive user filtering at the GIG side (not the user side) for information delivery, fault tolerant mechanisms, and controlled filter propagation.
-- Develop a context aware system, incorporating sensors and software to detect the warfighter's operational conditions and current cognitive state, and to detect if the warfighter has incorporated the situation awareness data that has been presented.
-- Incorporate additional tools for presenting and understanding situation awareness, including mapping and line of fire tools.

	FY 2006	FY 2007	FY 2008	FY 2009
Heterogenous Urban Reconnaissance Team (HURT)	7.220	5.782	5.000	4.000

(U) The Heterogeneous Urban Reconnaissance Team (HURT) initiative develops integrated tactical planning and sensor management systems for heterogeneous collections of unmanned platforms operating in urban environments. HURT employs a model-based control architecture with dynamic teaming and platform-independent command and control. The system registers new platforms with the battle manager (kinematics, maneuverability, endurance, payloads, and communications links) to facilitate platform-independent tasking. HURT provides a commander's interface that allows collaborative tasking of the platforms in the form of operational missions, such as search, track, identify, or engage, rather than routes and events. Additionally, it supplies computationally intensive decision aids, such as advanced 4D airspace and groundspace deconfliction tools, route planners, and task/platform assignments algorithms. The technology presents mission status and future courses of action to commanders for collaborative adjudication. HURT enables augmentation of low-footprint, rapidly deployable, easily sustainable human command structures with teams of machines operating together. HURT technology is planned for transition to the United States Marine Corps, U.S. Special Operations Command, and Air Force Special Operations Command.

(U) Program Plans:
- Selected a baseline planning/control algorithm.
- Developed a centralized information management server.
- Define multi-user reconnaissance missions.
- Assess the ability of the planning/control algorithms to effectively use each platform.
- Conduct field tests at an urban warfare training facility.

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	FY 2006	FY 2007	FY 2008	FY 2009
Tactical Group Decision Analysis Support System	3.268	4.329	5.812	7.000

(U) The Tactical Group Decision Analysis Support Systems program will develop distributed group decision analysis and network management tools. These tools will increase the tempo of the tactical commander's observe-orient-decide-act loop, the quality of decisions, the contribution of data point input across the organization, and the necessary communications capabilities needed to support this decision structure. This effort will develop a set of tools to evaluate risks and identify optimal "network configuration pivot points," and ideally will automate specific configurations for each network element. The Command, Control, Communications, and Computers (C4) tool suite provides the warfighter with a reliable communications network, which is critical to successful military operations. The tools will be applied in crisis management situations for tactical commanders and could be transitioned to existing emergency response command and control systems as well as emerging tactical command and control systems. The technologies developed under this program are planned for transition to the Army.

(U) Program Plans:

- Develop novel data structures and algorithms to exploit as many individual contributions as possible to a group decision problem in order to provide a comprehensive and well-founded automated decision.
- Create distributed infrastructure and user interface mechanisms to support real-time group decision analysis without the need for expert facilitators/participants to be in the same place at the same time.
- Provide a capability for continuous tracking of real-world events as well as stakeholder revisions related to the decision, to alert the tactical commander when the decision that was made is no longer optimal.
- Develop prototype decision analysis systems and validate that these systems lead to more effective decision making.
- Perform analysis of requirements for C4 capabilities including contingent event specification and network requirements representation.
- Refine and scale strategies for automating the configuration reasoning tasks for future C4 networks.

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	FY 2006	FY 2007	FY 2008	FY 2009
Dynamic Airspace Allocation	0.000	2.500	4.000	7.000

(U) The goal of the Dynamic Airspace Allocation program is to maximize airspace utilization through dynamic military airspace management. Today's labor-intensive human centric airspace management processes result in an inefficient use of airspace and limit the density and responsiveness of airborne systems. The program will evaluate and develop technologies for an automated system that efficiently manages all objects in the airspace to include munitions, manned aircraft, and unmanned air vehicles. The automated system will be developed as a replacement for current processes and will support all service users. Challenges to be addressed include maintaining real-time position and kinematic information for all objects in the airspace and the development of algorithms to dynamically reallocate airspace without human involvement. The capabilities developed by this program will benefit all of the services.

(U) Program Plans:
- Develop and simulate potential system architectures.
- Develop a preliminary design for the system.
- Demonstrate critical technologies.
- Develop and test a prototype system.

	FY 2006	FY 2007	FY 2008	FY 2009
Predictive Analysis for Naval Deployment Activities (PANDA)	0.000	7.825	11.054	15.054

(U) Predictive Analysis for Naval Deployment Activities (PANDA) develops technology to automatically learn normal activity models (motion and emission) for maritime surface vessels, automatically detect anomalous behavior, provide context modeling to resolve known categories of anomalies (e.g., due to weather and business rule changes), and alert processing. The resulting technology can be extended and applied to a wide range of applications including ground vehicles, troop movements, and individual targets of interest (e.g., suspected insurgents),

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as the methods of tracking those targets improves. The initial application will be anomaly detection in the maritime domain. PANDA technologies are planned to transition to the Office of Naval Intelligence and the Fleet Commanders.

