RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)						DATE February 2008	
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 2007	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
Total Program Element (PE) Cost	229.399	255.235	338.964	283.277	284.710	289.469	298.657
Command & Control Information Systems CCC-01	54.499	50.581	52.562	63.670	65.577	65.577	65.576
Information Integration Systems CCC-02	104.291	101.305	126.707	96.154	97.568	99.549	99.548
Classified CCC-CLS	70.609	103.349	159.695	123.453	121.565	124.343	133.533

(U) Mission Description:

(U) The Command, Control and Communications Systems 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.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE: February 2008
APPROPRIATION/BUDGET ACTIVITY: RDT&E, Defense-wide; BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE: Command, Control and Communications Systems; PE 0603760E

(U) Program Change Summary: *(In Millions)*

	FY 2007	FY 2008	FY 2009
Previous President's Budget	227.626	256.868	267.786
Current Budget	229.399	255.235	338.964
Total Adjustments	1.773	-1.633	71.178
Congressional program reductions	0.000	-1.633	
Congressional increases	0.000		
Reprogrammings	7.600		
SBIR/STTR Transfer	-5.827		

(U) Change Summary Explanation:

FY 2007	Decrease reflects a below threshold reprogramming and the SBIR/STTR transfer.
FY 2008	Decrease reflects reductions for Section 8097 Contractor Efficiencies and Section 8104 Economic Assumptions.
FY 2009	Increase reflects enhancements in the C2 area for the introduction of cognitive computing tools into on-going C2 programs, offset by other C2 program completions, increases to communications efforts to fund continuation and expansion of the Wireless Network After Next (WNAN) and Optical RF Communications programs, and increases to classified programs.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Command, Control and Communications Systems PE 0603760E, Project CCC-01

COST (In Millions)	FY 2007	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
Command & Control Information Systems CCC-01	54.499	50.581	52.562	63.670	65.577	65.577	65.576

(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 2007	FY 2008	FY 2009
Joint Air/Ground Operations: Unified, Adaptive Replanning (JAGUAR)	9.178	8.531	7.761

(U) The Joint Air/Ground Operations: Unified, Adaptive Replanning (JAGUAR) program improves 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. In the latter case, the system captures the innovation and retains the strategic maneuver for future mission plans. JAGUAR monitors actual plan

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Command, Control and Communications Systems PE 0603760E, Project CCC-01

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 late FY 2009.

(U) Program Plans:

FY 2007 Accomplishments:

- Equipped a training facility with software tools and human observers to capture plans as constructed, executed, and modified.
- Developed dynamic plan generation to accommodate popup targets or mission changes.
- Developed continuous plan monitoring to assess deviations from plans.

FY 2008 Plans:

- 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.

FY 2009 Plans:

- Conduct operationally realistic experiments at Air Force Distributed Mission Operations Center.

	FY 2007	FY 2008	FY 2009
Heterogenous Urban Reconnaissance Team (HURT)	22.270	5.000	4.358

(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 4-D 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. There is a Memorandum of Agreement in place with the U.S. Special Operations Command.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Command, Control and Communications Systems PE 0603760E, Project CCC-01

(U) Program Plans:
FY 2007 Accomplishments:
– Conducted two live-fly exercises of prototype system.
FY 2008 Plans:
– Expand capability to include taskable sensors on manned aircraft.
– Integrate into combat aviation brigade testbed at Ft. Hood.
FY 2009 Plans:
– Support user training operations at Ft. Hood.

	FY 2007	FY 2008	FY 2009
Collision Avoidance & Dynamic Airspace Control*	2.500	4.000	5.000

*Formerly Dynamic Airspace Allocation.

(U) The goal of the Collision Avoidance and Dynamic Airspace Control 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. Further, the introduction of unmanned aircraft has increasingly complicated the challenge, leading to operating constraints and the potential for mishaps related to the different characteristics of manned and unmanned systems. This program will evaluate and develop technologies for an automated and distributed system that efficiently manages all objects in the airspace to include munitions, manned and unmanned aircraft. Specifically focused on the needs of the military, the program will enable provable levels of safety while ensuring military freedom of maneuver. The automated system will be developed as a replacement for current management systems and processes and will support all service users. Challenges to be addressed include complex algorithms and network information exchange, and integration with legacy, degraded and intentionally disruptive aircraft. The program will also explore novel concepts of operation enabled by radically enhanced airspace utilization. The capabilities developed by this program will benefit all of the Services.

(U) Program Plans:
FY 2007 Accomplishments:
– Examined potential system architectures.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Command, Control and Communications Systems PE 0603760E, Project CCC-01

FY 2008 Plans:
- Develop and simulate potential system architecture models.
- Develop a preliminary design for the system.

FY 2009 Plans:
- Demonstrate critical technologies.

