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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, R-1 #47					
COST *(In Millions)*	FY 2000	FY2001	FY2002	FY2003	FY2004	FY2005	FY2006	FY2007	Cost To Complete	Total Cost
Total Program Element (PE) Cost	175.665	128.778	117.451	104.480	107.700	108.100	103.100	103.100	Continuing	Continuing
Command & Control Information Systems CCC-01	98.776	78.133	67.331	58.234	70.188	73.263	67.263	67.263	Continuing	Continuing
Information Integration Systems CCC-02	76.889	50.645	50.120	46.246	37.512	34.837	35.837	35.837	Continuing	Continuing

(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 Command and Control Information Systems project is developing the technologies necessary to facilitate joint campaign planning and control throughout the battlespace. Programs include: the Joint Force Air Component Commander (JFACC), the Man and Machine Command and Control Program, the Information Assurance Science and Engineering Tools; Organically Assured and Survivable Information Systems; the Advanced Intelligence, Surveillance and Reconnaissance (ISR) Management (AIM) program; the Control of Agent-Based Systems program; Project Genoa; the Active Templates program; and Tera Hertz Operational Reachback (THOR) program.

(U) The Information Integration Systems project will develop the technologies necessary to ensure that the enhanced information required by battlefield combatants is available on a near real-time basis. Programs addressed in this project include: the Dynamic Database (DDB) program; the Airborne Communications Node (ACN) program; the Command Post of the Future program; Symbiotic Communications; the Next Generation (XG) program; and Advanced Speech Encoding program.

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

	FY 2000	FY 2001	FY 2002
Previous President's Budget	185.926	128.863	130.688
Current Budget	175.665	128.778	117.451

(U) **Change Summary Explanation:**

FY 2000 Decrease reflects several program repricings, the phase out of AICE and BADD programs and SBIR reprogramming.
FY 2001 Decrease reflects the Section 8086 reduction and the government-wide rescission.
FY 2002 Decrease reflects the completion of the Dynamic Database and Information Assurance Science and Engineering Tools programs.

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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 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	Cost to Complete	Total Cost
Command & Control Information Systems CCC-01	98.776	78.133	67.331	58.234	70.188	73.263	67.263	67.263	Continuing	Continuing

(U) Mission Description:

(U) Military operations that have taken place since the end of the cold war have demonstrated that current theater command, control, communications, intelligence/information systems, and planning and rehearsal systems lack the ability to fully support operations in complex, time-critical environments. These operations range 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 goals of the programs in this 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 Joint Force Air Component Commander (JFACC) program has addressed critical issues in military command and control (C2), specifically joint and coalition air operations. In the earlier phases of the program, it was noted that as each C2 element (observation, orientation, decision and execution) was driven toward progressively shorter timelines, dynamic instabilities in the decision loop became the key challenge to practical implementation of any new generation of C2 systems. JFACC developed and validated new C2 architectural concepts and appropriate control strategies with the ability to: (1) rapidly and efficiently respond to varying objectives and guidance, time constraints, changeable resources, erratic hostile responses, asymmetric threats and unpredictable anomalies (Agility); (2) proactively manage destabilizing events, such as time critical targets, while simultaneously avoiding undesirable long-and short-term effects, to include disruptive and inefficient impacts on downstream plans and operations (Stability); and (3) adapt to the wide spectrum of military conflicts and activities (Flexibility). The last phase of the JFACC program demonstrated the efficacy of using the mathematics and science of control theory as a foundation for generating a dynamic military C2 architecture. Final demonstrations and evaluations complete in FY 2001.

(U) Building upon the results of previous C2 efforts, the Man and Machine Command and Control (M2C2) program will generate decision and control-based software tools within dynamically adaptable C2 architectures to allow the commander to understand and make critical decisions within

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a complex, time-constrained environment. The M2C2 program will enable the commander to institute autonomic responses to a wide variety of threats in the presence of resource constraints and to issue guidance to both manned and autonomous entities in a coordinated manner at all levels of the C2 hierarchy. This program will provide the commander with the technological C2 tools that will allow real-time response in a dynamic, complex, high tempo environment.

(U) With the growing dependence on information systems and the pressing need to be able to get the right information to the right person at the right time, it becomes critical to deliver and protect information and assure the availability of associated services – particularly in a stressed environment. In FY 2000, the program that addressed such key issues, Information Assurance (IA), ended. The Information Assurance Science and Engineering Tools (IASET) program, while incorporating lessons learned from the IA program, addressed the assurance problem by investigating the underlying science that would allow a formal understanding of the problem at hand. The Information Assurance and Survivability programs, of which IASET was a part, were thoroughly reviewed in FY 2000 to ensure that information assurance and survivability needs of DoD are being met. As a result of the review, IASET will complete investigations in FY 2001 with key results being transferred to the Cyber Panel and Fault Tolerant Networking programs funded in PE 0602301E, Project ST-24.

