RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)								DATE February 2002	
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research				R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, R-1 #14					
COST *(In Millions)*	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	Cost To Complete	Total Cost
Total Program Element (PE) Cost	310.496	358.494	424.940	410.808	399.724	393.906	397.675	Continuing	Continuing
JASON ST-01	2.509	1.500	0.000	0.000	0.000	0.000	0.000	0.000	N/A
Intelligent Systems and Software ST-11	74.838	80.570	95.500	118.704	104.523	108.250	124.791	Continuing	Continuing
High Performance and Global Scale Systems ST-19	126.227	140.599	200.440	151.967	147.600	115.646	107.509	Continuing	Continuing
Information Assurance and Survivability ST-24	70.908	77.738	51.000	65.555	86.183	100.820	105.537	Continuing	Continuing
Asymmetric Threat ST-28	36.014	58.087	78.000	74.582	61.418	69.190	59.838	Continuing	Continuing

(U) Mission Description:

(U) The Computing Systems and Communications Technology program element is budgeted in the Applied Research Budget Activity because it funds projects directed toward the application of advanced, innovative computing systems and communications technologies.

(U) The JASON project funds an independent group of distinguished scientists and technical researchers that provides analysis of critical national security issues.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2002
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, R-1 #14

(U) The Intelligent Systems and Software project develops new information processing technology to provide fundamentally new capabilities of critical importance for a wide range of national security needs. This will enable advanced information systems (a) to more effectively accomplish computing and decision-making tasks in stressful, time sensitive situations; (b) to become active, autonomous agents/assistants of the warfighter by collecting, filtering, synthesizing and presenting information in a timely and relevant form; (c) to automatically exploit large volumes of speech and text in multiple languages; and (d) to revolutionize human-computer interaction via using spoken and written English and foreign languages.

(U) The High Performance and Global Scale Systems project develops the computing, networking, and associated software technology base underlying the solutions to computational and information-intensive applications for future defense and federal needs. These technologies will lead to successive generations of more secure, higher performance, and more cost-effective microsystems, associated software technologies, advanced mobile information technology and prototype experimental applications critical to defense operations.

(U) The Information Assurance and Survivability project is developing the technology required to make emerging information system capabilities (such as wireless and mobile systems) inherently secure, and to protect DoD's mission-critical information systems against attack upon or through the supporting infrastructure. These technologies will enable our critical systems to provide continuous correct operation even when they are subject to attack, and will lead to generations of stronger protection, higher performance, and more cost-effective security and survivability solutions scalable to several thousand sites.

(U) The Asymmetric Threat project addresses one of our Nations' most serious threats. They are not threats of a conventional, force-on-force engagement by an opposing military, but threats of an unconventional yet highly lethal attack by a loosely organized group of transnational terrorists or other factions seeking to influence U.S. policy. The goal of this project is to develop technological capabilities and a suite of tools to better detect and prevent attacks upon our critical DoD infrastructures.

(U) **Program Change Summary:** (*In Millions*)	**FY 2001**	**FY 2002**	**FY 2003**
FY02 Amended President's Budget	330.722	382.294	332.374
Current Budget	310.496	358.494	424.940

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2002
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, R-1 #14

(U) Change Summary Explanation:

FY 2001 Decrease reflects reprogramming of the Software Engineering Technology funding (Project ST-22) to OSD, the SBIR reprogramming and minor program realignments.

FY 2002 Decrease reflects congressional program reductions partially offset by congressional adds for RTAP, Systems Engineering for Miniature Devices, and Secure and Dependable Software.

FY 2003 Increase reflects expansion of Responsive Computing Architecture work in Project ST-19 and Asymmetric Threat programs in Project ST-28.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)								DATE February 2002	
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research				R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-01					
COST *(In Millions)*	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	Cost to Complete	Total Cost
JASON ST-01	2.509	1.500	0.000	0.000	0.000	0.000	0.000	0.000	N/A

(U) Mission Description:

(U) This project supports the JASON, an independent group of distinguished scientists and technical researchers that provides analysis of critical national security issues. JASON membership is carefully balanced to provide a wide spectrum of scientific expertise and technical analysis in theoretical and experimental physics, materials, information sciences, biology and other allied disciplines. The JASON process ensures that senior government leaders have the full range of U.S. academic expertise available on issues critical to national security involving classified and unclassified information.

(U) Program Accomplishments and Plans:

(U) FY 2001 Accomplishments:

- JASON. ($2.509 Million)
  - Continued studies of interest to DoD in multiple disciplines such as: counter proliferation of chemical and biological weapons; advanced space based systems; advanced computing; multi-layered infrastructure defense; advanced sensor technologies; dispersed land forces technology; battlefield information systems and military communications; ultra low power electronics; and advanced signal processing.

(U) FY 2002 Plans:

- JASON. ($1.500 Million)
  - Continue studies of interest to DoD in multiple disciplines such as: defense against bio-warfare and protection from information attack; operational dominance concepts, including, affordable precision targeting, mobile distributed communications, and future warfare concepts; advanced space based systems; sensor technologies; battlefield information systems; advanced computing; rocket

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2002
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-01

and launch technologies; supersonic laminar flow; signal processing; and the intersection of biology, information and physical systems.

(U) FY 2003 Plans:

- Not Applicable

(U) Other Program Funding Summary Cost:

- Not Applicable.

(U) Schedule Profile:

- Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)								DATE February 2002	
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research				R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-11					
COST *(In Millions)*	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	Cost to Complete	Total Cost
Intelligent Systems and Software ST-11	74.838	80.570	95.500	118.704	104.523	108.250	124.791	Continuing	Continuing

(U) Mission Description:

(U) This project develops and applies new software database management, and human computer interaction technologies to provide fundamentally new capabilities of critical importance for a wide range of national security needs. This will enable advanced information systems (a) to automatically exploit large volumes of speech and text in multiple languages; (b) to revolutionize human-computer interaction via using spoken and written English and foreign languages; (c) to more effectively accomplish computing and decision-making tasks in stressful, time sensitive situations and; (d) to become active, autonomous agents/assistants of the warfighter by collecting, filtering, synthesizing and presenting information in a timely and relevant form. A major initiative to provide the software necessary for high-end computing needs that are unique to future DoD requirements is also being funded. The project contains two thrusts: Human Language Technology and Software for Situational Analysis. In addition, other stand-alone efforts are being funded: High Confidence Composing Architectures, DARPA Agent Markup Language, Taskable Agent Software Kit, Comparable High Assurance Trusted Systems, Rapid Analytic Wargaming and DefenseNet:

(U) The **Human Language Technology** thrust is comprised of two programs involving human-machine communication -- Communicator and Babylon -- and four efforts involving human-human communication -- Translingual Information Detection, Extraction and Summarization (TIDES), Effective Affordable Reusable Speech-to-Text (EARS), Multispeaker Environments (MUSE), and Global Autonomous Language Exploitations (GALE).

Situation Presentation and Interaction:

- The Communicator program is creating a dialog-based information interface that allows warfighters to acquire theater information, order logistical support, or obtain mission planning execution information without the need for a second human in the information loop. The dialog-based system has a scalable interface that allows the warfighter to accomplish the tasks (e.g. receive orders, reammunition, identify the threat unit to their immediate front) regardless of skill level. The system supports the warfighter without access to a computer screen, keyboard or mouse. In fact, the warfighter does not even need a computer system at all. Early prototypes of the Communicator have impressed Service users. Communicator will specifically deliver a dialog-

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2002
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-11

based logistics ordering system for the USMC (logistics management at the tactical level), a maintenance assistant for F-18 ground crews at Patuxent NAS, and a shipboard C2 and status system for the USS SEA SHADOW.

- Babylon provides the tactical warfighter with real-time, face-to-face speech translation during combat and humanitarian operations in foreign territories. The program addresses domain-specific translation accuracy and response time. Rudimentary versions of the program relying on simple dictionaries and phrases have been deployed on a test basis in Afghanistan. Future versions will offer most flexible and fluid translation capability that will be more conducive to normal human speech.

Automated Exploitation of Speech and Text in Multiple Languages:

- Translingual Information Detection, Extraction and Summarization (TIDES) aims to revolutionize the way time-critical intelligence is obtained from speech and text, dramatically increasing the quantity, quality, and timeliness of reporting. TIDES is developing impressive new technology to enable English-speaking operators and analysts to exploit the huge amounts of speech and text that are available electronically but currently unexploitable due to vast volumes or insufficient foreign language skills. This will enable commanders to carry out critical missions and protect U.S. forces around the world. TIDES is creating powerful new capabilities for Detection (finding or discovering needed information), Extraction (pulling out key information), Summarization (substantially shortening what a person must read), and Translation (converting foreign language material to English).

- Effective Affordable Reusable Speech-To-Text (EARS) will create speech-to-text (automatic transcription) technology whose output is substantially richer and much more accurate than currently possible. EARS is a passive listening technology focusing on the most critical languages and media for a wide range of national security applications. It will enable effective automatic detection, extraction, summarization, and translation from broadcasts and telephone conversations. One follow-on program is planned to build on the accomplishments of EARS -- Multiple Speaker Environments (MUSE). MUSE will focus on producing readable transcripts from multi-party speech from command centers and meeting rooms. A second follow-on program -- Global Autonomous Language Exploitation (GALE) will develop techniques for discovering critical intelligence by autonomously exploiting large volumes of streaming speech and text in multiple languages. GALE is intended to exploit the value of information products generated by EARS and TIDES.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2002
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-11

(U) Two complementary efforts are budgeted in the **Software for Situational Analysis** thrust: the Information Management Program and the Rapid Knowledge Formation program.