	FY 2007	FY 2008	FY 2009
Advanced Ground Tactical Battle Manager	4.133	6.000	8.389

(U) The Advanced Ground Tactical Battle Manager program develops 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 elicits skeletal courses of action through a graphical interface with unit commanders and extends plans by applying adversarial reasoning techniques to identify vulnerabilities and opportunities in the predicted enemy course of action. Finally, it examines modifications or counteractions to reduce vulnerabilities. Products will transition to the Army.

(U) The Real-time Adversarial Reasoning and Decision-making (RAID) program develops technologies to anticipate enemy actions, especially in urban operations against irregular combatants. Experiments demonstrate how RAID can assist a Distributed Common Ground System-Army operator in the preparation of better intelligence products as compared to those built by un-assisted analysts.

(U) The Know What Is to Know Subsystem (KWIKS) develops 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 is more effective, rapid, complete identification of enemy state, resulting in achieving mission objectives with fewer friendly casualties and lower collateral damage.

(U) 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 explores closed-loop simulation to integrate planning,

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Command, Control and Communications Systems PE 0603760E, Project CCC-01

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 allows a proactive rather than reactive stance in the command of the battlefield giving the U.S. warfighter the advantage.

(U) Program Plans:

– RAID

FY 2007 Accomplishments:

-- Developed an exercise environment with the Army Battle Command Battle Labs.
-- Defined interfaces to existing and future Army intelligence and command and control systems.
-- Completed experimentation on predictions and counteractions.
-- Completed experiment on concealment and deception.

FY 2008 Plans:

-- Integration and transition into the Distributed Common Ground System-Army.

– KWIKS

FY 2008 Plans:

-- Extend and develop emerging computational techniques for analysis of information state under conditions of adversarial concealment and deception and partial observability.
-- Design and execute a series of realistic wargame-based experiments to enhance and validate the capabilities of the system.

FY 2009 Plans:

-- Adapt and validate the system for transition requirements.

– Deep Green

FY 2008 Plans:

-- Create initial Deep Green subsystems/components including Crystal Ball (assembles a diverse set of candidate plans and provides an integrated probabilistic overlay for all), Commander's Associate (induces the commander's intended plan from multi-modal man-machine dialog), and Blitzkrieg (fast multi-resolution combat model that permits high quality playoffs across the portfolio of planning options).

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Command, Control and Communications Systems PE 0603760E, Project CCC-01

FY 2009 Plans:

-- Extend technologies to monitor an ongoing operation and update the likelihoods that the possible futures being generated by Deep Green will actually occur.

-- Integrate major components to produce an initial prototype Deep Green system that enables proactive (vice reactive) battle management.

	FY 2007	FY 2008	FY 2009
Urban Commander	4.006	8.000	6.000

(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.

(U) 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 are being built. The system consists of five elements: 1) multi-spectral sensor suite; 2) high resolution digital display; 3) inertial measurement unit; 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. 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. 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. 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.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Command, Control and Communications Systems PE 0603760E, Project CCC-01

(U) The ULTRA-VIS program develops an integrated system to provide Army and Marine small unit leaders with the ability to conduct daytime operations in an urban environment. The system includes 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 support information management to allow the squad leader to hand-off actionable information and direct alerts to the squad/fire teams for real-time collaboration without overload. ULTRA-VIS relays 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 system synthesizes 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 empowers 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.

(U) Program Plans:

– Multi-spectral Adaptive Networked Tactical Imaging System (MANTIS).

FY 2007 Accomplishments:

-- Fabricated three MANTIS functional prototypes (two helmet-mounted, one handheld) for evaluation.
-- Conducted independent laboratory/field tests of MANTIS prototypes.

FY 2008 Plans:

-- Transition to the U.S. Army (PEO Soldier).

– ULTRA-VIS

FY 2008 Plans:

-- 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.

FY 2009 Plans:

-- 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.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Command, Control and Communications Systems PE 0603760E, Project CCC-01

	FY 2007	FY 2008	FY 2009
Tactical Group Decision Analysis Support System	2.329	2.000	0.000

(U) The Tactical Group Decision Analysis Support Systems program develops distributed group decision analysis and network management tools. These tools 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 develops a set of tools to evaluate risks and identifies optimal "network configuration pivot points," and automates 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 apply to 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 transition to the Army.

(U) Program Plans:

FY 2007 Accomplishments:

- Developed automated reasoning including fast Boolean (a deductive logical system) solvers that satisfy million-variable problems in seconds.
- Built "model finders" that compile first-order logic into Boolean logic and take advantage of Boolean solvers.
- Developed strategies to formalize planning problems as deductive reasoning problems.

FY 2008 Plans:

- Perform scaling and laboratory-based experimentation.

