RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)						DATE February 2004	
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development			R-1 ITEM NOMENCLATURE Command, Control and Communications Systems PE 0603760E, R-1 #43				
COST (In Millions)	FY 2003	FY2004	FY2005	FY 2006	FY 2007	FY 2008	FY 2009
Total Program Element (PE) Cost	115.654	193.562	225.784	222.153	245.421	257.002	279.250
Command & Control Information Systems CCC-01	25.661	44.408	56.629	56.148	65.388	82.354	98.960
Information Integration Systems CCC-02	69.165	101.399	103.146	110.230	121.406	116.078	121.777
Asymmetric Systems CCC-03	20.828	0.000	0.000	0.000	0.000	0.000	0.000
Classified CCC-CLS	0.000	47.755	66.009	55.775	58.627	58.570	58.513

(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 2003**	**FY 2004**	**FY2005**
Previous President's Budget	117.164	242.738	279.855
Current President's Budget	115.654	193.562	225.784
Total Adjustments	-1.510	-49.176	-54.071
Congressional program reductions	0.000	-51.176	
Congressional increases	0.000	2.000	
Reprogrammings	-1.510	0.000	
SBIR/STTR transfer	0.000	0.000	

(U) Change Summary Explanation:

FY 2003	Decrease reflects minor reprogramming.
FY 2004	Decrease results from congressional termination of the Asymmetric Systems Project (CCC-03), reductions to the Collaborative Operational Planning Environment and Adaptive Waveforms programs and undistributed reductions, offset by an add for secure digital coherent optical communications.
FY 2005	Decrease reflects the elimination of Project CCC-03 and rephasing of the THOR program.

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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 2003	FY 2004	FY 20054	FY 2006	FY 2007	FY 2008	FY 2009
Command & Control Information Systems CCC-01	25.661	44.408	56.629	56.148	65.388	82.354	98.960

(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 nor 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. They 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. They provide secure multimedia information interfaces and assured software 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) Warfighter dependence on information systems is growing. It is essential that DoD systems deliver and protect information and assure the availability of associated services – particularly in a stressed environment. Included in this project are Organically Assured and Survivable Information Systems (OASIS), Active Templates (AcT), Joint Air/Ground Operations: Unified Adaptive Replanning (JAGUAR), Advanced Ground Tactical Battle Manager, Effects Based Network Targeting, Predictive Battlespace Awareness, Banshee, Comprehensive Force Protection, Urban Commander, and Command and Control for CollaboRobotic Systems (C^3RS).

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(U) Program Accomplishments/Planned Programs:

	FY 2003	FY 2004	FY 2005
OASIS	17.493	9.227	0.000

(U) The Organically Assured and Survivable Information Systems (OASIS) program develops defenses against sophisticated future cyber attacks. The program supports sustained operation of mission-critical functions in the face of cyber attacks against DoD information systems. The goal is to develop and demonstrate organically survivable systems. OASIS delivers technologies that counter successful intrusions by means of tolerance and self-healing properties.

(U) The OASIS Demonstration/Validation program deals with the systems aspect of the intrusion problem. It integrates prevention, detection, response and tolerance technologies into a military system to significantly improve the survivability of the system in the face of a large-scale cyber attack.

(U) Program Plans:

- OASIS.
  - -- Demonstrate an experimental intrusion-tolerant database from commercial off-the-shelf components.
  - -- Prototype and evaluate a framework for tolerating intrusions in large-scale, heterogeneous, networked computing enterprises.
  - -- Build a distributed architecture for deploying intrusion tolerance mechanisms featuring explicitly stated but flexible tolerance policy.
  - -- Develop an integrity and availability framework that combines passive intrusion tolerance and active intrusion recovery mechanisms.

- OASIS Demonstration/Validation.
  - -- Integrate OASIS, other DARPA and commercial technologies to develop and demonstrate a survivable variant of the Joint Battlespace Infosphere (JBI).

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-- Demonstrate effectiveness of survivable architectures in the face of a determined cyber attack on critical military information system. The measure of success: continuation of critical functionality through a sustained cyber attack.
-- Validate survivability claims of technologies using recognized methodologies on operational systems.
-- Create novel approaches to composing assurance cases for large-scale systems.

	FY 2003	FY 2004	FY 2005
Active Templates (AcT)	3.836	2.968	0.000

(U) The Active Templates (AcT) program is producing robust, lightweight software technologies to improve Special Operations Forces mission planning and execution. Active Templates are distributed applications whose variables are linked to live data feeds and external problem-solving algorithms. AcT helps automate planning and execution by capturing, suggesting and updating critical information such as current state, goals, constraints, alternative actions, standard defaults, decisions in context and rationale. Active Templates are designed to be easily tailored, networked, noise-tolerant, user-supported, scalable, and widely adopted. AcT enables special operations planners to create plans six times faster, improve plan quality by considering up to eight times more options, reduce staff-hours required to track and coordinate missions by 60 percent, and enhance capture of lessons learned. This technology promises significantly improved national capability to respond in a crisis. Early prototypes of AcT technologies have been adopted and used by Special Operations Command (SOCOM), including use during Operation Enduring Freedom. There, they reduced plan development time by a factor of four and reduced personnel required for battle tracking by a factor of six. DARPA is working closely with the Joint Special Operations Command to develop temporal and spatial planning applications and simple forms-based coordination tools that may be defined dynamically by ordinary users in less than a day. Special Operations Command has approved a program for transitioning these technologies to the theater forces.