- The Information Management (IM) program increased the productivity of the Defense analyst by offering high performance retrieval, search and data extraction. The IM program developed algorithms and tools for clustering, classifying, visualizing, navigating and extracting critical data from extreme high volume sources based on an analysis of the meaning of information content of the information sources.

- The Rapid Knowledge Formation (RKF) program objective is to enable subject matter experts who are not Artificial Intelligence (AI) experts to build, share, and reuse large knowledge bases. RKF technologies will be evaluated in challenge problem experiments in microbiology and tactical ground combat. Technology challenges include direct knowledge entry by non-AI experts, coordinating entry of possibly overlapping and inconsistent knowledge by geographically distributed individuals, and achieving a knowledge entry rate (without AI training) of twice that of today's AI expert. The large knowledge bases (10^6 axioms) created by RKF are need for such complex problems as the detection and identification of evasive and concealed targets, offensive and defensive information operations, and Weapons of Mass Destruction (WMD) capability assessments of terrorist organizations. By the end of the RKF program, a number of sets of knowledge engineering and development tools will be provided to DoD and government organizations to be incorporated into their intelligence and warfare analysis systems. In addition, the new High Precision Knowledge Formation (HPKF) initiative will develop tools to build rich, complex, highly specialized knowledge bases needed to support precision tactical operations. Ground warfare tactics exhibit great variety and complexity, and depend greatly on complex relationships between natural and man-made elements of the battlefield. HPKF will develop tools to construct, maintain, and update knowledge about terrain features, mobility factors, sensor characteristics, weapons effects, and engagement tactics in combat situations ranging from desert warfare through infantry operations in jungle to urban combat. It will enable automated forces and planning systems to achieve precision engagement of hostile ground forces, both mechanized and dismounted.

(U) The High Confidence Computing Architectures program will provide a new generation of high-end high confidence computing systems for the national security and industrial user community (2007 – 2010). HCCA will address a number of critical technology barriers over the next decade: (1) extensibility of Moore's Law; (2) software availability/reliability of large scale computing systems; (3) integral hardware, software, application robustness; (4) intrusion resistance; (5) run-time software brittleness; (6) time-to-solution; and (7) cost of developing, operating, and maintaining DoD national security applications. This program, in conjunction with a complimentary high productivity computing system program

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2002
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-11

funded under this program element in Project ST-19, will create a new generation of high confidence computing systems characterized by balanced system architecture including high effective bandwidth, robust implementation, and responsive software/hardware components. These new systems will address on-going software challenges that confront both development and use of current high-end systems and applications, such as programming productivity, performance, portability, scalability, reliability, and tamper resistance. This effort has direct and crucial importance to national security and the intelligence communities.

(U) The DARPA Agent Markup Language (DAML) program will develop technologies to enhance interoperability among intelligence and combat information systems. It will extend the framework of the World Wide Web to go beyond documents and include active sensors, software tools, and databases, thus enabling agent-based software to exchange information automatically. DAML will develop a language to characterize software agents in machine-readable semantics (ontology), describing their data needs, data products, and services supplied. DAML will be demonstrated in operational environments, including both intelligence analysis (InteLink) and tactical battle management. The result will be new abilities to integrate, automatically, information across a variety of heterogeneous military sources and systems. In addition, the new DARPA Intelligent Software Toolkit (DIST) initiative will provide a set of tools to transform existing intelligence and command/control software to operate in network-centric computing environments, using DAML ontologies and service descriptions. Without automated tools, the cost of bringing older software systems into network-centric computing environments will be prohibitive. Tools will correlate application-specific ontologies to shared database schema, construct translators from application data structures to database schema, and build mediators that convert product streams from publishers to subscribers. The tools will be prototyped and evaluated within existing C4ISR support systems that contain high data-rate signal processing, sensor exploitation, and engagement planning applications.

(U) The Taskable Agent Software Kit (TASK) program will develop tools for the construction and analysis of multi-agent systems that realize a global objective through local decisions based on embedded models of the mission, the environment, and interaction with other agents. These synthesis and analysis tools will provide a sound, common engineering foundation for the development and deployment of high confidence agent-based computing solutions to a spectrum of military problems requiring robust, scalable, decentralized approaches in dynamically changing environments. While many agent-based systems are currently being built to support militarily relevant applications such as information retrieval and logistics, development methods are ad hoc and little is understood about how to engineer desirable global behaviors from local, autonomous actions and decisions or about how to mitigate and contain potentially undesirable emergent behaviors, particularly in highly dynamic and uncertain environments. This effort will explore methods derived from Control Theory, Decision Theory, and Operations Research for correctly modeling and building agent-based systems. Experiments will reveal the qualitative aspects of environments that favor the use of agent-based systems over conventional, centralized approaches. Beginning in FY 2002, the program will focus on surveillance and targeting missions for cooperative autonomous vehicles.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2002
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-11

(U) The Composable High Assurance Trusted Systems (CHATS) program is developing the tools and technology that enable the core network services to be protected from the introduction and execution of malicious code or other attack techniques and methods. These tools and technologies will provide the security services needed to achieve comprehensive-secure, highly distributed, mission-critical information systems for the DoD. A unique feature of CHATS is that these system capabilities will be developed by engaging the open-source community in security functionality for existing open-source operating systems. Additionally, DARPA will engage the open-source community in a consortium-based approach to create a "neutral", secure operating system architecture framework. This security architecture framework will then be used to develop techniques for composing OS capabilities to support both servers and clients in the increasing network-centric communications fabric of the DoD. In FY 2003 the CHATS program will move to project ST-24 in this program element.

(U) The goal of the Rapid Analytic Wargaming (RAW) program is to develop a faster than real-time analytical simulation to support U.S. readiness for both symmetric and asymmetric missions in the operational, analytical and training domains. The program will develop technologies to generate a full spectrum of known and emergent behaviors that will expand existing tools developed for more conventional conflict simulation to more realistically portray and project today's asymmetric threats.

(U) The objective of DefenseNet (DNET) is to dramatically increase the robustness, security and performance of the DoD information infrastructure by exercising architectural options based upon optical network components. The current Internet packet/router "connectionless" network architectures and fragile protocols no longer satisfy minimal DoD requirements either for security (e.g. the lack of attribution) or for performance (Quality of Service, Bandwidth). Recent advances in optical communications components and networks, driven by huge commercial investments in the past few years, have presented the DoD with a unique opportunity to rethink and deploy modern optical-based networks to meet its future mission needs. These new architectures promise inherently secure, symmetric (peer to peer) communications with bandwidths of 1000 times current DoD infrastructures. DefenseNet is budgeted in project ST-28 in FY 2002.

(U) Program Accomplishments and Plans:

(U) FY 2001 Accomplishments:

- Situation Presentation and Interaction. ($14.969 Million)
  - Demonstrated and evaluated dialogue performance for USMC small unit logistics; completed a complex travel task requiring negotiation twice as fast with automated service support as with the best human assistance.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2002
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-11

- Demonstrated and evaluated interaction of tasks with real-time, web-based, public data.
- Demonstrated in-vehicle dialogue for information services and navigation.

- Intelligent Software for Multi-lingual and Coalition Environments. ($21.513 Million)
  - Demonstrated ability to speed up the selection of valuable stories from news broadcasts (9-fold improvement).
  - Created a first generation text and audio processing system for integrating and evaluating additional capabilities.
  - Conducted a successful integrated feasibility experiment in the area of bio-security with Third Fleet personnel.
  - Conducted an initial evaluation of summarization technology.

- DARPA Agent Markup Language (DAML). ($14.496 Million)
  - Completed DAML language specifications.
  - Released working version of Briefing Tool for Intelink.
  - Released working version of DAML Search Tool on Intelink.
  - Released working version of DAML Ontology Creation Tool on Intelink.
  - Defined requirements to DAML for supporting non-pre-planned Agent interoperations.
  - Demonstrated utility of DAML Ontology Creation Tools to enhance the storage, access and organization of archival information at the Center for Army Lessons Learned.
  - Investigated alternative approaches to composable, high assurance, trusted systems based on the Robust Open Source development model.
  - Investigated the feasibility of and alternative approaches to high assurance trusted implementation languages and tools.
  - Investigated alternative approaches to development of both the high assurance trusted system protection profiles and the high assurance languages and tools.

- Taskable Agent Software Kit (TASK). ($4.750 Million)
  - Defined metrics for analysis of agents in the C4I military environment.
  - Performed agent-design method experiments.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2002
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-11

- Reuse Technology Adoption Program (RTAP). ($2.780 Million)
  - Developed an enhanced business model for software development.
  - Explored infrastructure characteristics needed to host a true "Global Information Grid."
  - Experimented on integrating specification-based testing with architecture specifications.