	FY 2007	FY 2008	FY 2009
Increased Command and Control Effectiveness (ICE)	0.000	3.000	6.000

(U) The Increased Command and Control Effectiveness (ICE) program develops and incorporates cognitive systems technology into operational Command, Control, and Intelligence (C2I) systems within each service. DARPA's Cognitive Systems programs have been developing

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Command, Control and Communications Systems PE 0603760E, Project CCC-01

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 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 funds 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, they efficiently sort, segregate, separate and identify relevant data based on priority hierarchies established by the command structure. For example, image data can be selected based on target priority, historical context or anomalous changes. Second, cognitive technologies adapt the presentation of information to suit the needs and preferences of the individual commander. Finally, cognitive systems 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), STRATCOM's Strategic Knowledge Integration Web (SKIweb), the Navy Marine Corp Intranet (NMCI), and the Web Timeline Analysis System (WebTAS) are candidate systems for insertion of this new technology. This will ultimately reduce the staffing footprint of command centers.

(U) Program Plans:

FY 2008 Plans:

- Develop initial prototypes of cognitively-enhanced versions of the following systems suitable (e.g., certifiable) for use on military networks: Command Post of the Future (CPOF); Strategic Knowledge Integration Web (SKIweb); Navy Marine Corp Intranet (NMCI); and Web Timeline Analysis System (WebTAS).

FY 2009 Plans:

- Develop and refine advanced operational prototypes of cognitively-enhanced versions of the CPOF, SKIweb, NMCI, and WebTAS systems that would provide users with advanced information management capabilities such as learning to anticipate users' information needs, pre-fetching needed information, learning users' interests, alerting users about the occurrence of events of interest, coordinating teams, and managing message traffic.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Command, Control and Communications Systems PE 0603760E, Project CCC-01

– Demonstrate, test, and evaluate PAL-enhanced information systems in military exercises to validate that the PAL technologies are robust to the dynamics and uncertainties of the battlefield and dramatically compensate for end-user "cognitive overload".

	FY 2007	FY 2008	FY 2009
Predictive Battlespace Awareness	2.258	3.000	1.000

(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 enables commanders to pre-position sensors, weapons, and information to counter the opponent's actions. The program develops model and knowledge-based techniques to predict areas of operation and tactical objectives. The technology supports 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 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 both enables commanders to avoid canned responses and supports rapid incorporation of insights about new enemy strategies, capabilities, and tactics from peacetime to the heat of battle. The program significantly enhances 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:

FY 2007 Accomplishments:

– Developed algorithms to decompose information needs into steps to be performed by experts.
– Developed schema to allow experts to register with the system.

FY 2008 Plans:

– Downselect algorithms for match-making, negotiation, monitoring and assimilation.

FY 2009 Plans:

– Define a system architecture.
– Integrate selected technologies and conduct collaboration demonstrations.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Command, Control and Communications Systems PE 0603760E, Project CCC-01

	FY 2007	FY 2008	FY 2009
Predictive Analysis for Naval Deployment Activities (PANDA)	7.825	11.050	14.054

(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), 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:

FY 2007 Accomplishments:

- Implemented initial motion-based learning algorithms.
- Implemented and tested adaptive context model.

FY 2008 Plans:

- 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.
- Discover and learn correlated activities, integrate on two nodes simultaneously, and conduct SeaTrial Demonstration.

FY 2009 Plans:

- Rapidly relearn models in response to sudden changes and generate timely alerts, integrate with three nodes simultaneously, and conduct SeaTrial Demonstration.

(U) Other Program Funding Summary Cost:

- Not Applicable.

THIS PAGE INTENTIONALLY LEFT BLANK

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)						DATE February 2008	
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development			R-1 ITEM NOMENCLATURE Command, Control and Communications Systems PE 0603760E, Project CCC-02				
COST (In Millions)	FY 2007	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
Information Integration Systems CCC-02	104.291	101.305	126.707	96.154	97.568	99.549	99.548

(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.

(U) **Program Accomplishments/Planned Programs:**

	FY 2007	FY 2008	FY 2009
Polarized Rotation Modulation (PZRM) Communications	4.127	1.398	1.000

(U) The goal of the Polarized Rotation Modulation (PZRM) Communications program is to develop new extremely high data rate, point-to-point, or point-to-multipoint wireless communications waveform using the PZRM/Orthogonal Signal Spectrum Overlay (OSSO) communications concept to exploit the presently unused polarization and rotation dimensions of radiation. The PZRM communications program will investigate the use of polarization, including OSSO, 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. OSSO enables multiple orthogonal signals to overlay one another in the same radio bandwidth thereby increasing spectral efficiency. 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 capacity of existing radio channels without increasing spectrum or modem complexity. The program will be demonstrated as an enhancement to an otherwise state-of-the-art communications system. The PZRM technology will transition to Service applications in FY 2009.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Command, Control and Communications Systems PE 0603760E, Project CCC-02

(U) Program Plans:

FY 2007 Accomplishments:

- 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.