(U) The coming generation of collection systems will provide dramatically increased volumes of higher fidelity data to the operational decision-maker. The challenge will be to dynamically manage and synchronize this advanced collection architecture with the next-generation processing, exploitation and dissemination capabilities to provide the critical information to the decision maker in the constantly changing operational situation. The Advanced Intelligence, Surveillance and Reconnaissance Management (AIM) program will develop Collection Strategies and Multi-asset Synchronization components to dynamically optimize/synchronize, schedule, and task the spaceborne, airborne and ground based collection, processing, exploitation and dissemination architecture. The AIM program will optimize intelligence, surveillance and reconnaissance (ISR) support to precision engagement and tactical operations by providing proactive information support to the warfighter, continuous integration of operations and ISR, responsive ISR timelines, optimal ISR confederation management, and synchronization of ISR asset and exploitation tasking. AIM will ensure near-real-time information support to commanders and the Joint Task Force by providing all echelons with: a common view of the collection environment; current status of collection, processing, exploitation and dissemination operations; faster than real-time modeling and simulation in support of trade-off decisions; and the ability to conduct real-time multi-echelon coordination and shared decision making.

(U) The Control of Agent-Based Systems (CoABS) program will explore the ability to rapidly assemble a set of disparate information systems into a coherently interoperating whole. This will be done without having to redesign legacy systems and will include interoperation with non-DOD governmental systems and open-sourced systems not built to a pre-existing government standard. The development and implementation of mobile agents and agent-communication languages will help both in the facilitation of the multi-systems integration and in controlling the information flow

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to alleviate bandwidth saturation and degraded quality of service. The CoABS program will demonstrate and deploy a middleware-based approach, and eventual toolkit, to support interoperable of heterogeneous systems in coalition operations and will enable the interaction of military and non-military resources in critical operations.

(U) Project Genoa is developing tools and a prototype infrastructure for collaborative crisis understanding and management for the national security community ranging from the National Command Authorities to Commanders of the Unified Commands. The growing transnational threats increase the need for early crisis discovery and mitigation. To develop timely preemptive or mitigating strategies, Project Genoa's objectives are to: (1) decrease the decision cycle time from days to hours by reducing the time it takes to go from problem detection to providing the decision maker with actionable options; (2) increase the number of situations that can be managed simultaneously by an order of magnitude; (3) decrease the reaction time when new information is received; and (4) reduce number of military deployments. The key enabling technologies are: knowledge discovery of critical information from unstructured multimedia sources; structured argumentation to capture and present reasoning from evidence to conclusion; and a comprehensive corporate memory that will enable comparison of critical information across situation, time and organization. The current clients for components of the prototype system are Joint Chiefs of Staff and Defense Intelligence Agency, Office of Assistant Secretary of Defense (International Security Affairs), Joint Counter-intelligence Assessment Center, and Command-in-Chief Pacific (J3).

(U) The Active Templates (AcT) program will produce a robust, lightweight software technology for aiding in the automation of detailed planning and execution for military operations using a plan spreadsheet metaphor. Active Templates are distributed data structures whose variables will be linked to live data feeds or problem-solving methods. AcT will assist with automated planning and execution by capturing, improving and updating critical information such as current state, goals, constraints, alternative actions, standard defaults, decisions in context and rationale. Active Templates will be designed to be user-tailorable, networked, noise-tolerant, user-supported, scalable, and widely adopted. As a result, the technology to be fielded will provide faster plan generation (six times), improved plan quality (eight times more options considered), 60 percent reduction in staff-hours required to track and coordinate missions, enhanced ability to capture lessons learned, and improved national capability to respond in a crisis. Early prototypes of AcT technologies have been adopted by Special Operations Command where they have been shown to accelerate temporal planning by a factor of four and reduce the number of personnel required for battle tracking by a factor of six. DARPA is working closely with the Joint Special Operations Command to add spatial planning capabilities and simple forms-based coordination tools that may be defined dynamically by ordinary users in less than a day. Experiments (e.g., time-and-motion studies) with these technologies show improvements in the range indicated above.

(U) The Tera Hertz Operational Reachback (THOR) program will 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

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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 will 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 airborne assets, as well as megabit-per-second connectivity and reachback to and from terrestrial and maritime forces will be demonstrated.

(U) The Organically Assured and Survivable Information Systems (OASIS) program will transition technologies that allow systems to continue to operate correctly in the face of successful intrusions and attacks through tolerance and self healing properties. Further investigation of the theory of information survivability and metrics will be pursued in conjunction with Cyber Panel and Fault Tolerant Networks to provide the scientific foundation for information survivability technologies.