(U) Program Plans:
- Develop a data representation and template library for critical planning parameters for template adaptation and merging.
- Demonstrate advanced tools for extending term-ontology to avoid duplication and conflicting semantics.
- Develop a planning and execution shell including tools for template development such as selecting and tailoring dependencies and problem solving algorithms.
- Incorporate advanced problem solvers like generative planning, temporal/uncertain reasoning, and triggering for complex events.

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- Demonstrate temporal, spatial, and forms-based mission planning and execution control tools.
- Measure their effectiveness in special operations exercises.
- Transition to U.S. Special Operations Command (SOCOM) and to all theater special operations commands.

	FY 2003	FY 2004	FY 2005
Joint Air/Ground Operations: Unified, Adaptive Replanning (JAGUAR)	0.710	8.298	11.929

(U) The Joint Air/Ground Operations: Unified, Adaptive Replanning (JAGUAR) (formerly Advanced Sensor/Strike Battle Manager) program improves air operations staff conduct of complex campaigns that employ new air platforms featuring precision sensors, precision weapons and communications relays. JAGUAR technology makes use of a) targeting information, both for sensor targets and for strikes, expressed both as point targets and area targets (search, combat air patrol); b) rules of engagement and procedural constraints such as airspace restrictions; and c) 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. It allows pilots and commanders either to choose conventional tactics or to invent unconventional operations. In the latter case, the system captures the innovation and makes it available for future mission plans. JAGUAR monitors actual plan execution against expected results and alerts commanders to significant differences. It captures statistical descriptions of insignificant differences to help assess the robustness of future plans.

(U) Program Plans:

- Equip a training facility with software tools and human observers to capture plans as they are 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.

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	FY 2003	FY 2004	FY 2005
Advanced Ground Tactical Battle Manager	2.841	6.000	9.000

(U) The Advanced Ground Tactical Battle Manager program develops automated decision support tools for Army and Marine tactical commanders at the battalion level and below. The program also provides support for combined operations employing dismounted soldiers, manned platforms, and autonomous vehicles. It elicits skeletal courses of action through a graphical interface with unit commanders and extends those plans by applying templates for tactical operations. Adversarial reasoning techniques are used to identify vulnerabilities in the extended plan. Finally, it proposes workarounds or embellishments to reduce those vulnerabilities. A variant of the program would issue plans to subordinate unit commanders and human controllers, and possibly also push necessary elements of the plan to automated platforms or automated battle managers.

(U) Program Plans:
- Develop an exercise environment with the Marine Corps Warfighting Lab.
- Define interfaces to existing Marine command and control systems.
- Develop prototype tools to augment capability.
- Conduct experiments to ascertain values of tools.

	FY 2003	FY 2004	FY 2005
Effects Based Network Targeting	0.781	0.000	0.000

(U) The Effects Based Network Targeting program developed technology to identify, find vulnerabilities in, target and anticipate workarounds in enemy networks. These techniques use all-source information to continuously update models of adversary networks. Program technology applies to any kind of network. Examples include air defense, military C2, telecommunications, transportation (land, rail, air, and water) and energy (fuel, coal, and electric power). This program has moved to PE 0603766E, Project NET-01.

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(U) Program Accomplishments:
- Identified real-world examples of complex network effects, in conjunction with existing target analysis organizations.
- Determined the network models required to analyze those effects and the sources of information available to update them.

	FY 2003	FY 2004	FY 2005
Predictive Battlespace Awareness	0.000	5.000	7.000

(U) The Predictive Battlespace Awareness program will develop technology to predict the range of an opponent's future actions. It will enable commanders to preposition sensors, weapons and information to counter the opponent's actions. The program develops model- and knowledge-based techniques to predict areas of operation and operational and tactical objectives. It supports the modeling of large-scale courses of action. Program techniques permit on-the-fly tailoring of models and contextual knowledge and leverage knowledge of sensor effectiveness, mobility factors and tactical templates and target characteristics. It is developing techniques for variable-fidelity prediction, such as the ability to predict 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 effective use of sensors and other resources in proactive modes. The program empowers commanders to avoid canned responses. It supports rapid incorporation of insights about new enemy strategies, capabilities, and tactics from peacetime to heat of battle. The program significantly enhances today's mostly manual, slow planning and analysis processes.

(U) Program Plans:
- Survey recent military operations to identify cases where opponent's actions could have been anticipated.
- Define a set of realistic challenge problems, including scenarios and a realistic 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., for 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.

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	FY 2003	FY 2004	FY 2005
Comprehensive Force Protection	0.000	3.500	7.000

(U) The Comprehensive Force Protection program is developing a rapidly deployable system to provide assured protection of permanent or temporary U.S. base camps in hostile territory. It includes wide-area sensors and platforms to maintain continuous surveillance of the camp area. The sensors detect potential intruders and weapon launches. It also includes a suite of airborne sensor platforms that can be tasked rapidly to investigate potential threats or to 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 to authorize precision weapons to engage them. The system maintains continuous perimeter surveillance, allows rapid investigation and, when authorized, attack threats.