FY 2008 Plans:

- Conduct over-the-air satellite testing to demonstrate utility over waveforms currently in use.

FY 2009 Plans:

- Complete final demonstrations and transition to the Services.

	FY 2007	FY 2008	FY 2009
Advanced HF Communications	3.300	2.500	0.000

(U) The goal of the Advanced HF Communications program is to investigate techniques 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 in reducing the size, weight and power (SWaP) requirements for SOF applicability. The technologies developed under this program are planned for transition to the Special Forces.

(U) Program Plans:

FY 2007 Accomplishments:

- Designed miniaturized antennas that allow man-portable radio systems to operate over a wideband at HF and low VHF frequencies to permit substantially enhanced range and data rate with maximum penetration in jungle environments.
- Conducted field tests in a dense pine forest.
- Demonstrated an over-the-horizon point-to-point communication capability that supports real-time video with low-output power over tactically significant ranges (> 1 km).

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Command, Control and Communications Systems PE 0603760E, Project CCC-02

FY 2008 Plans:

– Perform propagation experiments to determine atmospheric effects on communications using the ground wave electromagnetic propagation modality.

	FY 2007	FY 2008	FY 2009
Next Generation (XG)	3.994	1.600	1.000

(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.

(U) Program Plans:

FY 2007 Accomplishments:

– Developed initial set of hardware prototypes and undertook initial field experimentation.
– Developed and evaluated 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.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Command, Control and Communications Systems PE 0603760E, Project CCC-02

– Demonstrated spectrum effectiveness and operational characteristics.
– Initiated transition to several candidate military radios.

FY 2008 Plans:

– Develop and demonstrate large-scale network organization and adaptation.
– Conduct medium and large-scale military scenario demonstrations.

FY 2009 Plans:

– Continue transition to candidate military radios.

	FY 2007	FY 2008	FY 2009
Advanced Speech Encoding (ASE)	5.383	3.992	3.995

(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 ASE technology is planned for transition to the Special Operations Command and the Communications and Electronics Command of the U.S. Army after a prototype demonstration scheduled for FY 2009.

(U) Program Plans:

FY 2007 Accomplishments:

– Demonstrated that a 600 bps coder substantially exceeded the ASE program goal in three harsh noise environments.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Command, Control and Communications Systems PE 0603760E, Project CCC-02

FY 2008 Plans:
- Develop a prototype real-time ultra-low-bit-rate communication system integrating the ASE VOCODER technology and a military radio.
- Develop techniques to capture and enhance sub-vocal signals to enable stealth communication among warfighter teams.
- Explore the nature of sub-vocalic signals (physiological source, speaker dependence, and robustness) and the information content of the signals.

FY 2009 Plans:
- Demonstrate a robust sub-vocalic silent-speech communications system.
- Demonstrate the ultra-low-bit-rate communication system in the field.

	FY 2007	FY 2008	FY 2009
Optical & RF Combined Link Experiment (ORCLE)	16.180	34.142	52.067

(U) The Optical & RF Combined Link Experiment (ORCLE) program 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 using optical and RF communication adjunct techniques 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 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 Special Operations Forces and the Air Force.

(U) Program Plans:

FY 2007 Accomplishments:
- Completed initial investigation and research of optical pointing, acquisition and tracking.
- Demonstrated ability to transfer large data rates using combined optical and RF links over long distances.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Command, Control and Communications Systems PE 0603760E, Project CCC-02

FY 2008 Plans:
- Plan range and flight demonstrations of air-to-ground-to-ground hybrid FSO/RF links with high availability and gigabit data flows.
- Design and engineer a prototype hybrid FSO/RF high-capacity network system.
- Investigate the optical channel obscuration mitigation using ultra-short pulse lasers and partially coherent beams.
- Construct and field test a brassboard system incorporating the FSO/RF components and dynamic network communication and interface system.
- Plan experiments of air-to-air-to-ground nodes that will operate in direct interface to the Global Information Grid (GIG) and the tactical network gateway.

FY 2009 Plans:
- Perform range and flight demonstrations of air-to-ground-to-ground hybrid FSO/RF links in operational representative environment.
- Demonstrate high availability and gigabit data flow network performance with air-ground-ground using multiple FSO/RF nodes.
- Integrate and test the ORCLE terminals to verify performance and readiness for field experiments and demonstrations.
- Develop, design, and build hardware and software of a prototype system for integration into military air and ground platforms.
- Plan field demonstrations of ORCLE networking that supports multiple airborne platforms, a ground node with direct interface to the GIG, and a ground node with an interface to a tactical gateway supporting IP-addressable nodes.