(U) Program Plans:

- Develop new technologies and system architectures to support distributed learning of activity pattern models from complex spatio-temporal, all-source data.
- Demonstrate that individual and class-of-vessel motion-based activity patterns can be learned and used to detect anomalies.
- Use patterns to predict movements and classify (groups of) vessels as potentially (non) hostile with a low incidence of false alarms.
- Learn and detect multi-ship correlated activities.
- Incorporate context models.
- Leverage detection/tracking capabilities to include large and small (harbor) vessels.

	FY 2006	FY 2007	FY 2008	FY 2009
Increased Command and Control Effectiveness (ICE)	0.000	0.000	3.000	9.000

(U) The Increased Command and Control Effectiveness (ICE) program will develop and incorporate cognitive systems technology into operational Command, Control, and Intelligence (C2I) systems within each service. DARPA's Cognitive Systems programs have been developing the machine learning, reasoning, and human-machine dialogue technologies necessary to create cognitive assistants. This new technology promises to enable information systems to adapt – during deployment, in real time – to the changing conditions that military commanders confront. Information systems will automatically adjust to new environments and new users, helping commanders adapt to evolving situations and priorities, and accelerating the incorporation of new personnel into command operations. This program will fund the portions of the technologies developed in the Personalized Assistant that Learns (PAL) program (funded in PE 0602304E, Project COG-02) that are ready for application to command and control systems.

(U) From an operational perspective, cognitive approaches to information processing offer three major enhancements to current command and control systems. First, it will efficiently sort, segregate, separate and identify relevant data based on priority hierarchies established by the command structure. For example, image data could be selected based on target priority, historical context or anomalous changes. Second,

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cognitive technologies can adapt the presentation of information to suit the needs and preferences of the individual commander. Finally, cognitive systems will make relevant data generally available to all users both during collaborative planning processes and individual tactical analysis. In short, cognitive technology is introducing the equivalent of "just in time" inventory management to information management for command decision-making.

(U) The Army's Command Post of the Future (CPOF), the Navy's Composeable FORCENet (CFn) and the USAF's Air Tasking Order (ATO) information systems with the Air Operations Center (AOC), have been identified as target systems for the application of this new cognitive systems technology. These systems support complex situation assessment and decision making, process massive data streams and require users to integrate uncertain and dynamically changing information. They represent a spectrum of potential needs and constraints and taken together will assure that cognitive systems technology is of general applicability and utility throughout the military. Cognitive assistants will enable users to handle additional tasks as well as tasks of greater complexity. This will ultimately reduce the staffing footprint of command centers.

(U) Program Plans:

- Develop an initial prototype of a cognitively-enhanced CPOF system.
- Field test and refine the initial cognitively-enhanced CPOF prototype to validate that the cognitive technologies are robust to the dynamics and uncertainties associated with real use in an operational setting.
- Develop an advanced prototype of a cognitively-enhanced CPOF system that would learn to anticipate users' information needs, to pre-fetch needed information, to coordinate teams, and to manage message traffic.
- Field test and refine the advanced cognitively-enhanced CPOF prototype to validate that the cognitive technologies are robust to the dynamics and uncertainties associated with real use in an operational setting.
- Develop an initial prototype of a cognitively-enhanced Air Tasking Order (ATO) information systems with the Air Operations Center (AOC).
- Field test and refine the initial cognitively-enhanced Air Tasking Order (ATO) information systems with the Air Operations Center (AOC).
- Develop an initial prototype of a cognitively-enhanced Composeable FORCENet (CFn).
- Field test and refine the initial cognitively-enhanced Composeable FORCENet (CFn).
- Develop new concept of operations as necessary to support the deployment of cognitively-enhanced information systems.

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(U) Other Program Funding Summary Cost:

- Not Applicable.

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COST (In Millions)	FY 2006	FY 2007	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
Information Integration Systems CCC-02	100.255	100.275	85.123	83.825	83.495	88.495	90.495	90.495

(U) Mission Description:

(U) The goals of the Information Integration Systems project are to take diverse data inputs from a variety of sources, efficiently disseminate the information, and perform distributed and dynamic all-source correlation and fusion to produce an integrated, geo-spatially referenced, battlefield database and knowledge-base. Through the use of wideband dissemination and integrated sensor management, the project will also facilitate multi-site, real-time, collaborative situation assessment and course-of-action evaluations to enable true network centric warfare concepts. This project hosts many of DARPA's most innovative communications and networking systems. Programs funded are: Polarized Rotation Modulation (PZRM) Communications, the Connectionless Networking (CN) program, the Next Generation (XG) program, the Advanced Speech Encoding (ASE) program, the Symbiotic Communications (SYCO) program, the Optical & RF Combined Link Experiment (ORCLE) program, the Policy Based Network Management program, the Disruption Tolerant Networking (DTN) program, the Network Centric Operations/Battle Command program, the Ultra-Fast Radar (formerly Advanced Antenna Concepts) program, the Fiber-Optical Network for Aerospace Platforms program, the Advanced HF Communications program, the Communications to the Tactical Edge program, the Next Generation Routing and Addressing (formerly Self-Forming Networks) program, the Scalable MNW Architectures for Reconfigurable Transceivers (SMART) program, the DARPA Interference Multiple Access Communications program, the Tactical Combined Fiber-Optical and Free-Space Edge Network (formerly the Terabit Optical Ethernet) program, the SATCOM CX (formerly the Multiple-Input/Multiple-Output (MIMO) Satcom) program, the Wireless Network after Next (WNaN) program and the Networked Bionic Sensors for Language/Speaker Detection program.