(U) Program Plans:

- Review past and forecasted threat analyses to characterize intrusions, events, activities and signatures.
- Select a test area in which data on intrusions can be collected.
- Emplace a variety of sensors, both extant and developmental, into the test site along with a communications network back to a data analysis and command station.
- Collect data on a variety of realistic intrusions in a variety of weather conditions.
- Characterize the performance of candidate signal processing, target recognition and localization and environment monitoring algorithms on the test data.
- Select a set of algorithms for a baseline system build.
- Construct and calibrate a system performance model for the selected algorithms.
- Exercise the baseline system in the testbed and compare results against the performance model.
- Selectively improve algorithmic components that contribute most to performance gaps.
- Iterate and demonstrate the final system in continuous operation at a CONUS base.

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	FY 2003	FY 2004	FY 2005
Urban Commander (formerly Collaborative Operational Planning Environment)	0.000	9.415	17.200

(U) The Urban Commander program 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 plan fragments constructed at different sites, transfers information among related parts of the plan 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 dismounts equipped with advanced heads-up displays and helmet-worn sensors. Finally, the system continuously assesses progress against the plan and alerts users to significant deviations.

- The Urban Commander effort develops planning and control tools tailored to dismounted operations in complex urban environments. Urban warfare combines limited sightlines and mobility with ever-insufficient knowledge of the disposition of enemy combatants, civilians, and the structures they occupy. 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. Elements of the Urban Commander program include 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 a situation and make plans to deal with it; and 4) analysis tools, to suggest locations and types of potential threats.

- The Multispectral Adaptive Networked Tactical Imaging System (MANTIS) effort develops, integrates and demonstrates a soldier-worn visualization system. The system consists of five elements: 1) a head-mounted multi-spectral sensor suite with a high resolution visor display; 2) an inertial navigation system; 3) a global positioning system (GPS); 4) a soldier-worn processor; 5) a high bandwidth transceiver; and 6) a power supply. It provides the warfighter with digitally fused, multi-spectral video imagery in real time from the helmet-mounted sensors. The system fuses imagery in the Visible/Near Infrared (VNIR, .4-.9 microns), the Short Wave Infrared (SWIR, 1-2 microns) and the Long Wave Infrared (LWIR, 8-12 microns) frequency bands. It displays the fused imagery on the helmet-mounted visor. The warfighter sees where the enemy cannot. MANTIS gives warfighters the advantage in operations at night and in smoke and

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fog. The soldier-worn, high-speed processor adaptively generates an optimized image under variable battlefield conditions. This process takes advantage of the unique signatures in each of the spectral regions. The system also allows the soldier to record the sensor video, and then play it back after taking cover. The record and playback feature includes electronic zoom, scroll, pan and panoramic image stitching. This furnishes a larger field of view to enhance context. The MANTIS INS and GPS devices provide precise soldier location and pose estimation, on which the digital display overlays battlefield information. In this way MANTIS furnishes the warfighter with augmented reality and increased situational awareness. The warfighter can share his position and images with others in real time by means of a high-bandwidth transceiver. The transceiver also allows the soldier to receive images and information from remote sensors. The coupling of the imaging system with the INS/GPS gives the soldier a "point-click-kill" capability for targeting smart weapons fired from elsewhere.

(U) Program Plans:

- Urban Commander.
  - -- Identify a set of urban combat scenarios ranging from peacekeeping to aggressive assault.
  - -- Document sets of mission tasks out of which tactical plans may be constructed.
  - -- Define a common plan representation, based on service training material, for combined arms operations.
  - -- Construct an initial collection of operational plans, for a variety of scenarios and force structures.
  - -- Develop tools to visualize, edit, modify and assemble new plans from mixed-mode human interaction at one location.
  - -- Develop mechanisms to define and enforce policies limiting the aspects of a plan deemed relevant to each location.
  - -- Construct protocols to propagate changes made at one location to other affected locations, in accordance with defined policy.
  - -- Build flexible algorithms to match changes received from remote locations to the aspects of a plan retained locally.
  - -- Demonstrate detection of plan inconsistencies and suggestion of useful corrections.
  - -- Conduct a series of laboratory evaluations with Army and Marine commanders to assess the quality and utility of program products.

- Multispectral Adaptive Networked Tactical Imaging System (MANTIS).
  - -- Deliver SWIR sensor assemblies (from prime and alternate suppliers) for evaluation.
  - -- Complete Independent Lab Characterization/Field Tests on SWIR sensors.
  - -- Complete system design analyses.
  - -- Incorporate selected sensors in complete system design.

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-- Independently evaluate multi-sensor imagery and processing capability.
-- Complete prototype design.
-- Deliver two MANTIS prototypes for evaluation.
-- Complete independent lab/field tests of MANTIS prototypes.
-- Transition to US Army/Objective Force Warrior and/or other transition partners.

	FY 2003	FY 2004	FY 2005
Command and Control for CollaboRobotic Systems (C3RS)	0.000	0.000	4.500

(U) The Command and Control for CollaboRobotic Systems (C3RS) effort develops integrated tactical planning and battle management systems for heterogeneous collections of unmanned platforms operating in urban environments. It employs a model-based control architecture to allow new platforms to enter the system at any time. Commanders register new platforms with the battle manager by submitting platform capability models (kinematics, maneuverability, endurance, payloads and communications links). C3RS provides a commanders' interface which allows collaborative tasking of the platforms in the form of operational missions, such as search, track, identify, or engage, rather than routes and events. It supplies computationally intensive decision aids, such as advanced 4D airspace and groundspace deconfliction tools, route planners and task/platform assignment algorithms. The technology presents mission status and future courses of action to commanders for collaborative adjudication. C3RS enables augmentation of low-footprint, rapidly deployable, easily sustainable human command structures with teams of machines operating together. It defines suitable roles for human command staffs charged with controlling squads of automated forces.