	FY 2007	FY 2008	FY 2009
Disruption Tolerant Networking (DTN)	8.425	7.205	7.625

(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.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Command, Control and Communications Systems PE 0603760E, Project CCC-02

These protocols will be implemented in a typical military system to verify both the performance of the protocol and to validate the utility. The DTN technology is planned for transition to the Army and Marines in FY 2009.

(U) Program Plans:

FY 2007 Accomplishments:

- Commenced research to show "fuzzy scheduling" can make network routing decisions in the presence of uncertainty about available or optimal paths.
- Developed mechanisms to allow code-base-independent environmentally-aware selection of routing algorithms.
- Demonstrated that information organized into bundles can be delivered across intermittently-connected networks.
- Enabled networks to deliver traffic without the end-to-end address and routing information using deferred, hierarchical address binding techniques.
- Demonstrated trusted delivery of bundles across networks in which access to a public key infrastructure is not reliable.
- Demonstrated distributed in-network cache and indexing services and improved reliability with DTN-over-Internet Protocol (IP) vice end-to-end IP.
- Demonstrated information binding on demand from a network cache.
- Investigated policy cognitive operation by moving intelligence into networks to make the best choices on delivery.
- Completed initial integration of DTN into USMC Command and Control On-the-Move Network Digital Over-the-Horizon Relay (CONDOR) system; incorporated DTN into USMC laptop build.

FY 2008 Plans:

- Integrate distributed in-network caching and indexing services into DTN system.
- Integrate information binding on demand from a network cache into DTN system.
- Demonstrate temporal security architecture.
- Demonstrate policy cognitive operation choosing best delivery options.
- Complete equipment integration into USMC CONDOR systems. Integrate DTN into military tactics, techniques, and procedures.

FY 2009 Plans:

- Integrate temporal security architecture into DTN.
- Deploy prototype DTN system tactical networks.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Command, Control and Communications Systems PE 0603760E, Project CCC-02

	FY 2007	FY 2008	FY 2009
Conflict Modeling, Planning, and Outcomes Experimentation (COMPOEX)*	11.926	3.229	1.000

*Formerly Network Centric Operations/Battle Command.

(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) The Conflict Modeling, Planning, and Outcomes Experimentation (COMPOEX) research effort is developing technologies that will enhance the capability of leaders to plan and conduct government campaigns. This includes a comprehensive suite of decision support tools that help leaders with: visualizing and understanding the situation and the complex operational environment they must operate in; constructing and managing plans that enable the commander to synchronize and integrate interdependent effects over a long period of time; employing the best sequence of unified actions to produce the desired effects; and generating and exploring options and courses of action to understand the range of outcomes and appreciate the side effects that may occur.

(U) 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 with more comprehensive capabilities transitioning incrementally by FY 2009.

(U) Program Plans:

FY 2007 Accomplishments:

- Successfully conducted limited objective experiments with Joint Force Command (JFCOM) and other military participants.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Command, Control and Communications Systems PE 0603760E, Project CCC-02

– 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.

FY 2008 Plans:

– Develop and demonstrate technologies to support humans in authoring courses of action, development and campaign plans; 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 2009 Plans:

– Complete final demonstration and transition to the Services.

	FY 2007	FY 2008	FY 2009
Retro-directive Ultra-Fast Acquisition Sensor (RUFAS)*	5.345	3.530	0.000

*Formerly Ultra-Fast Radar.

(U) The Retro-directive Ultra-Fast Acquisition Sensor (RUFAS) effort will design, construct, and demonstrate 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. Combining and tailoring 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 RUFAS technology is planned for transition to the Army and Marines.

(U) Program Plans:

FY 2007 Accomplishments:

– Modeled, simulated, and demonstrated detection of fluctuating and multiple targets.
– Conducted X-band radar free space test using early prototype bench equipment.
– Developed prototype X-band noise correlating radar with a retro-directive antenna with five times reduction in acquisition time compared to traditional electronically-steered search-mode radar and mechanically scanned radars.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Command, Control and Communications Systems PE 0603760E, Project CCC-02

– Conducted successful field demonstration of scale projectile target.

FY 2008 Plans:

– 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.
– Conduct production manufacturability study.
– Conduct cost benefit track study to verify RUFAS design capabilities.
– Develop full-scale prototype radar with the size, weight, and power required for military utility.

	FY 2007	FY 2008	FY 2009
Fiber-Optical Network for Aerospace Platforms	3.525	2.500	5.845

(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. This will have 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.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Command, Control and Communications Systems PE 0603760E, Project CCC-02

(U) Program Plans:

FY 2007 Accomplishments:

- Developed unclassified networking requirements for various tactical and wide body military aircraft for enabling open discussions in the international standards bodies.