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(U) Program Accomplishments/Planned Programs:

	FY 2006	FY 2007	FY 2008	FY 2009
Polarized Rotation Modulation (PZRM) Comms (formerly Secure Adaptive Waveforms)	2.013	5.127	4.398	0.000

(U) The goal of the Polarized Rotation Modulation (PZRM) Communications program is to develop new extremely high data rate, point-to-point, wireless communications using the PZRM communications concept, which can be implemented at any wavelength – RF to visible – to exploit the presently unused polarization and rotation dimensions of radiation. The PZRM communications program will investigate the use of polarization, including orthogonal signal spectrum overlay, modulation and the ability for conventional radios to carry all information over the transmitted signal amplitude, phase and frequency. Polarization modulation introduces an additional dimension. A radio with four polarization possibilities would transmit four times the information with all other aspects of the waveform held constant. Use of the antenna as part of the information processing architecture of a radio has not been previously performed. This technology will greatly increase the capability of existing channels without increasing spectrum or modem complexity. The program will be demonstrated as an enhancement to an otherwise state of the art networking system. The Polarization Modulation technology will begin transition to Service applications in FY 2008.

(U) Program Plans:

- Performed simulations to determine bit error rates and the optimum modulation schemes commensurate with the center frequencies and bandwidth permissible.
- Conducted simulations to verify performance predictions and identify component elements.
- Construct a demonstration prototype and undertake laboratory tests to validate PRZM concept.
- Demonstrate at long range under operational conditions.

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	FY 2006	FY 2007	FY 2008	FY 2009
Connectionless Networking (CN)	5.707	5.580	4.000	2.000

(U) In order to bring data efficiently from high value, but energy limited sensors (such as unattended ground sensors (UGS)), into system architectures like that associated with DARPA's Network Embedded Systems Technology (NEST), a new fundamental emphasis must be placed on how these kinds of sensor networks communicate. The Connectionless Networking (CN) program will develop technology to allow networks (such as UGS) to send and receive messages without initial link acquisition or previous sharing of routing information. This will improve energy usage per bit of delivered information by as much as 100 to 1,000 times compared to conventional and near-term deployable communications systems. Conventional radio link and network designs expend most of the energy on link establishment and maintenance, as well as packet and network overhead. This energy requirement not only limits the lifetime of energy-limited systems, it unnecessarily fills the radio spectrum, limiting available bandwidth, creates unnecessary risks of detection, and increases thermal loads. These impacts are especially severe for communications with proliferated sensors, or remotely operated weapons. Eliminating the requirement to maintain a continuous network link would enable these platforms to provide continuous connectivity without consumption of power, or compromising emanations. The CN program will exploit existing and available signal processing components, intelligent (processing and memory intensive) routing, and availability of situational information to demonstrate a total energy savings of at least 100 times typical connection oriented network applications. The Connectionless Networking technology is planned for transition to the Special Operations Command, Army, Navy, and Air Force for unattended ground sensors and low duty cycle applications beginning in FY 2009.

(U) Program Plans:

- Translated CN technology design and simulations into actual hardware and software.
- Designed and fabricated prototype CN network node devices, and performed laboratory demonstrations.
- Develop and evaluate candidate approaches for implementation complexity, on-board processor and memory capability/power, overhead, scalability and performance.
- Design and fabricate prototype Connectionless Networking node devices with hardware and form factor suitable for military applications.
- Conduct 30 node field demonstrations using CN devices in a form factor suitable for transition.

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	FY 2006	FY 2007	FY 2008	FY 2009
Next Generation (XG)	10.916	1.869	5.000	5.000

(U) The Next Generation (XG) program goals are to develop both the enabling technologies and system concepts to provide dramatic improvements in assured military communications in support of a full range of worldwide deployments through dynamic spectrum access. U.S. Forces face unique spectrum access issues in each country in which they operate due to competing civilian or government users of national spectrum. These constraints must be reflected in all force planning and may preclude operation of critical systems. Coalition and allied operations are even more complex to manage, and may severely limit the U.S. ability to fully exploit its superiority and investment in information technology. The XG program approach is to develop the theoretical underpinnings for dynamic access to the spectrum, the technologies and subsystems that enable dynamic access, and the system prototypes to demonstrate applicability to legacy and future DoD radio frequency emitters. The program is investigating methods to leverage the technology base in microelectronics with new waveform and medium access and control protocol technologies to construct an integrated system. The program goals are to develop, integrate, and evaluate the technology to enable equipment to automatically select spectrum and operating modes to both minimize disruption of existing users, and to ensure operation of U.S. systems. The result of the XG program will be to develop and demonstrate a set of standard dynamic spectrum adaptation technologies for legacy and future emitter systems for joint service utility. The XG Communications technology is planned to transition to the Army for implementation in a range of current and future communication systems including the Joint Tactical Radio Systems clusters in FY 2009.

(U) Program Plans:

- Developed initial set of hardware prototypes and undertook initial field experimentation.
- Developed and evaluated candidate approaches for implementation complexity, on-board processor and memory capability/power, overhead, scalability and performance.
- Developed final set of hardware prototypes to evaluate and demonstrate system capabilities in an operational exercise.
- Demonstrated spectrum agility performance of prototypes in field experiments.
- Demonstrated spectrum effectiveness and operational characteristics.
- Develop and demonstrate large-scale network organization and adaptation.
- Conduct medium and large-scale military scenario demonstrations.