(U) Program Plans:
- Select a baseline planning/control algorithm.
- Develop hybrid state models of each vehicle.
- 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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(U) Other Program Funding Summary Cost:

- Not Applicable.

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COST (In Millions)	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	FY 2008	FY 2009
Information Integration Systems, CCC-02	69.165	101.399	103.146	110.230	121.406	116.078	121.777

(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: Airborne Communications Node (ACN)/Adaptive Joint C4ISR Node Advanced Concept Technology Demonstrator (AJCN ACTD), the Secure Adaptive Waveforms (SAW) program, the Connectionless Networking (CN) program, the Next Generation (XG) program, the Advanced Speech Encoding (ASE) program, the Symbiotic Communications program, the Tera Hertz Operational Reachback (THOR)/Optical & RF Combined Link Experiment (ORCLE), the Space-Based Networking program, the Policy Based Network Management program, the Disruption Tolerant Networking program, the Network Centric Operations / Battle Command program, the Advanced Antenna Concepts program, the Navy Photonics program and the Command Post of the Future (CPOF) program.

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

	FY 2003	FY 2004	FY 2005
Airborne Comms Node (ACN)/AJCN ACTD	20.102	4.300	0.000

(U) The Airborne Communications Node (ACN) program will enable an affordable, autonomous communications infrastructure that simultaneously provides assured communications, situational awareness and signals intelligence (SIGINT). ACN payloads can be integrated on platforms ranging from High Altitude Endurance (HAE) unmanned airborne platforms (e.g., Global Hawk) to vessels or ground vehicles. The ACN system will be scalable such that payloads for various platforms can be constructed from a core set of common circuit boards and chassis.

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The ACN on an HAE platform will provide wide-area wireless communications and SIGINT services over the theater of operation for joint and multinational forces by establishing an early robust airborne infrastructure for intra-theater line-of-site (LOS) and reachback beyond line-of-site (BLOS) situations without the need for large in-theater assets. ACN will augment and enhance the battlefield communications infrastructure in order to adapt communications, situational awareness and SIGINT services to the flow of battle. Therefore, the ACN system needs to be adaptable, interoperable, robust, secure, and affordable within the size, weight and power constraints of the intended platforms. Additionally, the ACN architecture allows for the implementation of technologies that can securely adapt the various wireless systems (such as unattended ground sensors (UGS)) and command & control tiers that will exist in the future network centric battlesphere. The ACN system operational utility will be assessed by U.S. Joint Forces Command as part of a Joint ACTD, named the Adaptive Joint C4ISR Node (AJCN) that began in FY 2003 and will complete in FY 2005 with an extended user evaluation in FY2006 – FY2007. The ACTD, jointly funded by DARPA, Army, Air Force, U.S. Joint Forces Command, and the Office of the Secretary of Defense, will integrate ACN payloads onboard Air Force and Army aircraft.

(U) Program Plans:

- Conducted a flight demonstration lab payload and began integration of the flight payload that will be used for the Interim Joint Military Utility Assessment (IJMUA).
- Integrated a Joint Tactical Radio Systems (JTRS) Software Component Architecture (SCA) 2.2 Core Framework and showed the ability to run software waveforms using that SCA implementation.
- Integrated AJCN payload and antennas on C-23 aircraft and conducted an Interim Joint Military Utility Assessment (IJMUA) of multi-mission functionality.
- Conducted flight test on C-23 to evaluate in-flight co-site mitigation performance.
- Integrated JTRS (Single Channel Ground Air Radio System) SINCGARS waveform within AJCN architecture to demonstrate feasibility of porting JTRS waveforms.
- Initiated development of Concept of Operations, Tactics, Techniques and Procedures (TTP), and training package.
- Investigate technologies to provide secure waveforms.
- Investigate technologies to incorporate other systems (such as UGS) into the ACN architecture.
- Investigate technologies for advanced networking concepts, especially between dissimilar platforms.
- Integrate AJCN payloads on 2 Hunters and 2 NKC-135s.

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	FY 2003	FY 2004	FY 2005
Secure Adaptive Waveforms (SAW) (formerly Adaptive Waveform (AW))	0.000	6.272	7.800

(U) The Secure Adaptive Waveforms (SAW) program, and the related PRZM program, will address lessons learned from the Airborne Communication Node (ACN) program concerning the need for secure communications waveforms. The SAW program will develop and demonstrate an adaptive waveform agile communications system that can change structure (frequency, modulation, data rate, hop rate, code, etc.) on a periodic or aperiodic basis to minimize the probability of detection, interception, and exploitation in order to support covert operations. New means of conducting secure communications are needed because the commercial availability of high performance RF components makes the basic tools necessary for conducting signals intelligence (SIGINT) exploitation available to our adversaries. It is realistic to assume that adversaries will soon have the capability and means to develop software exploitation techniques that make even the most advanced U. S. communications systems vulnerable. To defeat this threat, the technical goal is to eliminate repeatability in transmissions by adapting the waveform randomly and forcing random network routing. In keeping with the multi-INT focus of the ACN program, secondary objectives of the SAW program include making the system capable of simultaneously supporting multiple missions, to include communications, SIGINT, radar, and electronic warfare.