FY 2008 Plans:

- Develop the architecture of the avionics optical network that satisfies the aforementioned requirements.
- Develop the following key optoelectronic components: tunable digital and analog transmitters, multi-channel digital and analog receivers, tunable digital and analog receivers, and passive wavelength routing components.
- Demonstrate the ability to integrate into a single component the appropriate combination of optoelectronic devices to reduce system size, weight and power.

FY 2009 Plans:

- Validate the architecture of the fiber-optic avionics network and conduct an analysis to estimate the resulting network reliability and survivability under various failure scenarios.
- Continue development of the key optoelectronic components.
- Test the ability to interconnect digital and analog client equipment with the developed optoelectronic components.

	FY 2007	FY 2008	FY 2009
Next Generation Routing and Addressing	3.557	3.750	4.550

(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 internet protocol (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 development of new network addressing schemes will reduce the load on routers as well as greatly simplify router configuration. These networks will be a paradigm shift such that numbered IP addresses will no longer exist, and changes to the Domain Naming Server (DNS) system will allow for services to mobile users. This program is planned for transition to the Services in FY 2012.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Command, Control and Communications Systems PE 0603760E, Project CCC-02

(U) Program Plans:

FY 2007 Accomplishments:

- Conducted market survey of existing router techniques and current research efforts.
- Conducted research on Routing Protocols and Management (RPM) for high capacity networks.
- Developed concept ideas for novel methods to allow multi-path route discovery, improved network routing efficiency, and improved authentication/attribution.

FY 2008 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.

FY 2009 Plans:

- Develop changes to DNS functions to accommodate the forwarding services to mobile users.
- Conduct demonstrations in operationally relevant environments.

	FY 2007	FY 2008	FY 2009
Scalable MMW Architectures for Reconfigurable Transceivers (SMART)	7.534	8.200	8.540

(U) The Scalable MMW Architecture for Reconfigurable Transceivers (SMART) program will develop an integrated, surface-emitting panel architecture for millimeter wave (MMW) transceiver arrays. The program will culminate in an objective demonstration of a large (at least 400 element), coherent, active electronically steerable array (AESA) achieving an output power density of $5W/cm^2$ and a total layer thickness of less than 1cm. Taken together, these values would represent a vastly greater "functional density" (e.g., power density, expressed in W/cm^3) than achievable with current MMW architectures, such as slats or bricks, without compromising performance in other areas (e.g., receiver noise figure). The 3-Dimensional (3-D) multi-layer modules that will be developed during the SMART program will greatly reduce AESA packaging complexity. Such compact, heterogeneously integrated, batch-fabricated, radio-frequency (RF) sub-array "building blocks" will be combinable to form arbitrarily large arrays. New capabilities, such as the ability to construct reconfigurable and/or multi-band AESAs and other MMW circuits,

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Command, Control and Communications Systems PE 0603760E, Project CCC-02

will be enabled by this architectural approach. This program will transition through industrial producers of MMW radar systems for DoD applications.

(U) Program Plans:

FY 2007 Accomplishments:

- Demonstrated multilayer wafer scale assembly and interconnect processes.
- Demonstrated beamforming-on-a-chip.
- Demonstrated 96GHz power amplifier at world-record 19.6 dBm.
- Four-layer thermal test coupon demonstrated with micro heat sink demonstrated 31 degrees centigrade per watt thermal resistance.

FY 2008 Plans:

- Achieve an integrated, sixteen element (4x4) transmit (only) millimeter-wave AESA with output power greater than 5W/cm² and thickness less than 10mm.
- Demonstrate in an anechoic chamber the ability to direct the beam.
- Initiate development of prototype receiver components.

FY 2009 Plans:

- Incorporate receive capability into the AESA while maintaining the thin dimension.
- Demonstrate high isolation between transmit and receive functions.
- Conduct evaluations and demonstrations of prototype components.
- Initiate development of integrated prototype receiver using digital and analog logic technologies.
- Initiate development of design automation algorithms and tools.

	FY 2007	FY 2008	FY 2009
DARPA Interference Multiple Access (DIMA) Communications	7.104	6.398	5.399

(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

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Command, Control and Communications Systems PE 0603760E, Project CCC-02

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, multi-user detection processing, covertness, robustness and platform size, weight and power requirements. The DIMA Communications program will develop and demonstrate a system based on multi-user detection concepts that can take advantage of overloaded channels while operating in an environment absent of infrastructure (ad-hoc networked.) The technologies developed under this program are planned for transition to the Army and SOCOM in FY 2010.