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	FY 2006	FY 2007	FY 2008	FY 2009
Advanced Speech Encoding (ASE)	6.699	5.383	4.992	4.257

(U) The Advanced Speech Encoding (ASE) program will achieve an order of magnitude reduction of voice communication bit rates in noisy military environments over current state-of-the-art voice encoders (VOCODER). Such a reduction will significantly decrease the probability of detection of transmitted signals and will also decrease the required transmit energy, thereby increasing battery lifetime. The program will pursue two novel approaches toward achieving its goal. One approach builds upon multiple noise-immune sensors that have been combined with traditional coding algorithms to achieve significant improvements in intelligibility and quality in harsh noisy environments at 2,400 bits per second (bps). This approach will be extended to nontraditional ultra-low-bit-rate coding algorithms in order to achieve 300 bps coding capability in harsh military environments. Alternative approaches will also be explored, such as the communication without acoustic information achieved by extracting laryngeal and sublingual muscle signals that are produced when a person generates sub vocal speech. This approach will yield a revolutionary capability in situations where stealth is of the utmost importance, or in situations where acoustic signals cannot be used, such as under water. The Advanced Speech Encoding technology is planned for transition to the Communications and Electronics Command of the U.S. Army after a prototype demonstration scheduled for FY 2009.

(U) Program Plans:

- Demonstrated a voice communication system (sensors plus coder) operating at 1,000 bps that is at least as good as today's DoD standard in harsh military noisy environments.
- Demonstrate a 300 bps VOCODER with intelligibility, quality and aural speaker recognition in harsh military noisy environments that is at least as good as today's DoD standard.
- Develop a prototype communication system and demonstrate the capability for ultra-low-rate coding in a field demonstration.
- Develop techniques to capture and enhance sub vocal signals to enable stealth communication among the warfighter teams.
- Explore the nature of sub vocalic signals (physiological source, speaker dependence, and robustness) and the information content of the signals.

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	FY 2006	FY 2007	FY 2008	FY 2009
Symbiotic Communications (SYCO)	8.738	2.375	0.000	0.000

(U) The Symbiotic Communications (SYCO) program is developing an airborne passive radar system to enable precision targeting and battlefield situational awareness. SYCO will generate high resolution Synthetic Aperture Radar (SAR) imagery. This system will operate passively and be effective in clear and adverse weather. SYCO has demonstrated a proof-of-concept through ground-based and airborne flight tests. Additionally, a design for a real-time prototype, as well as automated algorithms to enable real-time processing have been developed and tested. To complete this project, the prototype will be developed and packaged to be form/fit/function compatible for transition. The SYCO technology is planned for transition for Service applications in FY 2008.

(U) Program Plans:
- Demonstrated ground based RADAR operation with real sources.
- Demonstrated airborne RADAR operation with real sources.
- Completed end-to-end system design.
- Develop real-time airborne demonstrator system.
- Demonstrate high resolution SAR at national imagery interpretability rating scale level 4.
- Participate in limited user testing.

	FY 2006	FY 2007	FY 2008	FY 2009
Optical & RF Combined Link Experiment (ORCLE)	21.041	14.597	7.560	10.000

(U) The Optical & RF Combined Link Experiment (ORCLE) seeks to develop combined radio frequency (RF) and free space optical (FSO) communications as well as networking technologies that exploit the benefits of complementary path diversity. This effort will demonstrate improved battlespace communications using a hybrid RF and FSO link in air-to-air-to-ground environments. The central challenge is to enable optical communications bandwidth without giving up RF reliability and "all-weather" performance. ORCLE will develop RF and FSO

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propagation channel analysis, coding techniques and modeling to include weather, atmospherics and aero-optics to provide the joint force commander assured high-data rate communications. The technical objective is to prototype and flight demonstrate hybrid FSO/RF air-to-air-to-ground links that combine the best attributes of both technologies and simulate hybrid network performance. The ORCLE technology is planned for transition to the Air Force in FY 2009.

(U) Program Plans:
- Perform range and flight demonstrations of air-to-air-to-ground hybrid FSO/RF links with high availability and gigabit data flows.
- Investigate the optical channel obscuration mitigation using ultra short pulse lasers and partially coherent beams.
- Execute common/combined FSO/RF apertures that enable transition to operational platforms as replacements rather than addition to current systems while maintaining or improving current capabilities.

	FY 2006	FY 2007	FY 2008	FY 2009
Policy Based Network Management (PBNM)	2.599	0.000	0.000	0.000

(U) Drawing upon lessons learned from the Airborne Communications Node/Adaptive Joint C^4ISR Node (ACN/AJCN) program and previous DARPA programs in mobile ad-hoc networking, the Policy Based Network Management (PBNM) program has enabled reliable and understandable control of non-homogeneous ad-hoc networks and other communications systems that must interact to support the commander's mission objectives. This effort created a system control methodology allowing intuitive control over complex communications systems while still preserving the flexibility of the emerging ad-hoc networks. In addition to creating a method for an operator to understand the state of the network, PBNM allows the network to implement the commander's intent for the operation by dynamically changing function and allocation throughout the duration of a mission. PBNM controls traffic at the application level by making the system aware of what is currently possible, what is currently allowed, and how communications are expected to change over the duration of a mission.