(U) The goal of the Polarized Rotation Modulation (PRZM) 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 PRZM communications program will investigate the use of polarization modulation and the ability for conventional radios to carry all information over the transmitted signal amplitude, phase and frequency. Polarization modulation introduces as 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 increase in spectrum or modem complexity. The program will be demonstrated as an enhancement to an otherwise state of the art networking system.

(U) Program Plans:

- Secure Adaptive Waveforms.
  - Initiate system design effort.
  - Initiate red team development of commercial off-the-shelf based exploitation receiver.

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  - Analyze processing required and size terminal.
  - Demonstrate and assess random network routing performance.
  - Develop and demonstrate ability to generate single-mission dynamic waveforms in response to various stimuli (environment, quality of service, data type).
  - Demonstrate performance against red team commercial off-the-shelf based exploitation receiver.

- Polarized Rotation Modulation Communications
  - Perform simulations to determine bit error rates and the optimum modulation schemes commensurate with the center frequencies and bandwidth permissible.
  - Conduct simulations to verify performance predictions and identify component elements.
  - Construct a demonstration prototype and undertake laboratory test to validate PRZM concept.
  - Demonstrate in field conditions at long range under operational conditions.

	FY 2003	FY 2004	FY 2005
Connectionless Networking (CN)	0.000	8.372	7.800

(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 of the Airborne Communications Node (ACN) 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, in turn, improve energy per bit of delivered information by as much as 100 to 1,000 times compared to conventional and near-term deployable communications systems such as contemplated by both commercial and military users. 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 such as proliferated sensors or remotely operated or updated weapons. Eliminating the requirement to maintain a continuous network linkage would enable these platforms to provide continuous connectivity without consumption of power, or compromising emanations. The CN program will exploit current signal processing components, intelligent (processing and memory

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intensive) routing, and availability of situational information to demonstrate a total energy savings of at least 100 times typical connection oriented network applications.

(U) Program Plans:
- Investigate specific technology requirements for each of the traditional wireless networks.
- Determine layer specific solutions.
- Investigate layer integrating approaches.
- Model acquisition and media access; network and transport design; and aggregate energy cost savings.
- Predict achievable performance improvement.
- Develop and evaluate candidate approaches for implementation complexity, on-board processor and memory capability/power, overhead, scalability and performance.

	FY 2003	FY 2004	FY 2005
Next Generation (XG)	8.912	18.305	15.571

(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 the dynamic redistribution of allocated spectrum along with novel waveforms. 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 control of the spectrum, the technologies and subsystems that enable reallocation of the spectrum, and the system appliqué prototypes to demonstrate applicability to legacy and future DoD radio frequency emitters. The approach plans to investigate methods to leverage the technology base in microelectronics with new waveform and medium access and control protocol technologies to construct an integrated system. The proposed 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 adaption technologies for legacy and future emitter systems for joint service utility.

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(U) Program Plans:

- Conduct CONUS and OCONUS spectrum usage analysis.
  - -- Analyze military bands during force exercises.
  - -- Analyze civilian band usage in a variety of locales (urban and rural settings).
  - -- Optimize correlation between distributed nodes.
- Investigate concepts for employment and utility of a dynamic waveform to the warfighter.
- Conduct lab demo of sense and adaptation technology performance.
  - -- Perform analysis and simulation of multiple control protocols.
  - -- Use military band spectrum analysis to assess subsystem technology development.
- Develop testbed for hardware in-the-loop testing of concepts.
- Characterize next generation and RF component technology for inclusion into eventual demonstrator.

	FY 2003	FY 2004	FY 2005
Advanced Speech Encoding (ASE)	8.491	9.683	6.228

(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 vocoders. The program will compress speech to bit rates between 200 bps and 800 bps while producing speech quality at least as good as that produced by the current DoD standard and maintaining that quality and bit rate in noisy military environments. Reduction of voice communication bit rates will decrease the probability of detection of transmitted signals and also decrease the required transmit energy, hence increasing battery lifetime. ASE will reduce voice communication bit rates by directly measuring the glottal excitation function, using non-acoustic sensors allowing for a more accurate determination of the parameters needed for speech encoding. The ASE program will develop novel noise suppression and low-rate vocoding approaches that exploit the additional information provided by the noise-robust non-acoustic sensors. Reliable authentication of the speaker's identity using vocal excitation measurements will be investigated along with technologies for secured voice communications systems that are encrypted on the basis of the user's voice.

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(U) Program Plans:
- Demonstrate encoded speech intelligibility for noisy environments that is equal to or better than that achieved with current systems for environments that are at least 40 dB quieter.
- Demonstrate 200 - 800 bps vocoders with speech quality and intelligibility at least as good as the DoD standard vocoders using vocal excitation measurements to extract speech information content in noisy environments.
- Investigate voice based authentication and encryption techniques.