(U) Program Plans:

FY 2007 Accomplishments:

- Completed development of DIMA testbed.
- Researched and developed computational algorithms for the Multi-User Dimension (MUD) and Parameter Estimation (PE).
- Commenced design of a test package to support development and demonstration of the system.
- Initiated development of a suitable Media Access Control (MAC) for a MUD-based system.
- Initiated the system design to support a two Field-Programmable Gate Array (FPGA).

FY 2008 Plans:

- Complete development of multi-user PE.
- Complete development of DIMA Infrastructure Free Waveform/MAC.
- Demonstrate real-time DIMA on a COTS platform.

FY 2009 Plans:

- Reduce complexity of DIMA system.
- Develop test and demonstrate real-time DIMA on a handheld platform
- Begin transition of DIMA program to Army and SOCOM.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Command, Control and Communications Systems PE 0603760E, Project CCC-02

	FY 2007	FY 2008	FY 2009
Tactical Combined Fiber-Optical & Free-Space Edge Network	3.024	3.000	4.250

(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 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 Army and Marines in FY 2011.

(U) Program Plans:

FY 2007 Accomplishments:

- Completed a feasibility study for using a tactical fiber-optic network as an infrastructure to enable reliable wireless communications to warfighters deployed deeply in areas of hostilities.

FY 2008 Plans:

- Evaluate the processing needs and practical limitations of the network's wireless communications capability.
- Create a suitable architecture for a passive, WDM fiber-optical network with high connectivity for increased reliability.

FY 2009 Plans:

- Develop prototype wireless base stations and associated processing equipment to enable the network's wireless communications capability.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Command, Control and Communications Systems PE 0603760E, Project CCC-02

- 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.
- Build and test a network testbed that is representative of tactical networks and environments.

	FY 2007	FY 2008	FY 2009
Wireless Network after Next (WNaN)	8.000	16.861	23.486

(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 network 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 2011.

(U) Program Plans:

FY 2007 Accomplishments:

- Completed architectural, functional, and electrical designs of the multi-channel WNaN radio that utilize high-volume, low-cost commercial-off-the-shelf (COTS) RF circuits narrowband tuning filters.
- Initiated the development of WNaN advanced networking technology.

FY 2008 Plans:

- Design, build, test, and demonstrate handheld/body wearable multi-channel WNaN radio that utilizes high-volume, low-cost COTS RF circuits narrowband tuning filters and dual-core digital signal process (DSP) baseband processing.
- Develop, integrate and test low risk and enhanced network technologies that exploit diverse paths and frequencies to support network scalability and network formation of tens of thousands of operational nodes.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Command, Control and Communications Systems PE 0603760E, Project CCC-02

FY 2009 Plans:
- Continue development, integration and testing of network technologies 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.
- Commence demonstration of large-scale operation of 500 to 1000 nodes integrated into a highly adaptive, dynamic, self-forming, self-healing WNaN military network.
- Develop and test 100 advanced prototype WNaN radios in final production form factor.

	FY 2007	FY 2008	FY 2009
Networked Bionic Sensors for Language/Speaker Detection	0.000	1.500	2.950

(U) The Networked Bionic Sensors for Language/Speaker Detection 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 Signal to Noise Ratio ((SNR) 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:

FY 2008 Plans:
- Develop system architecture to exploit low-power micro-sensor devices and networks.
- Develop speech recognition algorithms.

FY 2009 Plans:
- Laboratory performance testing.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Command, Control and Communications Systems PE 0603760E, Project CCC-02

	FY 2007	FY 2008	FY 2009
Mobile Networked Multiple-Input/Multiple-Output (MIMO) (MNM)	1.000	1.500	3.000

(U) The Mobile Networked Multiple-Input/Multiple-Output (MIMO) (MNM) project will pursue MIMO communication systems, which have the potential to increase data rates by 10-20 times above current systems. MIMO will use a multipath to create parallel channels in the same frequency band thereby increasing spectral efficiency. This effort will demonstrate the MNM capability under dynamic urban Non-Line-of-Sight multipath channel conditions where conventional techniques are degraded. Final efforts will culminate in the development of a wideband form-factor (Joint Tactical Radio System (JTRS) cluster 1 size PC card) system. MNM was previously funded in PE 0603764E, Project LNW-03. The MNM technology is planned for transition to the Army in FY 2010.

(U) Program Plans:

FY 2007 Accomplishments:

- Researched and designed variable bandwidth MIMO radio that can be reconfigured on a per-packet basis.
- Delivered and demonstrated first generation MNM node including mobility up to 70 mph.

FY 2008 Plans:

- Carry out field trials collecting data in diverse environments including urban, residential, littoral, and rural.
- Demonstrate multi-node MIMO operation.
- Demonstrate MAC-PHY interface that can be configured on a per-packet basis.
- Demonstrate wideband interference mitigation using various techniques.