(U) Program Accomplishments and Plans:

(U) FY 2000 Accomplishments:

- Joint Force Air Component Commander (JFACC). ($ 20.948 Million)
  - Developed a reconfigurable model that simulates the dynamic phenomena within the military air operations enterprise.
  - Experimentally investigated the stability effects of new control technologies and C2 architectures incorporated within the air operations domain.
  - Evaluated performance improvements gained by implementing combined optimal asset allocation and route planning for simulated air operations.

- Information Assurance. ($ 35.500 Million)
  - Demonstrated automated capabilities that enable dynamic, secure collaboration between enclaves including data and invocation flow rules.
  - Demonstrated real-time, finer-grained advanced attack detection and response at the application layer, operating system and network infrastructure. Coupled advanced attack detection capabilities with automated system security and administration tools to enhance integrated monitoring and control of network services, detected attack status, and system configuration.

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- Dynamically and automatically managed allocation of components and resources to reconstitute critical functions that have degraded.
- Demonstrated security policy interoperability between enclaves.
- Explored knowledge base approach to adaptive systems management.
- Improved assurance measurement and risk analysis by establishing value functions for user data.
- Enhanced object assurance granularity by augmenting Common Object Request Broker Architecture Security (CORBASEC).
- Completed selection of basic Information Assurance Science and Engineering Tools (IASET) architecture for incorporation into an integrated design environment.
- Conducted initial IASET experiments with information assurance design methodologies emphasizing the application of science-based metrics in assessment activities.

- Advanced ISR (Intelligence, Surveillance and Reconnaissance) Management (AIM). ($ 7.038 Million)
  - Developed collection, exploitation and dissemination synchronization techniques to link all phases of ISR management in support of the warfighter.
  - Developed Multi-Asset Synchronizer to provide near real time organization and synchronization of multiple disparate sensor assets; installed and operated at U.S. Southern Command.
  - Initial automated collection strategy tools passed to the Integrated Collection Management efforts in the Defense Intelligence Agency.
  - Conducted operational "proof of concept" experiments with prototype AIM components at U. S. Southern Command.
  - Developed and demonstrated a preliminary capability to optimally allocate distributed ISR resources over extended period of time horizons using a market-oriented programming approach.
  - Conducted technical assessments of emerging AIM technologies, including multi-asset synchronization and strategy development.

- Control of Agent-Based Systems (CoABS). ($ 16.326 Million)
  - Developed and demonstrated a flexible information infrastructure and an interoperability tool called the Agent Grid.
  - Supported the dynamic deployment of complex applications for dynamic domains such as military command and control. These applications require the composability, adaptability and autonomy provided by software agents interoperating in dynamic, mixed-initiative teams with human users. This Agent Grid provides access to shared protocols and ontologies, mechanisms for describing agents' capabilities and needs, and services that support interoperability among agents at flexible levels of semantics distributed across a network infrastructure.

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- Project Genoa. ($ 11.422 Million)
  - Knowledge Discovery: Transitioned a knowledge discovery tool to Intelink Management Office; developed and implemented information extraction from text and extensive use of innovative visualization of complex information relationships.
  - Structured Argumentation: Refined crisis models, developed tools for scenario based, alternative futures reasoning, and developed collaborative option generation. Continued work on meeting transcription. Began development ability to navigate and play back corporate memory.
  - Experimented with products from Information Assurance projects to enable a multi-intranet system to operate at mixed security levels.
  - Continued evaluation by users from the national security community.

- Active Templates. ($ 7.542 Million)
  - Developed and encoded templates of standard operating procedure, which integrated causal model capability to show how constraints, event triggering, inference and uncertain reasoning can be utilized for fast crisis planning and execution.
  - Created a flexible networked architecture that supports template linking, dynamic connections, consistency management and dynamic information sharing. Characterized performance in terms of connection speed, message throughput and consistency maintenance.
  - Developed and demonstrated temporal plan editor and execution monitoring tool now adopted by several Special Operations organizations.

(U) FY 2001 Plans:

- Man and Machine Command and Control (M2C2) (Formerly Dynamic Command and Control). ($ 10.924 Million)
  - Develop design specifications for selected decision-making tools (controllers and state estimators) within a dynamic, multi-faceted architecture.
  - Initiate an extensive library of operational "plant" models, which can support a wide range of computational to operational experiments.
  - Experimentally evaluate the command and control architecture and design concepts produced during this phase.
  - Continue to explore new and innovative theories, techniques, and tools for enabling agile and stable military operations.
  - Develop technology, algorithms and software tools for team composition and allocation to military operational tasks based upon collective goals.

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- Joint Forces Air Component Commander (JFACC). ($ 7.000 Million)
  - Complete experimentation and evaluate effectiveness of C2 architectures incorporated, via simulation, into air operations systems.