	FY 2003	FY 2004	FY 2005
Symbiotic Communications	18.004	19.696	12.726

(U) Future combat systems increasingly rely on accurate intelligence preparation of the battlefield. This includes timely and accurate georegistration of all sensed data for precision weaponry on targets (including mobile targets). The single biggest error source that exists in the georegistration process is the lack of accurate knowledge of the terrain. Current national databases provide only coarse Level 1 data; Level 2 data will become available in the next several years. Neither Level 1 nor Level 2 data is sufficient to take full benefit of even current generation weapon accuracies, and the situation will worsen as weapons navigation and guidance systems improve at a faster pace. In order to overcome this, the Symbiotic Communications (SYCO) program will develop an airborne system that can generate, in real-time, Digital Terrain Elevation Data (DTED) with a precision commensurate with NIMA defined Level 4. This system will operate in all weather and passively. Additional attributes being explored include production of synthetic aperture radar (SAR) imagery and ground moving target indication (GMTI) to facilitate the detection, tracking and engagement of moving targets passively and in all weather conditions. Finally, exploration of techniques for using multiple frequencies to achieve enhanced spatial resolution leading to a potential DTED Level 5 precision will be conducted. Initial flight tests have been conducted that demonstrate the basic feasibility of SYCO operating modes and support studies of SYCO measurement phenomenology.

(U) Program Plans:
- Conduct ground experiments for terrain scatter characterization.
- Conduct system analyses and trade studies.
- Develop hardware and conduct planning for early flight tests.
- Investigate terrain classification using polarization, spatial and spectral diversity.

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- Investigate high-resolution passive imaging of emitters.
- Investigate potential platforms and begin hardware optimization process.
- Develop data processing architecture and algorithms for non-real time system.
- Conduct flight tests with non-real time system to validate algorithms.
- Demonstrate Digital Terrain Elevation Data (DTED) 3 with non-real-time processing of flight data.
- Develop real-time airborne system.
- Demonstrate DTED Level 4 with real-time processing of flight data.

	FY 2003	FY 2004	FY 2005
Tera Hertz Operational Reachback / Optical & RF Combined Link Experiment	9.930	34.771	24.519

(U) The Tera Hertz Operational Reachback (THOR) program's goals were to mature required technologies and credibly demonstrate a system able to provide a high data rate (internet-like) backbone to the tactical user whether airborne, terrestrial, or maritime. By focusing on the militarily unique need for a truly mobile and deployable high-data-rate infrastructure that extends access to existing commercial and military terrestrial fiber infrastructures, the Department's vision of a "Global Grid" will be enabled by creating the high-data-rate nexus among the terrestrial, space, and air grids. This is expected to be accomplished by leveraging the commercial global optical fiber network, multi-quantum well retro-reflectors, and advances in optical phased array technology that have been motivated by directed energy applications. Together, these technologies enable the creation of a hybrid fiber-free space optical network extension. Gigabit-per-second connectivity and long-haul reachback to and between deployed theater command nodes, airborne, and maritime assets will be demonstrated in the final year of the program.

(U) In FY 2003, DARPA revamped the THOR program in order to properly demonstrate the advantages of free space optical (FSO) communications when simultaneously operating with more traditional and mature radio frequency (RF) communications techniques. This effort, the Optical & RF Combined Link Experiment (ORCLE) seeks to develop a combined RF & 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 environment. The central challenge is to enable optical communications bandwidth without giving up RF reliability and "all-weather" performance. This effort complements the capabilities in Mobile Free Space Optics under THOR. ORCLE will develop RF and FSO propagation channel analysis, coding techniques and modeling to include weather, atmospherics and aero-optics to

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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.

(U) Program Plans:

- During THOR, modeled route diversity, switching and self-correcting power of the networks as effective cloud mitigation strategy.
  - -- Determined that high bandwidth tip/tilt correction is effective for active tracking on both transmit and receive nodes.
  - -- Analyzed modeling retro reflectors used as Identified Friend or Foe which support link acquisition.
  - -- Developed initial multiple access receiver technology to reduce size and weight by sharing receiver optical hardware.
  - -- Developed non-mechanical beam steering to high performance levels that reduced size, weight and power.

- During ORCLE, develop a networking schema for quality of service using RF for latency sensitive assured delivery and FSO for bulk high bandwidth transfers that are less latency sensitive using a dynamic & synergistic dual physical layer.
  - -- Develop compact beam steering using a small form factor and wide field of view.
  - -- 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 2003	FY 2004	FY 2005
Space-Based Networking	0.000	0.000	4.000

(U) The goal of the Space-Based Networking program is to provide a self-forming, self-healing mobile ad hoc network (MANET) in space between micro-satellites performing a space surveillance and awareness mission to/from other satellites and ground stations. This program leverages other DARPA efforts related to unfettered access to space and space control with a transition targeted to the Air Force. Significant technical obstacles include networking using high speed RF and optical links with high latencies due to distances of hundreds of kilometers, topology formation among fast moving nodes yet in predictable paths (orbits) or locations (ground-based), and the power, size, and weight constraints associated with space operations using micro-satellites.

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(U) Program Plans:
- Develop network protocols for use in challenging space environments with high data rates.
- Perform simulation analysis of candidate network protocols.
- Perform a ground-based test of the network protocols using surrogate physical layer technology.