- Software for Situational Analysis. ($16.330 Million)
  - Deployed scalable prototype analysis environment in defense application with the ability to perform analysis across multiple repositories of information (including retrieval based on meaning, indexing, filtering based on relevance to user task, user defined alerting, and categorizing).
  - Demonstrated secure, distributed, repository architecture supporting digital objects of arbitrary type.
  - Developed and conducted user-centered value-added evaluation.
  - Demonstrated direct knowledge entry by a novice (2K axioms/month) for a military problem.

(U) FY 2002 Plans:

- Situation Presentation and Interaction. ($13.719 Million)
  - Communicator.
    -- Finalize and present to the dialog and speech communities, the evaluation protocols and metrics for heterogeneous human computer dialog systems.
    -- Transition Small Unit Logistics prototype to USMC for continued refinement and limited production in support of the Small Unit Logistics ACTD and the Commandants Warfighter Laboratory at Marine Corps Base Quantico.
    -- Define and publish final (release) version of the Galaxy-Communicator 4.0 hub architecture for general use in the dialog systems development community.
    -- Finish evaluation of commercial "smart-phone" technology vs. military-specific prototypes for cost, ruggedness, and other selection-based criteria.
    -- Conduct proof of concept demonstration of Communicator technology on the USS SEA SHADOW and with F-18 maintenance crews.
    -- Evaluate a follow-on research program for dialog systems.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2002
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-11

-- Promote standardization with the Galaxy-Communicator architecture through the World-Wide-Web-Consortium Voice Browser Group (W3C-VB).

– Babylon.
-- Establish baseline hardware design for handheld translation technology.
-- Upgrade DARPA one-way technology to limited two-way translation.
-- Initial software decision approvals for full-featured DARPA two-way translation.
-- Multi-lingual data collection: Pashto, Dari, Farsi, Arabic, Mandarin, and two languages to be determined (for contingency operations).
-- Production of prototype hardware handheld devices for field evaluations and acceptance.
-- Initial coordination with U.S. Army PM Soldier for software integration into land warrior Block III (version 3.0).

- Automated Speech and Text Exploitation in Multiple Languages. ($22.071 Million)
  – Translingual Information Detection, Extraction and Summarization (TIDES).
  -- Demonstrate ability to detect and track events described in English and Chinese news sources.
  -- Create an initial capability to process Arabic text and audio sources.
  -- Demonstrate ability to extract key information (about people, places, organizations, and relationships) from English sources.
  -- Conduct an initial evaluation of machine translation technology.
  – Effective Affordable Reusable Speech-To-Text (EARS).
  -- Launch effort to develop automatic techniques to produce rich, readable transcripts of broadcasts and telephone conversations in English, Chinese, and Arabic.

- Software for Situational Analysis. ($12.026 Million)
  – Rapid Knowledge Formation.
  -- Demonstrate knowledge entry rate of 50K axioms/month from each of 25 subject matter experts in a biowarfare challenge problem.
  -- Assess multi-user (25-50 individual) system design.
  -- Resolve scaling bottlenecks.
  -- Create complex theories using undergraduate biology and medical curricula.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2002
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-11

- High Confidence Computing Architectures. ($4.000 Million)
  - Initiate industry concept studies in high confidence computing and critical technologies required to realize a high productivity computing system to support critical DoD high capability computing missions in the latter part of this decade.
  - Initiate assessment of critical technology barriers, such as system robustness and brittleness, for high-end systems to be implemented in the latter part of this decade.

- Composable High Assurance Trusted Systems (CHATS). ($6.400 Million)
  - Develop an operational prototype of the Composable High Assurance Trusted System.
  - Develop operational capability of candidate high assurance trusted implementation language and tools.
  - Validate the CHATS for resistance to malicious code and other system attack techniques and methods.
  - Investigate the range and alternative high value applications and services needed and required to interoperate with the composable high assurance technology.
  - Develop protection profiles for the preferred applications and services.
  - Investigate alternative approaches to lifecycle management for the high assurance trusted operating systems technology; identify the best alternatives.

- DARPA Agent Markup Language (DAML). ($14.737 Million)
  - Define toolset for C2 application of DAML technologies.
  - Perform experimental analysis of Intelink DAML Briefing Tools.
  - Deploy DAML Search Tool on operational Intelink node.
  - Demonstrate Prototype DAML Ontology Creation Tool for web applications for the Military and National Intelligence Community.
  - Prototype selected DAML tools to enhance search and retrieval tools at the Center for Army Lessons Learned.
  - Conduct experimental analysis of DAML applications for naval and joint C2 interoperability including participation in Millennium Challenge.
  - Create repository of over 1,500,000 DAML statements on World Wide Web for experimental evaluation and design.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2002
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-11

- Taskable Agent Software Kit (TASK). ($5.617 Million)
  - Publish initial design and analysis techniques in two of the original three focus domains: (a) control and analysis of autonomous vehicles in dynamic environments and (b) decentralized, competitive resource allocation for logistics.
  - Perform final empirical validation experiments in competitive resource allocation and initial integration experiments in command and control domain.
  - Define consolidated evaluation scenario and series of challenge problems in surveillance and targeting.

- Reuse Technology Adoption Program (RTAP). ($2.000 Million)
  - Explore peer-to-peer communication models in context of military requirements.
  - Experiment with technologies for developing/evolving coalitions of software components.

(U) FY 2003 Plans:

- Situation Presentation and Interaction. ($13.405 Million)
  - Communicator.
    -- Transition Communicator technology to services based on proof of concept results. Communicator follow-on
    -- Publish multi-modal specification of the Galaxy-Communicator architecture.
  - Babylon.
    -- Integrate speech recognition engines into natural language parsers and translators.
    -- Distribute multilingual corpus to R&D community.
    -- Receive feedback from evaluators on DARPA two-way technology (deliver patches and fixes); units remain in operational use.
    -- Deliver upgraded handhelds (capable of supporting two-way technology) to software developers.
    -- Delivery of "alpha" versions of DARPA two-way software for initial user testing.
    -- Final languages selected for development.
    -- Language digital resource repository populated at Defense Language Institute (DLI).

- Automated Speech and Text Exploitation in Multiple Languages. ($22.095 Million)
  - Translingual Information Detection, Extraction and Summarization (TIDES).

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2002
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-11

-- Define architecture for a unified text and audio processing system that integrates Translingual Information Detection, Extraction and Summarization technologies.
-- Demonstrate ability to extract key information from Chinese or Arabic sources.
-- Demonstrate initial machine translation capability from Chinese to English.
-- Demonstrate ability to port capabilities to another language within three months.
-- Improve the performance of the enriched automatic speech transcription algorithm.

– Effective Affordable Reusable Speech-To-Text (EARS).
-- Create, demonstrate, and evaluate prototype system for producing rich transcripts from broadcasts in English, Chinese, and Arabic.

– Multispeaker Environments (MUSE) and Global Autonomous Language Exploitation (GALE).
-- Launch effort to develop automatic techniques to produce rich, readable transcripts of multiparty speech from command centers and meeting rooms.
-- Initiate multifaceted effort to develop techniques for discovering critical intelligence autonomously, exploiting huge volumes of streaming speech and text in multiple languages.

• Software for Situational Analysis. ($ 12.750 Million)

– Rapid Knowledge Formation.
-- Demonstrate building and use of an integrated knowledge base of 1 million axioms in less than one year.
-- Conduct Biowarfare challenge problem and develop proof-of-concept knowledge base in coordination with end users for transition purposes.

– High Precision Knowledge Formation (HPKF).
-- Evaluate ability of 1 mega-axiom knowledge base to support high-fidelity problem solving methods for situation awareness and tactical command and control.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2002
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-11

-- Define tactical air/ground combat challenge problem, select external decision aids, and prototype export/import of knowledge with those aids.

- High Confidence Computing Architectures. ($11.990 Million)
  - Perform industry concept and critical technology review for target high confidence system in the (2007 – 2009) time frame.
  - Perform university-oriented critical technology assessment and concept evaluation for target systems in the (2007 – 2009) time frame.
  - Release alpha system level confidence metrics and benchmarks to guide future program research and development activities.
  - Initiate multi-year research activities in high confidence computing systems.

- DARPA Agent Markup Language (DAML). ($11.510 Million) Deploy DAML-based technology to other intelligence service providers.
  - Prototype suite of DAML tools to enhance the storage, access and organization of archival information at the Center for Army Lessons Learned.
  - Deploy DAML tools as infrastructural support for naval and joint C2 interoperability.
  - Prototype DAML tools as infrastructural support to enhance the use of agents for coalition warfare command and control.

- DARPA Intelligent Software Toolkit (DIST). ($7.750 Million)
  - Prototype suite of additional tools to encapsulate legacy software to support DAML ontologies, logics, and service descriptions.
  - Build example mediators to convert data among DAML ontologies, referencing external knowledge bases as necessary.

- Taskable Agent Software Kit (TASK). ($9.000 Million)
  - Deploy initial agent-creation tools with predictable behaviors based on mathematical techniques for modeling and analyzing agent behavior.
  - Evaluate agent design techniques on initial challenge problems in surveillance.
  - Implement a framework for composing multiplayer games include those that are static, dynamic, and repeated games with uncertainty.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2002
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-11

- Rapid Analytic Wargaming. ($4.000 Million)
  - Establish operational testbeds in conjunction with one or more transition partners (Joint Forces Command (JFCOM), Joint Staff, and others).
  - Derive scalable abstract behavioral framework baseline to facilitate the identification and reuse of key military concepts across a broad context and multiple force structures and missions.
  - Develop hybrid gaming technologies that rapidly generate known and emergent behaviors and decisions for asymmetric scenarios based on historical and current context.
  - Test initial gaming technologies against both existing analytical tools and recent-world scenarios.