(U) Program Plans:
- Demonstrated, using wireless networked communications, the ability to control information traffic to satisfy commander's intent and mission needs.

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	FY 2006	FY 2007	FY 2008	FY 2009
Disruption Tolerant Networking (DTN)	6.633	8.425	8.205	6.100

(U) The Disruption Tolerant Networking (DTN) program is developing network protocols and interfaces to existing delivery mechanisms ("convergence layers") that provide high reliability information delivery using communications media that are not available at all times, such as low earth satellites, UAV over-flights, orbital mechanics, etc. The program is developing a single model for bundling information and ensuring its delivery, through a series of episodic communications links, from generator to user. Mechanisms and protocols that reduce bandwidth consumption, reduce latency, and improve reliability of information delivered to tactical deployments will be explored. The program is also exploring a new security model which protects information held in portable devices. To maximize the applicability and commercial viability of these protocols, and develop the basic software in an open source mode, the military, commercial and Internet communities have been engaged. These protocols will be implemented in a typical military system to verify both the performance of the protocol and to validate the utility. The Disruption Tolerant Networking technology is planned for transition to the Army and Marine Corps in FY 2009.

(U) Program Plans:

- Demonstrated that information organized into bundles can be delivered across intermittent networks.
- Investigated policy cognitive operation by moving intelligence into networks to make the best choices on delivery.
- Commence research to show "fuzzy scheduling" can make network routing decisions in the presence of uncertainty about available or optimal paths.
- Enable networks to deliver traffic without the end-to-end address and routing information using deferred, hierarchical address binding techniques.
- Develop mechanisms to allow code-base-independent environmentally-aware selection of routing algorithms.
- Demonstrate trusted delivery of bundles across networks in which access to a public key infrastructure is not reliable.
- Demonstrate distributed in-network cache and indexing services.
- Demonstrate information binding on demand from a network cache.

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	FY 2006	FY 2007	FY 2008	FY 2009
Network Centric Operations/Battle Command (Integrated Battle Command)	9.054	11.926	6.229	3.000

(U) The DoD is transforming to a more network centric focus for military operations. Network centricity, among other benefits, facilitates the sharing of situation information and access to resources. Shared situation awareness enables collaboration and self synchronization at all operational levels thereby greatly increasing mission effectiveness. Military campaigns in the future will not necessarily be focused solely on major military operations. These campaigns will involve attempts at conflict avoidance, and if this fails, possibly major combat operations with periods of various security, stability, reconstruction, transformation and transition operations. Future campaigns will be characterized by an increased demand for the commander to employ the most appropriate actions (diplomatic, information operations, military, economic, etc.) against the adversary's various political, military (air, land and sea; regular or irregular), economic, social, information distribution, infrastructure, etc. systems. Commanders in the future will use network centricity to access a larger base of knowledge sources and a greater range of resources and actions. Concurrently, the commander will be challenged to exploit these capabilities to achieve a mixture of appropriate effects.

(U) Until recently, the primary technological emphasis for network centric operations has been on improving command, control, communications and computing, intelligence, surveillance and reconnaissance (C^4ISR) systems to enable better sensor-decider-shooter linkages. While appropriate, there must also be more emphasis on technologies to assist commanders in understanding the complex operational environment, developing and managing intervention campaigns using an effects based approach to operations that employ all options available to the commander, and synchronizing combat operations, security, stability, reconstruction, transformation and transition operations over the entire time of the campaign.

(U) Initial technologies developed in the program are planned to transition to the Army Network Enabled Battle Command program and to the U.S. Joint Forces Command as an initial capability in FY 2006, with more comprehensive capabilities transitioning incrementally through FY 2009.

(U) Program Plans:

- Developed and demonstrated technologies for integrating modeling and visualization techniques into action/effects exploration and campaign planning with an emphasis on modeling an adversarial coalition's various political, social, economic, information dissemination, service infrastructure, etc. systems as well as its military or insurgent capabilities.

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– Develop and demonstrate technologies to support humans in authoring courses of action, development and campaign planning; decompose objectives, to effects, to nodes, to actions; capture and model interdependencies between assumptions, activities and intended objectives, and between intended and unintended effects; and assist the human in synchronizing objectives and activities.

	FY 2006	FY 2007	FY 2008	FY 2009
Ultra-Fast Radar (formerly Advanced Antenna Concepts)	4.769	7.345	3.530	1.000

(U) The Ultra-Fast Radar effort will entail the design, construction, and demonstration of an X-band noise correlating radar with a retro-directive antenna. This effort will research and develop a new type of radar sensor based on the correlations of the Gaussian noise received by an antenna array from a small object located in the far field of the antennas and the retro-directive re-radiation of the correlated noise. The combining and tailoring of noise correlating interferometry and retro-directive antenna arrays into retro-directive noise-correlating (RNC) radar will allow the radar to operate in omni-directional search mode. The result of this project will be a new type of search-mode radar having promising performance in terms of short acquisition time and low probability-of-intercept. The Ultra Fast Radar technology is planned for transition to the Army in FY 2009.