- Information Assurance Science and Engineering Tools (IASET). ($ 20.831 Million)
  - Develop initial science-based security enabling disciplines, methods, and preliminary tools that will allow for the design of measurable and useful Information Assurance systems. These deliverables will be provided to the ULTRA*LOG, OASIS, FTN and Cyber Panel programs.
  - Organically Assured and Survivable Information Systems (OASIS)
    - > Demonstrate real-time execution monitoring techniques and tools to mitigate malicious mobile code.
    - > Prototype demonstration of integrity mark technology for protection of sensitive imagery.
    - > Beta release of certifying compilers and security proof generators and checkers.
    - > Investigate new approaches to intrusion tolerance based on data, spatial, temporal and analytical redundancy and resource allocation; identify relevant challenge problems.
    - > Demonstrate self-protecting mobile agent prototype.
    - > Develop architecture for building intrusion tolerant systems from potentially vulnerable components by applying existing fault-tolerant approaches to intrusion tolerance support layered defenses, and provide resilience to attacks.

- Advanced ISR (Intelligence, Surveillance and Reconnaissance) Management (AIM). ($ 9.667 Million)
  - Explore new ISR system architectures and technologies to increase effectiveness and reduce man loading in tactical as well as planning applications.
  - Conduct operational evaluation of AIM automated collection Strategy Developer (SD) and Multi-Asset Synchronizer (MAS) technologies with U.S. Southern Command. Employ MAS as an off-line, real-time, component of operational exercise Unified Endeavor.
  - Expand SD and MAS capabilities to include tasking of GMTI and SIGINT sensors. Characterize performance of AIM components in terms of algorithm timeliness and quantitative collection needs derived from real time processing and exploitation systems such as Dynamic Database.
  - Evaluate dynamic re-planning capabilities as part of an integrated collection management demonstration linking AIM and Dynamic Database technologies in a novel control paradigm that enables responsive sensor management driven by data exploitation needs. Establish a collaborative engineering environment to conduct AIM/DDB experimentation.

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- Partner with the DIA Joint Intelligence Virtual Architecture program to explore use of their Joint Collaborative Environment as an application server for making AIM components more broadly and rapidly accessible to operational users.
- Experiment with NRO to introduce AIM technologies to their advanced concept development environment.

- Control of Agent-Based Systems (CoABS). ($ 12.116 Million)
  - Deploy agent technologies and tools using the Agent Grid for use in ACTD and Naval Fleet Battle Exercises activities.
  - Empirically demonstrate efficacy of approach in these realistic military domains.

- Active Templates. ($ 9.696 Million)
  - Integrate and demonstrate multiple templates merging by users to update information, add dependencies and attach problem-solvers.
  - Demonstrate initial capability to automatically and continuously compile geophysical information from different databases and other network information sources.

- Project Genoa. ($ 7.899 Million)
  - Complete development of corporate memory, future scenario generation tools and tailored presentation tools.
  - Develop and validate emerging concepts from collective reasoning applied to the asymmetric threat.
  - Investigate the use of intelligent agents to automate functions where possible.
  - Incorporate changes resulting from client evaluation in real world asymmetric environment.

(U) **FY 2002 Plans:**

- Man and Machine Command and Control (M2C2). ($ 10.416 Million)
  - Demonstrate prototype controllers, focusing on managing temporal and spatial battlespace dynamics.
  - Model ~20 entities with simple, tactical-level objectives and minimal battlespace uncertainty.
  - Evaluate potential for sensitivity analysis of decision metrics, course-of-action recommendations and adversarial inference information to provide useful data content to the Services.
  - Instantiate standard objects within an experimental framework with common messaging features.

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- Advanced ISR (Intelligence, Surveillance and Reconnaissance) Management (AIM). ($ 9.893 Million)
  - Evaluate integrated AIM capabilities for optimized ISR collection management to provide continuous dynamic and proactive collaboration between operations and ISR.
  - Develop user interface to include task valuation and prioritization methodologies in combination with quantitative data driven needs, for use in multi-user/multi-mission environments.
  - Conduct experimentation of AIM at Joint Battle Center.
  - Transition multi-asset synchronization and strategy developer tools to airborne and overhead collection systems including classified ISR management programs.

- Control of Agent-Based Systems (CoABS). ($ 9.893 Million)
  - Release Agent-Grid code and components tailored to military user needs and evaluated in military applications.
  - Evaluate in military applications including coalition operations and intelligence.

- Active Templates. ($ 9.893 Million)
  - Develop Active Template representation/library capabilities for extending the terms, critical planning parameters for template adaptation and merging.
  - Demonstrate advanced tools for extending term-ontology to avoid duplication and conflicting semantics.

- Project Genoa. ($ 0.989 Million)
  - Transition components to user agencies such as Joint Chiefs of Staff, Defense Intelligence Agency, OSD(C3I), OSD(ISA), etc.