- DefenseNet. ($3.000 Million)
  - Identify and select initial prototype network, infrastructure exercising architectural options, test QoS and performance
  - Expand testbed activities to test scaling of DNET bandwidth to endpoint devices of single streams in the range of 10-40Gb/sec.
  - Examine the options for tethering of DoD wireless communications networks from the DNET backbone.

(U) Other Program Funding Summary Cost:

- Not Applicable.

(U) Schedule Profile:

- Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)								DATE February 2002	
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research				R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-19					
COST *(In Millions)*	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	Cost to Complete	Total Cost
High Performance and Global Scale Systems ST-19	126.227	140.599	200.440	151.967	147.600	115.646	107.509	Continuing	Continuing

(U) Mission Description:

(U) This project develops the computing, networking, and associated software technology base underlying the solutions to computational and information-intensive applications for future defense and federal needs. These technologies will lead to successive generations of more secure, higher performance, and more cost-effective microsystems, associated software technologies, advanced mobile information technology and prototype experimental applications critical to defense operations. The project is comprised of four primary components in FY 2003 - - Networking, Responsive Computing Architectures, Network Embedded Technology, Autonomous Systems Control and Augmented Cognition - - plus two stand alone efforts: the Mixed Initiative Control of Automa-Teams and the Intelligent Micro-Systems Technology program.

(U) The **Networking** component is developing new paradigms in networking technologies to meet the future defense and national security needs. The aim is to create highly robust and rapidly configurable networking capabilities essential for both secure national infrastructure and ad-hoc military networks through key innovations in software and hardware technologies. The results will be applicable to wired, wireless and mixed networks. The Networking component is comprised of Network Modeling and Simulation, Active Networks, Ultra High-Performance Networking, and Coordinated Large Scale Network.

- The Network Modeling and Simulations (NMS) program (formerly Active Management and Control) will develop tools to address the challenge of predicting the end-to-end and internal behavior of complex networks over a broad range of time scales, network sizes and composition. New models and simulators will enable reliable and rapid planning, design, analysis and configuration of military and emergency networks with minimal manual intervention.

- The Active Networks program (formerly Active Management and Control) investigates the use of smart packet processing to enable new strategies in rapid network service introduction and enhancement. Active network-based authentication mechanisms will enable highly dynamic access control not possible with today's IP infrastructure.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2002
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-19

- The Ultra High-Performance Networking Program is advancing transparent all-optical networking and gigabit wireless techniques to dramatically enhance bandwidths available to end-applications. Gigabit end-speeds are essential for a multitude of defense applications involving distributed processing of sensor outputs. All-optical self-healing architectures are also being developed as a part of a concerted effort to create high-confidence networking infrastructure. New paradigms in wireless link techniques are also being explored to make possible robust networking in complex, harsh environments.

- The Coordinated Large Scale network (CLSN) program seeks to develop technology that will support a 1,000,000 node coordinated network that will function in real-time. This technology will enable self-adjusting networks for such application as high resolution, high fidelity reconnaissance and surveillance with a resolution of 12mm.

(U) The **Responsive Computing Architectures** component is bringing needed flexibility to DoD systems. It is developing integrated computing subsystems that will respond in real-time to dramatic changes in mission application requirements and operating constraints based on the mission-of-the-day. The current projects are focused on energy/power management, quality of service, and algorithm/application computing diversity and scalable computing efficiency. This technology has direct and significant impact for military systems such as the Land Warrior/Objective Force, ground and airborne autonomous devices, distributed sensors, space sensors, and intelligence collection ground systems. The Responsive Computing Architecture component is comprised of Power Aware Computing and Communications, High Productivity Computing Systems, Thermodynamics of Randomized Computing, Network-Centric Infrastructure for Command, Control and Intelligence, Adaptive Computing Systems, and Quorum.

- The Power Aware Computing and Communications (PAC/C) program is developing an integrated software/hardware power management technology suite comprised of novel techniques that may be applied at all levels of a system from the chip to the system level. Embedded military computing systems such as future Land Warrior systems, autonomous devices, distributed sensors, and space sensors have extreme dynamic computational and energy requirements. PAC/C will enable embedded computing systems to reduce energy requirements by ten to one hundred-fold for energy constrained military applications ranging from hand-held computing devices to unmanned aerial vehicles.

- The High Productivity Computing Systems (HPCS) program will provide the DoD with significant technology and capability advancements for the national security and industrial user communities by filling a high-end computing gap between today's late 1980's based technology High Performance Computing (HPCs) systems and the promise of quantum computing. This program is targeting high-

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2002
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-19

end computing, medium to long term, national security missions where U.S. superiority and security is threatened, according to two recent DoD studies. The proposed technology development plan is part of a three-phase program, in conjunction with the high confidence research component (Project ST-11) that will extend up to the end of this decade. The three phases are concept study, research and development (R&D), and full-scale development. Early identification of high-end computing application computing requirements, metrics, and performance prediction tools will be used through out the program to assess both technical and schedule progress. As an example, performance (efficiency) for critical national security applications will be improved by a factor of 10X to 40X.

- The Thermodynamics of Randomized Computing program is a revolutionary approach to energy reduction based on the fact that randomized algorithms, because of their associated error probability, allow computing with greater uncertainty or (thermodynamic entropy than corresponding deterministic algorithms) and hence consume less energy. This program will provide an early proof-of-concept of the proposed novel idea from an energy perspective.

- The Network-Centric Infrastructure for Command, Control and Intelligence (NICCI) program is developing technologies to automatically create virtual work centers, called "habitats," that can bring together the right combination of people, computer systems, robots, and data to accomplish a specific set of tasks. These habitats can be dynamically reconfigured because they are "aware" of the interrelated combat conditions and the context of the environment. New technologies will be developed to allow the warfighter, at any level of command, to rapidly assemble a habitat that addresses the needs of a specific task e.g., geographic situation awareness, or command interfacing with coalitions.

- The Adaptive Computing Systems (ACS) program allowed DoD to develop a wide variety of specialized systems by reusing a relatively small set of hardware designs, each of which can be affordably produced in high volumes. Much of the technology developed under ACS was transitioned to the application focused Mission Specific Processing (MSP) program funded under PE 0602702E, Project TT-06, Advanced Tactical Technology.

- The Quorum program (formerly Systems Environments) developed, reusable software capabilities and tools that can be customized easily by programmers to meet the demanding scalability and dependability requirements of network-centric combat systems, such as shipboard computing environments, avionics mission computing systems, and anti-aircraft defense. Quorum technologies are the foundation for two key open architecture initiatives: (1) Aegis Baseline 7 Phase II, the new open architecture for the Aegis Weapons System and (2) extension of Boeing's Bold Stroke avionics architecture for the F-15 to allow cross-platform coordination across tactical networks in

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2002
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-19

support of time-critical retargeting. In both cases, Quorum's quality-of-service middleware and resource management technologies allow satisfaction of mission-critical requirements on an evolving commercial off-the-shelf technology base, reducing development and life-cycle costs. In addition, Quorum has allowed DoD system integrators to keep short life span computation systems (2-5 year lifespan) current and effective in platforms with far longer service lives (20 plus years).

(U) The **Network Embedded Technology** component will develop software technology to build distributed, real-time, and embedded applications, ranging from tens of computing nodes to over a million. Each program is driven by carefully selected Open Experimental Platforms (OEPs) to facilitate the continuous evaluation of progress and end-user influence. By using major theoretical breakthroughs during the past decade in hybrid systems, statistical physics, finite-size scaling, generative programming, and distributed control, the programs have solid foundation to achieve the ultimate goal of revolutionizing how software-intensive embedded platforms are built for the DoD. The Network Embedded Technology component is comprised of Networked Embedded Systems Technology and Program Composition for Embedded Systems.

- The Networked Embedded Systems Technology (NEST) program will provide robust coordination and synthesis services subject to extreme timing, power, and resource constraints for networked embedded systems. With the coming wave of MEMS-based fine-grain distributed control applications, "smart" structures for active acoustic and structural damping and large space-antennas built with Gossamer structures impose great technical challenges. These applications contain at least 100,000 simple computing nodes. NEST is about unprecedented scaling. If successful, the reusable code-base, tools and reference applications delivered by the program, will dramatically simplify the software development task in a wide range of future weapon systems. If not done, application developers will need to constantly reinvent theoretically involved and computationally complex solutions for embedded subsystem coordination and synthesis, which cannot provide sufficient guarantees for predictable behavior of large-scale systems.