(U) Program Plans:

– Modeled, simulated, and demonstrated detection of fluctuating and multiple targets.
– Conducted X-band radar free space test using early prototype bench equipment.
– Develop an X-band noise correlating radar with a retro-directive antenna to show an approximately 5-times reduction in acquisition time compared to traditional electronically-steered search-mode radar, and an even greater reduction in comparison to mechanically scanned radar.
– Design and demonstrate ultra-fast radar using retro-directive antenna arrays that will show a significant reduction in probability-of-intercept compared to traditional search radars based on coherent transmitters.
– Determine if the concept offers significantly reduced cost and greater simplicity to radar development and antenna designs than current systems.

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	FY 2006	FY 2007	FY 2008	FY 2009
Fiber-Optical Network for Aerospace Platforms	4.000	5.125	5.000	5.000

(U) The Fiber-Optical Network for Aerospace Platforms program will facilitate building or upgrading military aircraft and other aerospace platforms with a fiber-optical networking infrastructure with many capabilities that are well beyond those of currently used copper-based technology. Originally, the program focused on specific technologies for application on the Navy's EA-6B Prowler aircraft, however, the program has been broadened to focus on technologies that will provide advanced capabilities to a multitude of military aircraft, shipboard and aerospace platforms. These new capabilities include: scalability in bandwidth and number of connected devices; immunity to electromagnetic interference (EMI) and cable cross-talk; reduced cable and overall system weight and volume; increased reliability without an associated weight or volume penalty; ease of integration and future upgradeability; and the ability to carry mixed analog and digital signal formats. This will be accomplished by taking full advantage of fiber-optical wavelength-division-multiplexing (WDM) technology and leveraging optoelectronic and photonic integration techniques developed in DARPA photonics components program. To reduce size, weight and power requirements and to increase the reliability and the flexibility of interconnecting arbitrarily placed client devices with various signal formats, use will be made of passive, transparent, wavelength-routing technology at the core of the network, and tunable optical transmitters and receivers (transceivers) to inter-connect the client devices at the edge of the network. The technologies developed under this program are planned for transition to the Services in FY 2010.

(U) Program Plans:

- Compile an extended superset of the requirements for a network to be deployed in various target aerospace platforms.
- Create a suitable architecture for a mostly passive, wavelength-division-multiplexing (WDM) fiber-optical network with high connectivity for increased reliability.
- Develop a wavelength plan for interconnecting arbitrarily placed client devices using tunable optical transceivers.
- Develop a protocol for rapid restoration from multiple failures through protection switching or by re-tuning the optical transceivers.
- Conduct an analysis to estimate the resulting network reliability and survivability under various failure scenarios.
- Demonstrate the ability to interconnect client devices with a wide range of analog and digital signal formats.
- Demonstrate the ability to integrate the appropriate combinations of optical devices and components to reduce weight and volume.
- Build and flight-test a network test bed that is representative of a network suitable for one or more target aerospace platforms.

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	FY 2006	FY 2007	FY 2008	FY 2009
Advanced HF Communications	1.842	3.300	4.000	3.000

(U) The goal of the Advanced HF Communications program is to provide always-available, high-rate communications at long ranges for Special Operations Force (SOF) teams using miniaturized equipment. Currently SOF teams rely on satellite communications (Satcom) for long range connectivity. However, Satcom requires line of site access, and channel availability. The Advanced HF Communications will develop antenna and radio technology to provide high-rate communications at long ranges using ground wave and near vertical incidence skywave (NVIS) propagation. A fundamental challenge is reducing the size, weight and power (SWaP) requirements for SOF applicability. Novel miniature HF antenna technologies and channel adaptive radio technologies will be developed and demonstrated in man portable form factors. The technologies developed under this program are planned for transition to Special Forces in FY 2010.

(U) Program Plans:

- Investigate novel antenna designs for miniature form factor and high efficiency.
- Perform propagation experiments to determine atmospheric effects on communications using both ground wave and NVIS electromagnetic propagation modalities.
- Develop improved statistical models of atmospheric effects on communications to implement effective equalization techniques using state of the art digital signal processing components and algorithms.
- Develop a dual mode transceiver prototype in a package that validates the size, weight and power requirements of the SOF user.
- Perform a field demonstration on a prototype transceiver in various environments to validate the concept.

	FY 2006	FY 2007	FY 2008	FY 2009
Communications to the Tactical Edge	2.375	0.000	0.000	0.000

(U) The future DoD communications architecture will provide a multi-tiered capability consisting of: a worldwide, broadband Global Information Grid (GIG); transportable networks like the Army Warfighter Information Network-Tactical (WIN-T); and totally wireless mobile ad hoc tactical networks formed using the next generation Joint Tactical Radio System (JTRS) terminals. This program researched technology to

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make networks "user-aware" and oriented toward delivering tailored services to each user by dynamically balancing communications supply and demand. An Information Flow Control Network was studied that acts as a dynamic overlay to existing communications networks while simultaneously serving as an underlay to existing service oriented architectures and other middleware.

(U) Program Plans:
- Studied technology to implement a user-transparent service that dynamically monitors the communications supply available and the communications demand desired at each user (or end system) and is aware of the military missions being executed by each user.