- Organically Assured and Survivable Information Systems (OASIS). ($ 16.247 Million)
  - Develop an experimental intrusion tolerant database from COTS components.
  - Begin development of a system for automated behavior modeling of programs and information systems.
  - Explore design of intelligent systems that can judge the trustworthiness of their computational environment and make strategy and resource allocation decisions.
  - Design a framework for tolerating intrusions in large-scale, heterogeneous, networked computing enterprises.
  - Develop algorithms that tolerate random, unpredictable (Byzantine) faults resulting from a class of staged, coordinated intrusions.

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- Demonstrate a scalable intrusion-tolerant architecture for distributed services prototype.
- Explore the best approach to development of a self-healing system.
- Integrate OASIS technologies to demonstrate a notional intrusion tolerant architecture.

- Tera Hertz Operational Reachback (THOR). ($ 10.000 Million)
  - Initiate development of a high power laser source by phase combining multiple inexpensive lasers used by the telecommunications industry.
  - Demonstrate eight milli-Watt fiber laser phasing with an overall output equal to the number of fibers times their individual output power
  - Initiate development of a passive optical terminal.
  - Demonstrate Quantum Well Modulating corner cube retro reflector operation at 1.55 υm wavelength in the laboratory.
  - Investigate the use of steerable agile beam technology to eliminate the gimbols.
  - Complete system trade studies for a maritime terminal.

((U) Other Program Funding Summary Cost:

- Not Applicable.

(U) Schedule Profile:

Plan	Milestones
Jul 01	Demonstrate CINC to tactical level integrated combined arms execution command and control with small unit synchronizing toolkit.
Jul 01	Experiment with AIM/DDB technologies to explore utility for Dynamic Tactical Targeting applications.
Aug 01	Experiment in collaborative environment with NRO/ACDE program at TIC.
Aug 01	Initiate the development of selected prototype C2 tools from new control strategies and concepts.

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Sep 01	Demonstrate that users can tailor their own templates, update information, add dependencies and attach problem-solvers. Show that active template technology is scalable in that 50 templates have been built. Show that planning speed doubles and plan quality improves.
Dec 01	Transition AIM technology as basis for tactical level control of dynamic targeting.
Dec 01	Release product quality Agent Grid code and components tailored to military user needs and evaluated in military applications.
Jan 02	THOR solicitation for system integrator task.
Mar 02	Test and evaluate open and closed loop performance of AIM system to coordinate ISR collection assets in a dynamic and responsive multi-user environment.
Mar 02	THOR technology tasks contract award.
Apr 02	THOR system integrator contract award.
Jul 02	Conduct experimentation of AIM technology at operational command (e.g. Joint Battle Center (JBC)).
Sep 02	Show six-fold increase in execution replanning using Active Templates attached to live data feeds from battlefield sensors.
Sep 02	Transition AIM technology to DIA, CICMP.
Oct 02	THOR solicitation for core technology tasks.
Feb 03	Experimentally validate M2C2 system framework and prototype designs and concepts.
Jun 03	THOR preliminary design review.

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COST *(In Millions)*	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	Cost to Complete	Total Cost
Information Integration Systems CCC-02	76.889	50.645	50.120	46.246	37.512	34.837	35.837	35.837	Continuing	Continuing

(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. These goals are being addressed by the Dynamic Database (DDB) program, the Airborne Communications Node (ACN) program, the Command Post of the Future (CPOF) program, the Symbiotic Communications effort, the neXt Generation (XG) program and the Advanced Speech Encoding program.

(U) The overarching goal of the Dynamic Database (DDB) program is to continuously produce significant battlespace information from immense quantities of multi-sensor data in a manner responsive to tactical users at multiple echelons. More specifically, DDB ingests and registers Ground Moving Target Indicator radar, Signals Intelligence and Imagery (Synthetic Aperture Radar, Electro-Optic and Infra-Red) Intelligence raw sensor data to a common fiducial to reference all sensor data to a Common Targeting Grid. A Sensor History Database stores and maintains the output from the Change Detectors, and retains the raw sensor data as a pedigree. All-source Track and ID Fusion processes were developed to establish a derived Situation History Database by filtering tactically significant changes from the Sensor History Databases. Significant situation changes are shared throughout the DDB system through a scaleable High Performance Data Server, which connects the Sensor History Database nodes, algorithm applications, processors and information repositories. DDB "normalcy models" were then developed to establish conditions for change detection, to trigger external processes when conditions meet posted criteria, propagate updates/alerts across DDB processors, and support queries and searches of associated databases. DDB components have been integrated with components of the Advanced Intelligence, Surveillance and Reconnaissance Management (AIM) program to develop a control theoretic framework for sensor management and data exploitation. The coupling of these technologies will demonstrate a proof of concept in which additional data required by DDB processes is used to drive sensor collections. The DDB program concludes in 2001 and the technology demonstrated, to include the DDB-AIM experiment, will provide the underpinnings of the Dynamic Tactical Targeting (DTT) program beginning in FY 2002 (PE 0603762E, Project SGT-04, Sensors and Exploitation Systems).