- The Programmable Composition of Embedded Software (PCES) program is developing technology to support faster, more reliable development of software for distributed embedded software for intelligent systems. This technology will enable programmers to safely and productively integrate so-called "cross-cutting" aspects, such as concurrency, synchronization, security, and memory management, along with the core functionality that implements intelligent software interaction with a diverse suite of sensors and actuators in real-time. If successful, the reusable code-base, tools and reference applications delivered by PCES will leverage human effort to rapidly produce higher-quality, more adaptable software. It will also assure that the resulting software achieves required properties and will enable the production of high-confidence military systems that fundamentally depend on software operation.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2002
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-19

(U) The **Autonomous Systems Control** component will develop the tools necessary to deploy, control and coordinate the full spectrum of autonomous system resources effectively and efficiently in order to ensure mission success. DoD systems are rapidly becoming hybrids, incorporating both humans and autonomous system components such as robots and software agents; how the software will achieve that integration is the subject of this component. The Autonomous Systems Control component is comprised of Autonomous Negotiation Teams and Autonomous Software for Learning Perception & Control.

- The Autonomous Negotiation Teams (ANTS) program (formerly Mobile Code Software) will develop the software technology to resolve time-critical constraints in logistics and mission planning. The resource management problem will be solved via the interaction of lightweight, mobile software components using a bottom-up organization approach and negotiation as techniques for resolving ambiguities and conflicts. The technology will enable designers to build systems that operate effectively in highly decentralized environments, making maximum use of local information, providing solutions that are both good enough, and soon enough.

- The Autonomous Software for Learning Perception & Control program will program autonomous mobile robots to independently perform a variety of military tasks in a diverse spectrum of complex, dynamic environments. The goal is to achieve validated performance at near-human levels in a full range of real-world environments for perception-based autonomous vehicle driving/navigation and effective interaction of robots with humans. This program is pursuing several alternative approaches to augment pre-programmed activities and responses with powerful learning-derived competencies for perception and control analogous to those of biological systems. In other words, this software will enable autonomous systems to modify their behavior in response to real-world situations or barriers. Integrated perception, including fusion of data from multiple sensor and multiple processing modalities of the same data will reduce operator intervention and achieve semi-autonomous operation. The result will be highly capable robots that can learn new tasks and adapt quickly to new environments with minimal programming effort, with numerous applications in the battle space of the future.

(U) The **Augmented Cognition** component focuses on developing technologies to augment the warfighter's cognitive capacity and capabilities. This new area for expanding human capability seeks to augment human cognition and performance in the way that weapons, vehicles and sensors extend human abilities. The hypothesis of this emerging field is the impressive progress in neural science, computation and miniaturization can now be leveraged to enable new concepts of warfare. The Augmental Cognition component contains two efforts: Augmented Cognition and the Perceptual Processing Display program.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2002
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-19

- The Augmented Cognition (AugCog) program will develop the means to measure a subject's cognitive state in real time and manipulate it to accomplish the functions. The goal of the Augmented Cognition program is to develop methods that integrate digital devices that support memory, perception, and thinking, and link that support with the user's context state information to directly improve the overall cognitive performance of the warfighter.

- The Perceptual Processing Display program focuses on exploiting neuroscience and perceptual processing technologies to redesign devices that deliver information to the human perceptual system. These new devices will be able to extract relevant signal from extraneous background noise, through perceptual modeling. This program will develop technologies that simplify relevant, and eliminate irrelevant, information to improve perception, comprehension, memory, inference, and decision-making. Specifically, this program will demonstrate the manipulation of perceptual data along hundreds of dimensions of the human perceptual system, and will result in the doubling of human information processing performance.

(U) The Mixed Initiative Control of Automa-teams (MICA) program is developing algorithms, software, modeling and simulation capabilities to perform multi-level planning, assessment and control of distributed, autonomous combat forces. MICA will provide a strike commander the operational and mission planning tools to select optimal team composition, to perform dynamic tasking and re-tasking of teams, and to generate cooperative routes for autonomous Unmanned Combat Air Vehicles (UCAVs) in stressful operational missions, especially suppression of enemy air defenses. Mixed initiative control will develop collaborative strategies and tactics for these teams under the supervision of a single human operator, with adjustable autonomy determining the degree of human authority desired or required during task execution. Through the exploitation of control science metrics for stability, performance and robustness, these teams of cooperative, autonomous vehicles such as UCAVs will accommodate uncertainty in both the operating environment and feedback information, as well as address the presence of an intelligent adversary and fixed/mobile threats in the battlespace. An open experimental platform will be employed to evaluate these hierarchical battle management and control methodologies with humans-in-the-loop, initially in a simulation and subsequently in a hardware demonstration.

(U) The Intelligent Micro-Systems Technology (IMST) program will develop highly adaptable, highly integrated components (micro-systems) with the ability to self-assess and adapt in real-time, optimize their micro-level performance, and provide new levels of macro-level functionalities to meet the needs of new generations of military sensor and weapon systems. This program adds and integrates intelligence from the antenna, RF signal conditioning, signal processing, and sensor fusion at four levels of abstraction: hardware, component, system, and applications. The

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2002
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-19

distribution of intelligence at multiple levels will enable revolutionary applications thus far impossible due to the inflexible, centralized control architectures in previous generations of DoD systems.

(U) The Data Intensive Systems (DIS) component developed innovative data access techniques to enable new military capabilities with high rate sensor data streams and irregular data base memory access requirements. DIS developed hardware, software, and algorithmic approaches to computer memory organization and access to eliminate severe bottlenecks in present designs for defense applications such as dynamic, sensor-based processing, battlefield data-processing integration, and high-speed cryptographic analysis.

(U) The Information Technology Expeditions program developed technologies for software-programmable adaptive computing systems.

(U) The Systems Engineering for Miniature Devices (SEMD) research project focuses on the integration of existing/emerging technologies in the areas of mobility, power, sensing, actuation, communication, and computation, with a special focus on the software issues involved in controlling and programming these devices.

(U) The Secure and Dependable Software Program will develop technologies to enable production of secure and dependable software for military's mission-critical applications.

(U) Program Accomplishments and Plans:

(U) FY 2001 Accomplishments:

- Networking. ($24.053 Million)
  - Investigated alternative approaches to large-scale network engineering including simulation technology.
  - Demonstrated performance improvements of 100 percent for large multicast sessions based on active suppression of redundant acknowledgement and retransmission messages.
  - Integrated active network capabilities into Run-Time Infrastructure (RTI) for use with high-level architecture (HLA)-compliant simulations; held joint demonstration with Defense Modeling and Simulation Office (DMSO).
  - Developed models of traffic, network, and control suitable for on-line parameter tuning, dynamic reconfiguration, fault detection, and for meeting DoD mission critical requirements.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2002
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-19

- Initiated validation of modeling and simulation tools, and demonstrated predictive power of the models using measured network data.
- Initiated collaborative modeling and simulation experiments with Navy and Air force labs.
- Implemented and demonstrated non-specific congestion manager that coordinates and ensures fair throughput for multiple applications.
- Developed radar image enhancement algorithms using coherent processing of signals from multiple radar sources connected by a very high-speed network.
- Developed survivable key management and distribution architectures to protect against compromise and enable rapid network recovery and reconstitution.

- Data Intensive Systems and Software. ($11.589 Million)
  - Demonstrated advanced cache-based approaches for data-intensive applications.
  - Demonstrated compilation for new hierarchical memory architecture including automatic selection of instruction placement in either CPU or processors in memory.
  - Demonstrated the impact of in situ processing and a high-level graphics language abstraction that enables the computation 1,000,000 ray-patch intersections per second.
  - Demonstrated the processor-in-memory (PIM) concepts necessary to improve the execution of the NAS Conjugate Gradient benchmark by 20-fold over today's state-of-the-art memory limited applications.

- Adaptive Computing Systems (ACS). ($18.095 Million)
  - Implemented final Adaptive Computing Systems (ACS) design tool suites using high-level entry, e.g., for Java, C, Matlab, and Khoros.
  - Demonstrated 100x – 1000x reduction in compilation time for ACS implementations.
  - Implemented and demonstrated C compiler for hybrid chips.
  - Implemented and demonstrated ACS/heterogeneous processing Matlab design environment.
  - Implemented and demonstrated selected benchmark algorithms using ACS automated development environmental/tool aided design.
  - Demonstrated ACS defense system insertion for high dimensionality sonar beamforming, synthetic aperture radar (SAR), signal processing, and automatic target recognition (ATR).
  - Defined high level and low-level optimization approaches to implement Application Specific Integrated Circuit (ASICs).

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2002
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-19

- Defined the appropriate levels of customization that provide the greatest performance benefit for Digital Signal Processor (DSP) intensive ASIC based systems such as wide band adaptive radar receivers and IR image processing.
- Began the design of custom cell libraries and module generators.

- Quorum Program. ($28.966 Million)
  - Released prototype distributed object software with real-time Quality of Service (QoS) management.
  - Demonstrated support for mixed workloads of hard, soft, and non-real-time applications.
  - Demonstrated QoS-driven fault detection and recovery within 500 milliseconds.
  - Developed intermediate representations and mechanisms for code composition and transformation.
  - Developed models, specifications, code interpretations, and implementation mechanisms for embedded systems aspects, such as timing and fault tolerance.
  - Developed common graph-based program representations for software analysis.
  - Developed initial reusable embedded system aspect software.