	FY 2006	FY 2007	FY 2008	FY 2009
Next Generation Routing and Addressing (formerly Self-Forming Networks)	3.419	3.557	3.750	6.000

(U) The Next Generation Routing and Addressing program seeks to develop networks that use topographically distributed addresses (e.g., geographically or by organizational unit). Current network routing methodologies use IP address numbers that are distributed in no defined pattern or methodology. As a result, current routing systems spend large amounts of time and computing power updating and maintaining tables that 'point' to where different IP addresses are located geographically. The self-forming networks will reduce the load on routers as well as greatly simplify router configuration. These networks will be a paradigm shift in that numbered IP addresses will no longer exist, and changes to the Domain Naming Server (DNS) system will allow for services to mobile users to be incorporated. This program is planned for transition to the Services in FY 2011.

(U) Program Plans:
- Develop machine naming schema for data packets that are geographically based and that allow for fine grained control of precedence and improved quality of service capabilities.
- Develop tactical router replacements that work with existing computers/routers and require no new configuration and enable self-forming networks that will result in at least an order-of-magnitude reduction in training, configuration, and installation time.
- Develop changes to DNS functions to accommodate the forwarding services to mobile users.

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	FY 2006	FY 2007	FY 2008	FY 2009
Scalable MMW Architectures for Reconfigurable Transceivers (SMART)	5.370	8.534	8.200	8.540

(U) This program seeks to exploit recent advances in analog transmit and receive technology with progress in ultra-high speed logic to simultaneously reduce the transceiver phase noise and reduce analog device non-linearities with digital correction techniques. In particular, the current performance of Silicon Germanium and Indium Phosphide bipolar device technology is now fast enough, with cut-off frequencies of > 350 GHz, that error correction technique such as predistortion and feed forward correction can be considered for application to radio frequency (RF) components. The effort will develop new circuit topologies and algorithms along with cross technology integration schemes. This combination will increase the maximum signal data rate (increase the bits/sec/Hz) for DoD RF links. This program will transition through industrial producers of millimeter-wave radar systems for DoD applications.

(U) Program Plans:
- Study fundamental limits to RF communication links and perform system study.
- Define critical technical challenges to increasing link margin by improving component linearity.
- Establish program metrics for optimum RF link demonstration.
- Initiate component development and heterogeneous integration demonstrations.

	FY 2006	FY 2007	FY 2008	FY 2009
DARPA Interference Multiple Access (DIMA) Communications	5.080	8.458	6.398	5.494

(U) The DARPA Interference Multiple Access (DIMA) Communications program will develop a networked radio system that supports voice and data. The goal of this program is a network that is dynamically controllable using techniques such as reconfiguration, optimum resource allocations based on mission priorities, and dynamic policies, as opposed to relatively passive reactions to changes by the commercial infrastructure. This program will initially develop direct sequence spread spectrum (DSSS) communications technologies as a building block to enable robust, mobile, tactical wireless networks, which are the foundation for network centric warfare concepts. The fundamental technical challenges are scalability, covertness, robustness and platform size, weight and power requirements. The DIMA Communications program will

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develop and demonstrate a DSSS system based on multi-user detection concepts that can operate in an infrastructureless (ad-hoc networked) environment. The technologies developed under this program are planned for transition to the Army and SOCOM in FY 2010.

(U) Program Plans:
- Demonstrate feasibility of concept in a wireless test bed.
- Develop optimized waveform, multi-user detection processing and channel parameter estimation algorithms.
- Demonstrate system performance through a combination of simulation and hardware prototype field demonstrations.

	FY 2006	FY 2007	FY 2008	FY 2009
Tactical Combined Fiber-Optical & Free-Space Edge Network	0.000	3.024	3.000	7.000

(U) Based on technologies developed under the Next Generation Optical Networks program (budgeted in PE 0602303E, Project IT-03), the Tactical Combined Fiber-Optical and Free-Space Edge Network effort (formerly Terabit Optical Ethernet) will make it possible for the U.S. military to create a rapidly deployable, self-healing, tactical wavelength-division-multiplexed (WDM) fiber-optical network, combined with free-space optical and directed radio frequency (RF) networks, that can provide substantial communications capability to command centers deployed in somewhat mature areas of hostility. Key capabilities that will be enabled by this program include: (1) the elimination of power needs in the core of the network through the design and fabrication of passive wavelength-routing nodes that will allow the switching functions to be done via tunable optical transmitters and receivers (transceivers) at the edge of the network; (2) enhanced network survivability through a suitable highly connected network topology leveraging a fast-restoration protocol capable of rapid recovery from multiple network node and link failures; and (3) extended geographical coverage of the network to hundreds of kilometers, without requiring additional power at the core. In addition, protocols will be developed to enable the connection of this network to tactical wireless networks as well as to existing fixed networks allowing the efficient transmission of a combination of internet protocol (IP), digital video streams as well as analog and digital radar, electronic warfare (EW) and RF signals. The program will also include the development of techniques to realize ruggedized network nodes and interconnecting fiber cables, which are strung along the ground, buried in the ground and/or in riverbeds or other waterways. This program is expected to transition to the U.S. Army and U.S. Marine Corps in FY 2010.

(U) Program Plans:
- Characterize and model the network elements of a combined fiber/free-space optical network.