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(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). It is envisioned that ACN payloads will be integrated on platforms ranging from High Altitude Endurance (HAE) unmanned airborne platforms (e.g., Global Hawk) to tactical platforms (e.g., Predator, Army Tactical UAV). The ACN payload will be scalable such that payloads for various platforms can be constructed from a core module set. The ACN on a HAE 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) 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.

(U) In current tactical operations, ground commanders' conduct operations with a situational awareness that measures around 27 percent to 50 percent of ground truth. This uncertainity, often called the 'fog of war' slows down and degrades the quality of command decisions. Radical improvements in gaining situational awareness are necessary for effective tactical operations. The objective of the Command Post of the Future (CPOF) program is 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 will be addressed in order 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 is developing technologies that leverage the expertise of the commander by exploiting and augmenting natural cognitive abilities. The key technologies to be developed are: (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 hardware and software components that can be quickly configured and tailored to various command environments (stationary and mobile), at different echelons of command. The program concludes at the end of FY 2002.

(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 and in a few years Level 2 data will become available. This is insufficient to take full benefit of even current generation weapon accuracies and will continue to

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fall further behind as the weapons navigation and guidance systems improve at a faster pace. In order to overcome this, the Symbiotic Communications program will develop an airborne system that can generate, in real-time, Digital Terrain Elevation Data with a precision commensurate with NIMA defined Level 4. This system will operate in all weather and passively. An additional attribute being explored includes automated terrain categorization that can delineate degrees of wetness and discriminate between fields and trees. In addition, exploration of techniques for using multiple frequencies to achieve enhanced spatial resolution leading to a potential Digital Terrain Elevation Data (DTED) Level 5 precision will be conducted.

(U) The objective of the Battlefield Awareness and Data Dissemination (BADD) Advanced Concept Technology Demonstration (ACTD), which concluded in FY 2000, was to integrate and demonstrate information management and battlefield awareness technologies that allow operational users to easily access and exploit an expanded, massive information flow and for commanders to manage it.

(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. 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 an appliqué for legacy and future emitter systems for joint service utility.

(U) The Advanced Speech Encoding program will investigate the reduction of voice communication bit rates. 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 standard, and maintaining that quality and bit rate in militarily relevant noisy environments. Reliable authentication of the speaker's identity will also be provided. This will be accomplished by directly measuring the glottal excitation function, which, when combined with the information contained in the acoustic data, allows direct computation of the physical vocal tract transfer function. Furthermore, since the physical vocal tract transfer function is

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directly associated with the formation of phonemes, it is possible to recognize the phonemic information in the speech and transmit that thus allowing further data rate reductions. Finally, direct measurement of the vocal excitation waveform potentially provides a unique physiological set of metrics that can be used for speaker authentication.

(U) Program Accomplishments and Plans:

(U) FY 2000 Accomplishments:

- BADD ACTD. ($ 5.432 Million)
  - Completed the integration effort with DISA's products. Fielded BADD/DISA products to selected CINCs six months prior to the end of the ACTD. Continued upgrading capability (based on warfighter input/feedback) to provide a more enhanced version to the CINCs in the latter part of the fiscal year.
  - Provided interfaces that will allow other ACTDs and programs to take advantage of the BADD capabilities.
  - Upgraded the software to be compliant with the DISA next iteration of the DII COE. Transitioned capability to DISA.

- AICE. ($ 1.569 Million)
  - Completed closeout of AICE in concert with BADD ACTD transition.

- Dynamic Database (DDB). ($ 25.590 Million)
  - Continued development of the Ground Moving Target Indicator (GMTI), Signals Intelligence (SIGINT) and Imagery Intelligence (IMINT) Sensor History Database (SHDB) object schema to include pedigrees that automatically map entity-level situation assessments to multi-sensor source data through a scaleable High Performance Data Server (HPDS). Visible Electro-Optic (EO) data was added to the stored data-types.
  - Developed and validated "normalcy models" of GMTI, SIGINT and IMINT data over time. These normalcy models are used to set thresholds in remote sensor "trip wires" at strategic locations in the battlespace. Increased activity in one or more of the sensor types will trigger DDB to invoke algorithms for additional processing and cue operators to perform analysis of situation.
  - Demonstrated DDB component technologies and a loosely coupled system capability with the following results:
    - *System Modeling* - Quantified fusion gain as a function of sensor performance (revisit time, resolution, etc.)
    - *Registration* - proof of concept to automatically perform co-registration of GMTI, SIGINT, SAR, EO and IR data