- Power Aware Computing. ($20.040 Million)
  - Demonstrated flight-capable Synthetic Aperture Radar (SAR)/Automatic Target Recognition (ATR) system recognizing 30 target types in presence of camouflage concealment deception.
  - Continued evaluation of candidate power aware technologies and techniques that have high payoff potential for planned subscale demonstrations.
  - Identified potential small and medium scale power aware subscale demonstration candidates: Land Warrior system, smart munitions, autonomous, unmanned combat air vehicles, distributed sensors, and space sensors.
  - Defined a series of real world power aware system level energy scenarios for planned subscale platforms and applications.
  - Defined and initiated development of a power aware framework tool suite that will permit multiple level heterogeneous power aware systems to be integrated to enable system level power aware trades.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2002
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-19

- Mobile Code Software. ($17.429 Million)
  - Demonstrated and evaluated software agent's ability to approximate behavior tradeoffs and to utilize negotiation in advanced logistics scenario with a 3-second response requirement.
  - Demonstrated and evaluated software agent's ability for bottom-up organization in advanced logistics scenario with 100-1,000 components.
  - Prototyped implementation of negotiation technology in real-time scenario with a 500-millisecond response requirement.
  - Developed methods for maintaining and updating critical information (system and resource states, global time, etc.) system-wide, without centralized depository.
  - Investigated event/time triggered system synthesis methods subject to time, functional, performance, safety and security constraints.
  - Investigated design methods of embedded generators that guarantee selected behaviors of the generated systems.

- Information Technology Expeditions. ($2.605 Million)
  - Demonstrated adaptive reprogramming of hardware within a single clock cycle.
  - Defined operating systems for deeply networked multiple intelligent devices with varying data rates and processing power.

- Next Generation High End Computers Required for National Security. ($3.450 Million)
  - Developed massively parallel processor (MPP) computers that minimize porting effort from current vector platforms.
  - Demonstrated use of MPP architecture for interactive National Security applications.

(U) FY 2002 Plans:

- Networking. ($35.001 Million)

  - Active Networks.
    - - Develop Active Networking techniques for Distributed Simulation Internet Management, including techniques for the channelization of information and for enhanced filtering of data, resulting in the minimization of network bandwidth utilization and end-system receive-processing requirements in distributed simulations.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2002
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-19

- - Develop active Enabled Intrusion Detection and Response (IDR) prototype demonstrating more flexible, adaptive, autonomous, and dynamic Intrusion Detection with detection, tracing, response, and repair functions and including integration techniques such as capability encapsulation, self-adaptation, and intruder wrapping.
- - Develop and demonstrate obfuscation techniques for mobile agents that may be executing on malicious hosts, including self-monitoring and recovery techniques for obfuscated mobile agents.
- - Develop an active network operating system (AN OS) focused on a policy-free security architecture and availability within an active network, including inter-process (e.g., applet, servelet, execution environment) isolation within the same virtual machine.
- - Explore active network technology within mobile computing environment, including active power management, data prioritization, ad-hoc network hopping, and active security.
- - Develop active network techniques for distributed network management, resource control, and distributed network service deployment, configuration, and management.

– Network Modeling and Simulation.
- -Initiate the development of models to predict internal and end-to-end behavior of large networks at multiple time scales and resolutions.
- - Implement models and validate them in an experimental DoD test bed network with distributed simulation capability.
- - Investigate alternative control mechanisms to achieve desired service level agreements and Quality-of-Service.
- - Develop models for anomaly detection, fault diagnosis, and prediction of congestion onset and dynamics in large networks.
- - Develop a fast, programmable emulation capability that can facilitate on-line tests of control to assess unintended consequences.

– Ultra High-Performance Networking.
- - Design secure communication interfaces for gigabit-end flows.
- - Develop and demonstrate optical access nodes based on fast tunable-channel transmitters.
- - Demonstrate correlation of multi-gigabit per second transfer of radar signal streams from multiple sources.
- - Prototype digital amphitheater application tying thousands of event participants via an integrated video portal.
- - Demonstrate telepresence application with dramatically reduced processing overhead.
- - Demonstrate multiple video blanket media streams and client side browsers for display of these streams.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2002
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-19

- Responsive Computing Architectures. ($25.155 Million)
  - Power Aware Computing and Communications.
    - - Demonstrate 10X power/energy aware reduction techniques incorporating compiler, algorithms, runtime systems, and mission optimization approaches.
    - - Demonstrate 10X power/energy aware reduction techniques incorporating micro-architecture, input/output, memory, and component optimization approaches.
    - - Conduct preliminary PAC/C energy simulation/modeling framework concept demonstration.
    - - Select small and medium scale prototype candidates.
    - - Define small and medium scale prototype demonstration definition.
    - - Select final small and medium subscale platforms and application demonstrations.

  - High Productivity Computing Architecture.
    - - Identify application requirements.
    - - Initiate productivity benchmarks and stressmarks.
    - - Develop innovative programming models and virtual machine forms.
    - - Explore scalable computing programming and profiling techniques.

  - Network-Centric Infrastructure for Command, Control and Intelligence.
    - - Develop Joint Service experimental plans.
    - - Conduct studies and develop prototypes to assess the ability of emerging COTS infrastructure technologies to support habitat construction, evolution, and interaction.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2002
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-19

- Network Embedded Technology. ($27.000 Million)

  – Network Embedded Systems Technology.
  - - Conduct experimental and theoretical investigations on *phase-transition* effects, i.e., the dramatic changes from being easy to becoming intractable, in problems that involve the simultaneous satisfaction of multiple constraints.
  - - Investigate methods for the prediction of characteristics and for the detection of proximity of phase transitions.
  - - Develop experimental prototypes to test and evaluate algorithms and programs that solve constraint satisfaction problems by leveraging knowledge of phase transitions.
  - - Develop scalable, lightweight *coordination-services*, e.g., synchronizing clocks globally, achieving global consensus on shared data etc., for network embedded software technology applications.
  - - Investigate deterministic and probabilistic methods for self-stabilizing protocols.
  - - Investigate design approaches for the customization of coordination-services to specific applications.
  - - Develop formal modeling and verification techniques for coordination-services.
  - - Develop formal modeling methods for integrated coordination service packages.
  - - Investigate methods for the aggregation and automatic composition of coordination services to form one integrated package.
  - - Develop low-cost, open-experimental platforms for network embedded software technology.
  - - Demonstrate scalability and fault resilience of basic coordination service components in simple network embedded software technology applications.

  – Program Composition for Embedded Software.
  - - Develop techniques for incremental formal analysis and transformation of networked embedded software.
  - - Develop language representation and compiler techniques for aspect-oriented programming of fine-grained and coarse-grained aspect-oriented programming of embedded systems.
  - - Develop model-driven tools and representations for generating, optimizing, and configuring component-oriented middleware for networked embedded systems.
  - - Develop quality-of-service (QoS)-enabled services for persistence, fault tolerance, and multi-media sensor/intel data transmission.
  - - Demonstrate pair-wise interacting aspects and transformation strategies for coordinated operations between manned/unmanned air vehicles and shipboard command and control centers.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2002
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-19

- Autonomous Systems Control. ($26.864 Million)

  – Autonomous Negotiation Teams.
  - - Demonstrate ability to identify autonomous negotiating teams needed for cooperative flight scheduling and maintenance planning.
  - - Prototype implementation and evaluation of negotiation in real-time mission planning for UCAV operations.
  - - Demonstrate ability for hierarchical coalition formation in real-time.
  - - Demonstrate negotiation protocols for large, hierarchically organized coalitions.
  - - Integrate utility for the selection of negotiation strategies to meet goals of convergence, optimality, and timeliness.
  - - Demonstrate stable goal tracking ability under changing environments.
  - - Demonstrate avoidance of conflict by changing plans.
  - - Demonstrate ability to negotiate tasks in common real-time multiple target tracking problem with requirements of 0.25 ft error, 90% probability of disambiguation, and 500-millisecond response time.

  – Autonomous Software for Learning Perception & Control.
  - - Demonstrate behavior scalability and reuse.
  - - Demonstrate learning compatible knowledge representations.
  - - Demonstrate task-based, sensor data exploitation.
  - - Identify metrics for evaluation and associated evaluation methodologies.

- Augmented Cognition. ($11.200 Million)
  – Develop robust, non-invasive, real-time, cognitive state detection technology for measuring the cognitive processing state of the user.
  – Determine if a spatially-distributed, multi-modal, context-specific display system, as opposed to a conventional single screen display, provides an environment that makes it easier for people to encode, store, and retrieve information.
  – Evaluate/develop advanced cognitive function measuring devices, and establish principles and guidelines for their use.
  – Develop a set of conversational interruption strategies with cues that help bring a user back into the context of the interrupted task at the point where the user was interrupted.
  – Establish cognitive relaxed computer dialog architecture to support the warfighter interaction with the computer.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2002
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-19

- Mixed Initiative Control of Automa-Teams (MICA). ($11.779 Million)
  - Develop theories and baseline algorithms to assign autonomous combat vehicles to task-oriented teams.
  - Develop theories and baseline algorithms to assign mission-derived subtasks to each combat vehicle in a team.
  - Develop theories and baseline algorithms to generate routes and event schedules for each combat vehicle in a team.
  - Build an initial open experimental simulation environment, driven by UCAV suppression of mobile air defense elements.
  - Deploy a second phase open experimental simulation environment incorporating multiple UCAV teams and multiple command levels.