	FY 2003	FY 2004	FY 2005
Policy Based Network Management (PBNM)	0.000	0.000	2.000

(U) Drawing upon lessons learned from the ACN/AJCN program and previous DARPA programs in mobile ad-hoc networking, the Policy Based Network Management (PBNM) program seeks to enable 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 seeks to create a system control methodology that will allow 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 will allow the network to implement the commander's intent for the operation by dynamically changing function and allocation throughout the duration of a mission. PBNM will control 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:
- Develop robust, secure self-forming tactical networks able to be dynamically changed based on the commander's strategic and operational mission objectives.

	FY 2003	FY 2004	FY 2005
Disruption Tolerant Networking (DTN)	0.000	0.000	7.100

(U) Drawing upon technical challenges identified in specific programs such as ACN/AJCN and other non-ground based Mobile Ad-Hoc Network (MANET) based programs, the Disruption Tolerant Networking (DTN) will develop network protocols 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

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mechanics, etc. The program will develop a single model for bundling information and ensuring its delivery, even through a series of episodic communications links, from generator to user. DARPA will develop the specifications, engage the military, commercial and the Internet communities to maximize the applicability and commercial viability of these protocols, and develop the basic software in an open source mode. DARPA will then implement these protocols in a typical military system to verify both the performance of the protocol, and to validate the utility. These protocols are also applicable to NASA applications, such as deep space communications.

(U) Program Plans:

- Demonstrate that information organized into bundles can be delivered by the network.
- Commence research to show "fuzzy scheduling" can make network routing decisions in the presence of uncertainty about available or optimal paths.
- Investigate policy cognitive operation by moving intelligence into networks to make the best choices on delivery.
- Enable networks to deliver traffic without the end-to-end address and routing information using deferred, hierarchical address binding techniques.

	FY 2003	FY 2004	FY 2005
Network Centric Operations/Battle Command	0.000	0.000	7.500

(U) The DoD is transforming to a more network centric focus for military operations, e.g., FORCENet, Joint Battlespace Infosphere, and Future Combat Systems/Unit of Action (UA). Until recently, the primary technological emphasis has been oriented towards improving Command, Control, Communications and Computing, Intelligence Surveillance and Reconnaissance (C4ISR) systems to enable better sensor-decider-shooter linkages. To be more effective in joint operations, network centricity development must receive equal priority to facilitate battlefield understanding to the commanders at all echelons, in a form best suited for their information assimilation (receptive) and decision processes (intuitive). In other words, network centricity must improve the art of battle command, rather than just the science of C4ISR, to be a force multiplier. This new initiative will develop and demonstrate the enabling technologies for Network Centric Operations, with emphasis on creating understanding for battle command. It will seamlessly connect the Network Centric Enterprise and Network Centric Warfare layers through understanding, thereby enabling shared awareness, collaboration and self-synchronization among the various joint components and echelons. This program integrates technologies enabling secure, assured, multi-subscriber, multi-purpose (e.g., maneuver, logistics, intelligence) networks with commander-centric command and control / intelligence technologies, including forecasting /prediction of Courses of Action (COA) and

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sustainment tools, into one unified joint battle command system. It will allow the Strategic/Operational Commanders to simultaneously orchestrate and coordinate the deployment, combat operations and resourcing of multiple Units of Action supported by multi-service, interagency, multinational and nongovernmental activities. It will also support long range indirect fire support and effects, persistent theater Intelligence Surveillance Reconnaissance (ISR), and continuous sustainment. For example, results of this program could help the Army produce within 30 minutes, with a quality equivalent to what could be produced by a staff of senior planners with no time limit, (1) Running start insertion plan for multiple UAs; (2) transition plan for 3 UAs to maintain tempo in multiple battles; and (3) Operational maneuver of a UA by strategic air lift. Future capabilities include, but are not limited to: Network Centric Operations, including Enterprise and Warfare layers; synergistic battle command among all joint components and echelons; networked manned and unmanned systems; cognitive systems; and robust, secure self-forming tactical networks seamlessly connected to the Global Information Grid (GIG).

(U) Program Plans:

- Develop and demonstrate a single common architecture and common technology building blocks for seamlessly integrating the Strategic, Operational and Tactical levels of warfare.
- Research and demonstrate new protocols for MANET-type self-forming, ad hoc, tactical networks incorporating, low probabilities of detection and intercepts, spectrum efficient waveforms; advanced information assurance; and UAV gateways.
- Develop interface systems for seamlessly integrating data from MANET-type self-forming, ad hoc, tactical networks into high data rate internet-type networks like the GIG.
- Develop a military unique version of Code Division Multiple Access (CDMA) spread spectrum communications which may leverage commercial advancements in CDMA for the physical and media access control (MAC) layers.
- Develop methods for creating running estimates of operations and sustainment.
- Develop and demonstrate technologies for integrating prediction/forecasting techniques into COA generation and real time war gaming for understanding.
- Develop commander-machine interfaces, including receptive graphics generators, to facilitate intuitive decision making.
- Investigate e-commerce logistics techniques for application to battle space sustainment.