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- -- *IMINT* - Fusion of SAR and EO object and image change detection.
  - --- 100 times reduction in false alarms for open area conditions.
  - --- Ten times reduction in false alarms for partially obscured targets.
- -- *GMTI* - Five times improvement in track life continuity.
- -- *SIGINT* - Novel techniques for monitoring the battlespace environment.
  - --- Emissions density and profile of militarily significant events with probability of detection of 93 percent / probability of false alarm of ten percent.
  - --- Reconstructed tactical communication networks resulting in 68 percent of links identified.
- -- *Model Based Classifier* - First multi-phenomenology (SAR, EO, IR) processor.
- -- *Target Models* - First DoD common multi-sensor target database containing 33 SAR, 18 EO and three IR targets derived from a common parent CAD model.
- -- *All-source Track and ID Fusion*
  - --- First move-stop-move tracking capability.
  - --- Two to five times reduction in track fragmentation.
  - --- 60 to 90 percent probability of correct association from fused GMTI, SIGINT and IMINT kinematic and identity features.
- -- *Force Level Change Detection* - proof of concept to track and identify a platoon sized group with probability of detection greater than 95 percent and false alarm rate of less than five percent.
- Completed and demonstrated the DDB architecture design in the Component Experimentation and System Integration Laboratory (CESIL).

- Command Post of the Future (CPOF). ($ 14.129 Million)
  - Produced technology in the areas of automated visualization, multi-modal interaction (speech and gesture recognition) automated context tracking, dialog management and cognitive modeling.
    - -- *Advanced Visualization:* Developed new displays of military forces that improve Situational Awareness by from 27 percent to 86 percent of perfect awareness.
    - -- *Collaborative planning:* Developed radical new approach to collaboration that improves Common Situational Understanding from 27 percent to 92 percent perfect team understanding.
    - -- *Collaborative Execution:* Developed new collaborative interaction paradigm that enables parallel monitoring and execution.

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  - *Cognitive Modeling:* refined methodology for cognitive modeling of commanders' internal models of pattern recognition, information filtering, and force monitoring.
  - *Multi-Modal Interaction:* Continued development on multi-level input hierarchy that combines multiple speech and gesture recognizers. Experiments show improvements of recognition from 80 percent to 95 percent accurate.
  - *Dialog Management:* Demonstrated interactive dialog capabilities allowing commanders to query system by visual attribute.
  - *Automated context tracking*: Encoded the mental models captured in the CPOF commander's dialog system, and developed technologies for isolating and tracking cues for indexing the CPOF commander's dialog system.
- Completed the first series of limited objective experiments (LOEs).
- Instituted quarterly CPOF integration experiments to provide a venue for demonstration and assessment of new technologies.
- Initiated the integration environment identified technology components for future inclusion into a mobile, distributed Battle Board system.
- Encoded cognitive visualization principles into a knowledge base; developed tools for extracting and using visualization principles.

- Airborne Communications Node (ACN). ($ 30.169 Million)
  - Down selected two teams for technology enabling payload architecture and development. This architecture will be targeted to operate within the stringent environment of the unmanned aerial vehicles, thereby stressing the packaging technology required to meet the form, fit and function. The payload architecture is modular and scalable, enabling subsets of the full functionality to be transferred to other SWAP-limited platforms.

(U) FY 2001 Plans:

- Dynamic Database (DDB). ($ 5.100 Million)
  - Complete development of registration algorithms to co-register Ground Moving Target Indicator (GMTI), Signals Intelligence (SIGINT), and Imagery Intelligence (IMINT) data to a standard National Imagery and Mapping Agency (NIMA) terrain product - Common Image Base (CIB).
  - Complete algorithm development to use nonlinear techniques for automatic recognition of speakers and parameter characterization of emitters, derivation of tactical communications networks from communications emissions, recognition of new/different vehicular behavior from GMTI and near real time extraction of military objects from multi-spectral imagery.

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- Complete initial capability for object discovery of large numbers of tactically significant ground targets (moving and stationary) over a brigade size area. This capability is achieved by an All-source Track and Identification Fusion (ATIF) algorithm, which automatically builds and maintains position, kinematic and ID features. ATIF unique capability to track targets through multiple move-stop-move cycles will be demonstrated.
- Demonstrate an initial capability to derive force relationships among objects using the Force Level Change Detection (FLCD) algorithm.
- Demonstrate an interactive DDB system-level capability that performs multi-sensor object level fusion using a Kosovo-like data set. All DDB components will be integrated with the High Performance Data Server to show the ability to perform multi-INT change detection to extract objects in clutter, track objects through move-stop-move cycles and determine force relationships.
- Conduct proof of concept experiments integrating components of DDB and AIM technology in a control theoretic framework. Experimentation will deal with management of sensor collections to meet information needs derived from DDB (e.g., ATIF and supporting fusion algorithms) to reduce uncertainty and ambiguity about objects. The result is a net improvement in the tracking and identification of objects. This technology will transition to the Dynamic Tactical Targeting (DTT) program.