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- Create a suitable architecture for a passive, WDM fiber-optical and free-space network with high connectivity for increased reliability.
- Develop a set of passive, wavelength-routing nodes that can enable the realization of this architecture.
- Develop a wavelength plan for interconnecting client devices with tunable optical transceivers placed at the edge of the network.
- Develop a protocol for rapid restoration from multiple network node and link failures through re-tuning the optical transceivers.
- Conduct an analysis to estimate the resulting network reliability and survivability under various failure scenarios.
- Demonstrate the ability to interconnect client devices with a wide range of analog and digital signal formats and protocols.
- Devise appropriate protocols to enable the integration of the network with existing networks and tactical wireless networks.
- Develop techniques to realize ruggedized network nodes and fiber cables.
- Build and test a network testbed that is representative of tactical networks and environments.
- Investigate innovative methods and technologies for deploying, connecting and maintaining combined fiber-optical and free-space optical and RF networks.

	FY 2006	FY 2007	FY 2008	FY 2009
SATCOM CX (formerly Multiple-Input / Multiple-Output (MIMO) Satcom)	0.000	2.950	3.861	3.425

(U) The SATCOM CX program will develop a proof of concept system that will enable multiple users' access to 100 kilobits per second (kbps) satcom channels using the existing C-band satellite architecture. This new capability becomes possible, in part, by moving away from the existing paradigm regarding usage of these satellites. This new SATCOM CX paradigm envisions satellites as merely a node or relay for a single user. In communications terminology, the satellite is part of a single-input/single-output (SISO) channel. Instead, this program will consider the multiple satellites simultaneously. Using this approach, a multitude of co-channel users sends signals that illuminate a multitude of satellites. Powerful processing algorithms then isolate the individual communication links. Using the constellation in this manner provides signal gain and interference rejection.

(U) The most important advantage for military missions is the ability to use the existing C-band uplink infrastructure with antenna aperture areas several orders of magnitude smaller than are currently needed. The large size of current C-band ground station antennas is driven by the need to limit adjacent satellite interference rather than the need for additional link margin. Operation with drastically reduced apertures is possible

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if the requirement to avoid illuminating an adjacent satellite is removed. By relaxing beam size requirements, the ground terminal footprint can be reduced. Other satellite constellations with reduced coverage offer greater power and, hence, more capacity.

(U) The increased complexity of the SATCOM CX communication link demands dynamic and adaptive network protocols to ensure optimal performance is achieved. The technologies developed under this program will transition to the Services' expeditionary forces in FY 2010.

(U) Program Plans:
- Develop the system design requirements.
- Develop the system components.
- Integrate the components and demonstrate the communications capability.
- Demonstrate the fundamental capability enhancement using processed data.

	FY 2006	FY 2007	FY 2008	FY 2009
Wireless Network after Next (WNaN)	0.000	2.700	4.000	8.509

(U) The Wireless Network after Next (WNaN) program goal is to develop and demonstrate technologies and system concepts enabling densely deployed networks in which distributed and adaptive network operations compensate for limitations of the physical layer of the low-cost wireless nodes that comprise these networks. WNaN networks will manage node configurations and the topology of the network to reduce the demands on the physical and link layers of the nodes. The technology created by the WNaN effort will provide reliable and highly-available battlefield communications at low system cost.

(U) The WNaN program will develop a low-cost handheld wireless node that can be used to form high-density ad hoc networks and gateways to the Global Information Grid. This program will also develop robust networking architecture(s) and network technologies/processes that will exploit high-density node configurations. This program will culminate in a large-scale network demonstration using the multi-channel nodes. WNaN technology is planned for transition to the Army in 2010.

(U) Program Plans:
- Design, integrate and test handheld, multi-channel wireless nodes that utilize inexpensive RF circuits and narrowband tuning filters.

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- Develop, integrate and test network technologies/processes that exploit diverse paths and frequencies to support network scalability and network formation of tens of thousands of operational nodes.
- Demonstrate a communication system where the network layer can mitigate shortfalls in the physical layer.
- Demonstrate large scale operation of 500 to 1000 nodes integrated into a highly adaptive, dynamic, self-forming, self-healing WNaN military network.

	FY 2006	FY 2007	FY 2008	FY 2009
Networked Bionic Sensors for Language/Speaker Detection	0.000	0.000	3.000	5.500

(U) The Bionic Sensor program will develop and demonstrate low-power micro-sensor devices and networks for language/speech detection and recognition processing to detect voice activity, including speaker ID recognition in villages known to be insurgent recruitment "hot-spots". The system will use ultra low power signal conditioning/processing front end processors with language/speaker recognition algorithms for distributed sensor network applications in the battlespace. Networked bionic sensors will be able to make detections within meters from the target providing high SNR (Signal to Noise Ratio, of >10 dB) with sufficient recognition performance in an urban (non-telephonic) environment. This program will provide the ability to discretely monitor buildings, human presence detection/tracking in other sensitive areas, enable force protection, and provide Battle Damage Information. Intelligence, Surveillance, and Reconnaissance (ISR) capabilities can be enhanced with this technology by covertly detecting and tracking high value targets with hand emplaced or air deployed sensor networks. The technology developed is planned for transition to the Marines in 2010.

(U) Program Plans:
- Develop low-power micro-sensor devices and networks.
- Recognition of social associations.
- Identify insurgent and terrorist activity.

(U) Other Program Funding Summary Cost:

- Not Applicable.