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	FY 2003	FY 2004	FY 2005
Advanced Antenna Concepts	0.000	0.000	4.152

(U) The Micro-Aperture Circuit program will develop and implement advanced circuit theory (non-Foster matching) that will enable electrically short antennas to be used with similar effectiveness to larger ones, and to dynamically match antennas throughout a wide range of frequencies. Current antenna technology limits the ability to miniaturize the physical size of the antenna, resulting in a requirement for large platforms or physical deployments for frequencies suitable for special operations. Similarly, limited antenna bandwidth limits the ability to fully exploit software-based radios, such as Joint Tactical Radio System (JTRS), since the antennas they utilize are limited in bandwidth. Non-Foster matching greatly reduces the transmitter power needed to deliver a prescribed amount of Radio Frequency (RF) to an electrically-small antenna. Application of advanced technology (Wide-band gap materials, such as SiN) offers the ability to fabricate devices that can effectively couple to very non-resonant antennas. DARPA will develop the basic technology, and then apply it to develop radios with wide bands of operation and very small physical size. A potential application will be a self-contained cell phone size device that can use High Frequency (HF) to communicate around the world without any infrastructure.

(U) The Ultra-Fast Radar program 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 by interconnecting the receive elements to transmit elements in a conjugate ("van-Atta") fashion. The idea is the combining and tailoring of noise-correlating interferometry and retro-directive antenna arrays into retro-directive noise-correlating (RNC) radar. The combination of these innovations allows the radar to operate in omni-directional search mode by broadcasting white noise over a specified search angle determined by the beam pattern of the individual elements. Once a target of adequate cross section enters the beam within the range of the sensor, correlations appear in the noise power spectrum between neighboring antennas. The received noise power is then amplified by the transceiver electronic chain and re-transmitted directly towards the target in a process call the RNC feedback loop. 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.

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(U) Program Plans:

- Micro Aperture Circuit:
  - Develop negative inductors and capacitors in both grounded and floating configurations with antenna type devices capable of handling 5W or more of signal power.
  - Perform impedance matching to electrically-small antennas with optimal tradeoff among stability, frequency-response accuracy, bandwidth, and power handling ability.
  - Design and build an amplifier using a non-Foster matching circuit to deliver 5W or more to an electrically-small antenna.
  - Demonstrate the Micro-Aperture Circuit antenna concept in the development of radios with a wide band of operation and small physical size.

- Ultra-Fast Radar:
  - 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.

	FY 2003	FY 2004	FY 2005
Navy Photonics Program	0.000	0.000	3.750

(U) The Navy Photonics Program will develop and field technology in partnership with the Naval Air Systems Command (NAVAIR) Program Executive Office (Tactical Aircraft Programs) (PEO(T)) in a rapid research, development, and demonstration project. This effort will pursue opto-electronic integration of state-of-the art radio frequency (RF) and digital photonics, RF and Digital integrated circuits and micro-electro-mechanics (MEMS) Technologies for embedded Aerospace applications. The photonics technology from this effort will result in the development of a common optical backbone in place of many point-to-point links. The DARPA portion of the Navy Photonics Program will address high-risk

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development areas including reduction of fiber optic device size. As a result, this size reduction will enable placement of components in currently inaccessible locations (i.e., beyond the wing-fold). This program should result in a tighter integration of optical components with a decrease in unit size, increased reliability and decreased production costs. Based on the results of the risk reduction and accomplishments of this program, the goal is the operational transition into the Navy EA-6B Prowler and other tactical aircraft (i.e. EA-18, EA-35, E-2C, and MMA).

(U) Program Plans:

- Develop a fiber optic backbone network capable of interconnecting to the transmitter side of an electronic aircraft podded jamming system.
- Design optical components that will meet the volume, weight, and environmental specifications for an airborne platform.
- Integrate and reduce the size of the technology to allow the external optical interfaces to be positioned inside the electronic warfare equipment space.
- Perform flight demonstrations showing the use of the fiber optical backbone interconnected to the electronic attack aircraft jamming systems.

	FY 2003	FY 2004	FY 2005
Command Post of the Future (CPOF)	3.726	0.000	0.000

(U) The objective of the Command Post of the Future (CPOF) program was to improve the speed and quality of command decisions, more effectively disseminate command decisions, and reduce the number of staff members required to process and manage the information systems. Three important command functions were addressed to achieve this objective: 1) improved speed and quality of situation awareness; 2) improved speed of course of action (COA) development and selection; and 3) improved clarity of COA communication between commander and subordinates. For each of these command functions, CPOF developed technologies that leverage the expertise of the commander by exploiting and augmenting natural cognitive abilities. The key technologies developed were: (1) an integrated visualization environment for the commander and his staff; (2) a powerful and comprehensive human-computer interaction capability; (3) a robust collaborative communication environment for creating shared understanding among commanders and staff through both voice and visual interactions; (4) an integrated suite of systems to automate many of the lower level staff functions and automatically invoke and operate supporting, planning and analysis applications; and (5) a modular, portable suite of software components that can be quickly configured and tailored to various command environments (stationary and mobile), at different echelons of tactical command.

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(U) Program Accomplishments:

- Completed the final experiments in cognitive principals of visualization, multi-modal interaction, collaborative planning and command decision-making.
- Completed technology development of CPOF component technologies of dynamic visualization, multi-modal interfaces and collaborative planning.
- Integrated final component technologies and knowledge bases into the final prototype commander's mobile interactive display system, the BattleBoard; qualified system capabilities.
- Conducted validation experiments with the Army's Stryker Brigade Combat Team #2 at Ft. Lewis, and evaluate results for system improvements.

(U) **Other Program Funding Summary Cost:**

- Not Applicable.