FY 2009 Plans:

- Test an 8 node MNM radio network with baseline capability against the performance of a traditional single channel radio.
- Demonstrate energy aware link adaptation.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Command, Control and Communications Systems PE 0603760E, Project CCC-02

	FY 2007	FY 2008	FY 2009
VPN for ADHOC Networks	0.000	0.000	2.000

(U) Tactical implementation of Virtual Private Network (VPN) requires operators to log into gateways in the Continental U.S. to connect to each other. Operators do not like this because it can reveal whom and where operators are located. This program will define VPN encryption requirements, limitations of field computing devices (FCDs), and employ recent breakthroughs in ad-hoc networking to enable tactical VPN connectivity. Operational requirements include the need for client-to-client VPN connectivity on FCDs with ad-hoc, peer-to-peer connectivity. Technical approaches to be explored include advanced ad-hoc-networking protocols coupled with small footprint VPN encryption standards. Potential technologies to be investigated include ad-hoc networking and peer-to-peer protocols and advanced encryption technologies to meet VPN standards. The system will enable covert operators to exchange mission-critical information while maintaining covertness in the field. This technology will transition to SOCOM in FY 2010.

(U) Program Plans:
FY 2009 Plans:
- Design VPN client-side software.
- Lab test the VPN software against measured data and security requirements.
- Harden code for field evaluation.

	FY 2007	FY 2008	FY 2009
Symbiotic Communications (SYCO)	3.337	0.000	0.000

(U) The Symbiotic Communications (SYCO) program developed an airborne passive radar system to enable precision targeting and battlefield situational awareness. SYCO generated high-resolution Synthetic Aperture Radar (SAR) imagery. This system operated passively and is 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 ground tested. The SYCO airborne test-bed was modified for autonomous on-board real-time processing and image exploitation and flight-tested during FY 2007. To

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Command, Control and Communications Systems PE 0603760E, Project CCC-02

complete this project, the test bed will be upgraded and flight tested in early FY 2008 with a conformal antenna, to demonstrate form/fit/function compatibility for transition. The SYCO technology is planned for transition for Service applications.

(U) Program Plans:
FY 2007 Accomplishments:
- Demonstrated real time on board processing and exploitation of SYCO imagery.
- Integrated conformal antenna and demonstrated performance.

	FY 2007	FY 2008	FY 2009
Connectionless Networking (CN)	5.580	0.000	0.000

(U) The Connectionless Networking (CN) program developed technology to allow networks (such as unattended ground sensors (UGS)) to send and receive messages without initial link acquisition or previous sharing of routing information. This improved 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 and allowed data to be collected more efficiently from high value, but energy limited sensors. 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 particularly severe for communications with proliferated sensors, or remotely operated weapons. Eliminating the requirement to maintain a continuous network link enabled these platforms to provide continuous connectivity without consumption of power, or compromising emanations. The CN program exploited 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 CN technology is planning transition to the Special Operations Command, Army, Navy, and Marines for unattended ground sensors and low duty cycle applications.

(U) Program Plans:
FY 2007 Accomplishments:
- Fabricated interim radio frequency and digital boards for software development.
- Executed software and protocol development to incorporate highly adaptive operating modes.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Command, Control and Communications Systems PE 0603760E, Project CCC-02

- Completed final board design and layout.
- Investigated transition opportunities to the USMC Tactical Remote Sensor System program.
- Finalized transition approach with Special Operations Command, Army, Navy and Air Force.
- Completed system integration and demonstrate energy efficient sensor networking in field experiments.
- Completed software and protocol development.

	FY 2007	FY 2008	FY 2009
SATCOM CX	2.950	0.000	0.000

(U) The SATCOM CX program developed a proof of concept system that enabled multiple users' access to 100 kilobits per second (kbps) SATCOM channels using the existing C-band satellite architecture. This new capability became possible, in part, by moving away from the existing paradigm regarding usage of these satellites. This 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 considered multiple satellites simultaneously. Using this approach, a multitude of co-channel users send 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 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.

(U) Program Plans:

FY 2007 Accomplishments:

- Demonstrated concept feasibility by using the space segment (C-band transponder) and transmission channel to provide sufficient stability to support the phase locked loop (PLL) operation required by the SATCOM CX forward link algorithms to maintain expected gains.
- Demonstrated a significant gain in the signal-to-noise-ratio (SNR) that can be achieved by coherently combining two C-band channels using the SATCOM-CX algorithm.
- Demonstrated full duplex real-time SATCOM CX operation using non-form factor demonstration hardware.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2008
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Command, Control and Communications Systems PE 0603760E, Project CCC-02

– Developed production and operational cost reduction roadmap and transition plan.

(U) Other Program Funding Summary Cost:

- Not Applicable.