- System Engineering for Mini Devices. ($2.600 Million)
  - Continue system engineering for mini devices effort.

- Secure and Dependable Software. ($1.000 Million)
  - Initiate secure and dependable software development effort.

(U) FY 2003 Plans:

- Networking. ($29.150 Million)
  - Active Networks.
    - - Explore use of active network technologies in multiple environments, including high performance clusters and grids, advanced hardware platforms, and deeply networked systems.
    - - Investigate specification, formal analysis and verification of active network languages and methodologies.

  - Network Modeling and Simulation.
    - - Implement a measurement-driven, model-based, hybrid simulation emulation tool in a multi-operator network, achieving high level architecture compliance.
    - - Demonstrate 100x scalability in network size and 10 to 50x speed in simulation over existing techniques, and demonstrate network behavior prediction at scales ranging from msecs to hours over a wired network, and a wireless network of 100s of nodes.
    - - Demonstrate on line network controls including Quality-of-Service provisioning, dynamic reconfiguration, and on-line fielding of situation specific protocols.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2002
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-19

- - Demonstrate 10 to 100x improvement in fault diagnosis time, over current techniques.
- - Develop reduced order and aggregate models of network suitable for faster prediction and control.

– Ultra High-Performance Networking.
- - 10-node synchronization and peer discovery experiment.
- - Measurement and modeling of urban indoor and outdoor network links.
- - Design precision (1cm) network based geo-location system scalable to 100 nodes in an indoor setting.
- - Design base architecture for high-confidence networks that are robust to single-point physical-layer failures.
- - Demonstrate 10 node synchronization and peer discovery using impulse network nodes.
- - Demonstrate synchronizing activation and deactivation of an edge network composed of 100 nodes, scalable to 10,000 nodes.
- - Demonstrate hybrid optical / RF self-healing link at 600 Mbps.
- - Design a large-scale ad-hoc network including peer-to-peer with security mechanism that do not rely on hierarchical keys.
- - Demonstrate support to dynamic coalitions of components.

– Coordinated Large Scale network (CLSN).
- - Develop computation and coordination network technology that exploits MEMs technology application.
- - Initiate development of scale-down 1,000 node CLSN.
- - Use 1,000 node CLSN to demonstrate that the stringent computational requirements imposed by fine-grained distributed structure, extreme scaling, environment-induced high failure rates, and complex decentralized control can be met.

• Responsive Computing Architectures. ($59.140 Million)

– Power Aware Computing and Communications.
- - Incorporate experimental data collected at each of the five power aware levels: 1) mission, 2) subsystem/algorithm, 3) software/compilation, 4) operating systems, 5) architecture/devices into the power aware simulator library.
- - Provide a Beta release of the PAC/C energy aware simulator and modeling framework for the PAC/C subscale developers to evaluate.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2002
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-19

- - Develop firm power aware objectives for each of the major subscale application demonstrations based on experimental data and power aware simulation tools.
- - Finalize selection of the power aware technologies to be incorporated and demonstrated for each of the planned power aware subscale demonstration projects which include the following application areas: distributed sensors, space processing, Land Warrior/Objective Force, and communications.
- - Continue the development of the final subscale demonstration projects and provide interim demonstrations.

– High Productivity Computing Architecture.
- - Perform an industry concept and critical technology assessment review for viable HPCS systems for potential implementation in the (2007 - 2009) timeframe.
- - Perform university oriented critical technology assessment and concept evaluation for viable HPCS systems for implementation in the (2007 - 2009) time frame.
- - Release alpha “value-based” productivity metrics and benchmarks to guide future program research and development activities.
- - Define, approve and implement a multi-year research plan in high productivity computing systems.
- - Explore effective high bandwidth hierarchical memory subsystem for scalable high-end computing systems.
- - Explore a system architecture that will adapt to dynamic application types and work loads.
- - Address large system brittleness by exploring hardware and software reliability/fault tolerance capabilities, active application software bug tolerance, and intrusion identification and resistance.
- - Explore balanced “productive” system architectures balancing processors, memory, interconnects, software, and programming environments.

– Thermodynamics of Randomized Computing.
- - Establish the feasibility of using randomized algorithms to save energy via entropy management.
- - Define the computing model (BTFM) and demonstrate the thermodynamic behavior of randomized algorithms.

– Network-Centric Infrastructure for Command, Control and Intelligence.
- - Establish integration test bed.
- - Demonstrate decentralized mechanisms for enforcement of rules about habitat membership and task sequencing in habitats.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2002
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-19

- Network Embedded Technology. ($36.500 Million)

  – Networked Embedded Systems Technology.
  - - Develop embeddable services for transition-aware constraint solvers.
  - - Demonstrate real-time synthesis using transition-aware constraint solvers.
  - - Develop experimental prototype for distributed, anytime constraint solvers.
  - - Develop customizable and adaptable solutions for coordination-services for network embedded software technology applications.
  - - Extend self-stabilization approaches to hybrid systems.
  - - Develop formal models and formal verification of coordination service components.
  - - Develop tools for the automatic composition and verification of application specific coordination service packages.
  - - Demonstrate the synthesis of an optimized coordination service package on the experimental platform such as distributed avionics or space-based phased array antenna.
  - - Demonstrate the application design process and evaluate performance up to a 10^3 node system.

  – Program Composition for Embedded Software.
  - - Develop analysis techniques for multi-aspect interference.
  - - Develop control services for multi-media sensor data.
  - - Develop binding-time analysis and optimization tools.
  - - Develop dependence-based aspect composition techniques.
  - - Develop techniques for ensuring real-time and fault-tolerance service in combat systems.
  - - Demonstrate program composition services on shipboard weapons resource scheduling system.

- Autonomous Systems Control. ($25.500 Million)

  – Autonomous Negotiation Teams.
  - - Demonstrate ability of autonomous negotiation targets (ANTs) to resolve conflict under time limit by re-negotiating plans or modifying goals.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2002
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-19

- - Demonstrate ability of ANTs to maintain stability in changing environment.
- - Conduct final demonstration: coordinated, superior response in real-time ECM simulation.
- - Demonstrate ability to dynamic re-synthesis of the application under time limit using distributed constraint solvers.

– Autonomous Software for Learning Perception & Control.
- - Demonstrate adaptive generation of complex behaviors.
- - Demonstrate multi-sensor phenomenology enabled, outdoor navigation.
- - Demonstrate methods for directing perceptual attention.
- - Interim evaluation of human-humanoid interaction.
- - Demonstrate a trainable, perception-based, autonomous (indoor) navigation capability.
- - Develop integrated command control and resource management tools for large-scale distributed system of unmanned systems.
- - Demonstrate distributed autonomous behaviors that aggressively exploit the sharing of information between multiple unmanned surface vessels (USVs) to achieve cooperative target tracking, interception, and self-defense.

• Augmented Cognition. ($21.900 Million)

– Augmented Cognition.
- - Investigate how to develop and utilize necessary technologies such that routine tasks can be delegated to the computer as much as possible, thus freeing humans to attend to tasks that truly need their attention.
- - Identify the underlying neural generators and the respective neural mechanism of cognitive state. The functional formulation of neuronal mechanisms will allow predictions under a variation of parameters, such as stress and attention.
- - Conduct performance evaluations to baseline capabilities useful for controlling and monitoring human and robot systems, and demonstrate significant gains in effectiveness when cognition extends memory and perception, and focus of attention.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2002
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-19

- - Demonstrate and evaluate methods to use multi-modal query of digital memory to augment cognition by rapidly re-setting stylized context.
- - Continue the development of the Functional Optical Imaging sensor system based on Near InfraRed (fNIR) and to validate it as a means to monitor prefrontal cortex activity during select tasks relevant to cognition.
- - Develop a toolkit that allows on-line analysis of a user's self-regulatory mechanisms including sensory response, attentional augmentation of sensation, context updating, performance context tracking, and response and error monitoring.
- - Apply cognitive relaxed computer dialog architecture to support a practical low-cost prototype to demonstrate feasibility of the architecture and components.

– Perceptual Processing Displays.
- - Conduct experiments to determine optimal methodologies and technologies to expand and exploit the perceptual-cognitive processing bandwidth.
- - Develop software and hardware based on human behavior models and neuroscience to detect relevant signal from background noise that results in the extraction of salient information autonomously.
- - Design visual displays that deliver optimal information based on the human visual perception systems.
- - Develop an extremely feature-rich audio-interface based human auditory perception systems.
- - Demonstrate auto-adapting displays that adapt to the person, task, or display device.

• Mixed Initiative Control of Automa-Teams (MICA). ($22.000 Million)
– Extend algorithms and software to assign autonomous combat vehicles to task-oriented teams.
– Construct algorithms and software to allocate individual combat vehicles to each collaborative subtask.
– Design algorithms and software for collective trajectory generation with collision avoidance and self-reorganization in the presence fixed/mobile threats.
– Define algorithms and software supporting dialog between human commanders/operators and semi-autonomous entities to communicate recommended courses of action, appropriate feedback information, and decision tuning parameters.
– Deploy a third phase open experimental simulation platform stressing multi-team coordination, cooperative planning of sensor and weapon platforms, against difficult ground targets, with responsive operator control and intervention.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2002
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-19

  - Demonstrate cooperative management of 2-5 teams of 5-10 platforms and one operator with team self-organization in the presence of active threats.
  - Build a capstone simulation of an operational challenge problem with 5-10 teams of 20-30 platforms and an active/intelligent adversary.