- Command Post of the Future (CPOF). ($ 18.033 Million)
  - Continue to develop and integrate new CPOF technology into a complete CPOF commander's dialog system to enable commanders to improve the speed and quality of command decisions to stay ahead of the adversary's ability to react.
  - Integrate and test new versions of the technology components in a series of simulation-based decision experiments.
  - Integrate the most effective technology into a complete CPOF commander's dialog system for an end-to-end demonstration in a simulated joint exercise.
  - Begin preparations for an operational demonstration of the CPOF commander's dialog system in a joint field exercise in FY 2002.

- Airborne Communications Node (ACN). ($ 27.512 Million)
  - Complete development of critical technologies.
  - Verify the critical technologies at the component level.
  - Mature the ACN system architecture to a preliminary design.
  - Conduct laboratory demonstration of critical subsystems.
  - Initiate development of signal processing algorithms to exploit ACN technologies for situational awareness and RF mapping.

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- Conduct "rooftop" measurements to validate situational awareness concepts.

(U) FY 2002 Plans:

- Airborne Communications Node (ACN). ($ 16.048 Million)
  - Verify the system design through simulation and end-to-end laboratory demonstration.
  - Mature the architecture to a critical design.
  - Commence transition of system to services.

- Symbiotic Communications. ($ 21.396 Million)
  - Complete ground experiments for signal and terrain scatter characterization.
  - Complete initial development of range compression algorithms.
  - Complete system analyses and trade studies.
  - Complete planning and hardware development for early flight test.
  - Initiate development of data processing architecture and algorithms.
  - Investigate terrain classification using polarization, spatial and spectral diversity.
  - Investigate high-resolution passive imaging of emitters.
  - Investigate potential platforms and begin hardware optimization process.

- Command Post of the Future (CPOF). ($ 4.676 Million)
  - Complete the final experiments in cognitive principals of visualization, multi-modal interaction, dialog management and command decision-making.
  - Complete technology development of CPOF component technologies of dynamic visualization, multi-modal interfaces and dialog management.
  - Integrate final component technologies and knowledge bases into the final prototype commander's dialog system; qualify system capabilities.
  - Participate in an advanced warfighting experiment using the CPOF commander's dialog system as the primary command interface of the brigade and battalion level.

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- Transition and integrate the CPOF commander's dialog system into the Global Command and Control System (GCCS), the DARPA/Army Future Combat System (FCS) and the Army's Agile Commander testbed.

- Next Generation (XG). ($ 4.000 Million)
  - Initiate CONUS and OCONUS Spectrum Usage Analysis.
    --Military Bands during Force Exercises.
    --Civilian Band ussage in a variety of locales (urban and rural settings).
  - Award Initial technology and systems contracts.
  - Conduct Initial Design Reviews.

- Advanced Speech Encoding (Vocoder). ($ 4.000 Million)
  - Begin development of noise suppression algorithms.
  - Begin development of speaker authentication features and algorithms.
  - Begin development of less than one kb per second vocoder.

(U) Other Program Funding Summary Cost:

- Not Applicable.

(U) Schedule Profile:

Plan	Milestones
Airborne Communications Node:	
Sep 01	System performance review and simulation test results. TRL 4 laboratory demonstration.
Jan 02	System design review incorporating integration plan and physical architecture allocation.
Sep 02	Critical Design Review and TRL 5 laboratory demonstration.

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Command Post Of The Future:

Sep 01	CPOF Comprehensive Experiment Two to run at Fort Hood in warfighting experiment.
Sep 02	Demonstrate Course of Action (COA) level analysis within major Army exercises (e.g., Advanced Warfighter Experiment - AWE).

Symbiotic Communications:

Jul 01	Complete roof top ground experiments.
May 02	Complete terrain scatter studies.
Jun 02	Demonstrate range compression processing.
Apr 03	Complete early flight test.
Jun 03	Demonstrate SAR and DTED level three processing.
Aug 03	Preliminary Design Review for airborne system.

Next Generation (XG):

Nov 02	Initiate spectrum analysis research.
Sep 02	Initial system design, densing, dynamic waveform, sense and adapt technology development contract awards.
Feb 02	Analyze and measure spectrum usage in urban, open and forested environments.

Advanced Speech Encoding:

Mar 02	Performer contract awards.
Sep 02	Complete development of noise suppression algorithms.
Sep 03	Demonstrate less than one kb per second vocoder.