- Intelligent Micro-Systems Technology. ($6.250 Million)
  - Define the characteristics and information technology requirements for intelligent micro-systems at the hardware, component, system, and application levels.
  - Devise mathematical models of intelligent Microsystems and validate these models for a range of representative new and planned DoD systems.
  - Develop early system concepts and architectural alternatives for selected applications.

(U) Other Program Funding Summary Cost:

- Not Applicable.

(U) Schedule Profile:

- Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)								DATE February 2002	
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research				R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-24					
COST *(In Millions)*	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	Cost to Complete	Total Cost
Information Assurance and Survivability ST-24	70.908	77.738	51.000	65.555	86.183	100.820	105.537	Continuing	Continuing

(U) Mission Description:

(U) This project is developing the technology required to make emerging information system capabilities (such as wireless and mobile code/mobile systems) inherently secure, and to protect DoD's mission-critical systems against attack upon or through the supporting information infrastructure. These technologies will enable our critical systems to provide continuous correct operation even when they are subject to attack, and will lead to generations of stronger protection, higher performance, and more cost-effective security and survivability solutions scalable to several thousand sites. Technologies developed under this project will be exploited in High Performance and Global Scale Systems (Project ST-19), Command and Control Information Systems (Project CCC-01, PE 0603760E), Information Integration Systems (Project CCC-02, PE 0603760E), and in other programs to satisfy defense requirements for secure and survivable systems.

(U) Information Assurance and Survivability technologies will be developed for secure communications and computing for correlating and fusing cyber sensors and to mitigate national and defense computing infrastructure vulnerabilities that could be exploited by an information warfare enemy. Information Assurance and Survivability focuses on early prototypes of software technologies leading to protection for large-scale, heterogeneous networks and systems usable over a wide range of performance in diverse threat environments.

(U) The Dynamic Coalitions program will develop technologies to support the secure creation of dynamic coalitions including the necessary technologies for policy management, group communications, supporting security infrastructure services, data sharing, and joint collaboration spaces. These areas are critical for future warfighting scenarios as outlined by Joint Vision 2020, which states that future military operations will be increasingly conducted jointly, both with multiple branches of the U.S. Armed Forces and with allied, and coalition forces, requiring increased levels of interoperability.

(U) The Fault Tolerant Networks (FTN) program will develop technologies to provide continuous and correct network operation even when attacks are successful. These technologies will reduce the amount of damage sustained during an attack, allowing networks to maintain an acceptable, minimum level of functionality. Technologies for strengthening networks will be developed by introducing fault tolerance capabilities against possible attacks at the network level, emphasizing integrity and availability; and technologies for mitigating potential vulnerabilities

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2002
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-24

associated with denial of service attacks. The Critical Infrastructure Protection (CIP) program, as part of the FTN program, will transition networking technology to critical information and telecommunication systems that are essential for minimum network operations.

(U) Intrusion assessment technologies will be developed to detect security threats through correlation and analysis of observed/reported activities. Assurance and dynamic integration tools will allow security and survivability to be inserted into legacy systems, and will enable critical systems to reconfigure and survive in the face of detected threat and successful attack. Autonomic architectures will be investigated to provide intelligent but reflexive defenses that adapt rapidly in milliseconds to block or withstand many classes of known and unknown attacks. These technologies will assure code integrity, contain malicious code, and tolerate remaining attacks using survivable architectures. Cyber defense increasingly requires a system to monitor its health and to effectively integrate and orchestrate information assurance and survivability technologies. In this pursuit, a display and control architecture that allows warfighters to observe the performance, health and threat state of mission critical information systems and adjust security and survivability attributes is being developed in Cyber Panel technology projects. Cyber Panel will create technologies that enable human-directed command and control over cyber resources, providing operationally relevant cyber situational understanding, mission impact assessment, and cyber course of action planning, analysis, and execution. The Partners in Experimentation program will conduct security technology experimentation with operational military and coalition partners. Operational experimentation will provide valuable feedback to the security technology research and development process as well as demonstrating to operational personnel the benefits of advanced technology. The Partners in Experimentation program transitions to Command, Control and Communications Systems, PE 0603760E, Project CCC-01 in FY 2003.

(U) The Fundamentals of Computer Network Defense (FCND) program will develop the basic theoretical underpinning for securing networked systems. This includes assessing the spread and detection of malicious mobile code, development and validation of security metrics, development of a modeling and simulation environment to assess direct and collateral effects of network attacks, and an understanding of the threats posed by sophisticated adversaries.

(U) The Composable High Assurance Trusted Systems (CHATS) program is developing the tools and technology that enable the core network services to be protected from the introduction and execution of malicious code or other attack techniques and methods. These tools and technologies will provide the high assurance, trusted operating systems (OS) context/basis to host the planned security services needed to achieve comprehensive-secure, highly distributed, mission-critical information systems for the DoD. This project will fundamentally change the existing approach to development and acquisition of high assurance trusted operating systems technology. These trusted operating system capabilities will be developed by engaging the open-source community in security functionality for existing open-source operating systems. Additionally, DARPA will engage the

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2002
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-24

open-source community in a consortium-based approach to create a "neutral", secure operating system architecture framework. This security architecture framework will then be used to develop techniques for composing operating system capabilities to support both servers and clients in the increasing network-centric communications fabric of the DoD. These technologies are critical for defensive information warfare capabilities and are needed to ensure that DoD systems of the future are protected from imminent attack. This program was originally funded in this PE under Project ST-11 in FY 2002 and prior.

(U) Program Accomplishments and Plans:

(U) FY 2001 Accomplishments:

- Autonomic Information Assurance. ($14.870 Million)
  - Developed autonomic response architecture.
  - Identified promising assessment methodologies for more effective evaluation of very large information infrastructures.
  - Developed scalable models of very large information infrastructure.
  - Completed an internal study producing a framework for a survivable exemplar Global Information Grid (GIG) system (such as the Global Command and Control System - Maritime (GCCS-M), an operational mission critical information system used by the Navy), and a survivable Cyber Panel.
  - Transferred promising technologies for use by the Fault Tolerant Networking (FTN), Cyber Panel, and OASIS programs in FY 2002 and completed closeout of remaining Autonomic Information Assurance technologies.

- Cyber Command and Control/Strategic Intrusion Assessment. ($23.795 Million)
  - Merged elements of Cyber Command and Control and Strategic Intrusion Assessment to eliminate gap between cyber attack detection at network services level and assessment at system functional level and focused technologies toward a coherent cyber attack monitoring and response management system.
  - Developed correlation and analysis algorithms to detect and track complex multi-phase or large-scale cyber attacks.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2002
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-24

- Developed techniques for assessing cyber attack impact at the system functional level from network-level alerts such as signature, anomaly, and effects-based attack event detections.
- Developed algorithms for evaluating and executing coordinated defensive actions and attack responses, automatic and human-initiated, across a large distributed system.
- Transferred promising technologies for use by the Cyber Panel and OASIS programs in FY 2002 and completed closeout of remaining Cyber Command and Control/Strategic Intrusion Assessment technologies.

- Intrusion Tolerant Systems. ($2.186 Million)
  - Transferred promising technologies for use by the Organically Assured and Survivable Information Systems (OASIS) and Cyber Panel programs in FY 2002.
  - Investigated market-based and value-based resource allocation mechanisms.

- Fault Tolerant Networks. ($22.403 Million)
  - Developed techniques to isolate corrupted or malicious network entities.
  - Investigated progress-based network resource allocation mechanisms to prevent denial-of-service.
  - Investigated trust-chain techniques for network resource allocation and protection against denial-of-service.
  - Designed active techniques for traceback and automated responses.
  - Transitioned Secure Border Gateway Protocol (SBGP) to commercial off-the-shelf (COTS) router vendors and established necessary Public Key Infrastructure (PKI) that provides basic authentication and authorization for potential users.
  - Developed secure enhancements to the Domain Name System (DNS), which include the operational use of keys, the incremental deployment of secure protocols, and coping with the existence of faulty or malicious secured DNS zones. In addition, research addressed the improvement of the robustness of the DNS, using an arbitrary mesh of trust.

- Dynamic Coalitions. ($7.654 Million)
  - Prototyped protocols for negotiation of policies across coalition members.
  - Created methods for fast sender authentication, scalable key distribution for creation and rekeying of coalitions.
  - Extended existing PKI capabilities with protocols for cross certification of coalition members.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2002
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-24

(U) FY 2002 Plans:

- Fault Tolerant Networks. ($35.624 Million)
  - Demonstrate Source Path Isolation Engine (SPIE) experimentation using Collaborative Advance Interagency Research Network (CAIRN) and COTS Intrusion Detection System to show the trace of an attack back to its ingress point soon after attack.
  - Develop capability to provide detection of denial of service attacks on the Quality of Service (QoS) data flow and to isolate the attacking packet streams using the concept of congestion pricing in resource reservation, the security of resource reservation will be enhanced against insider router attacks.
  - Demonstrate a scalable architecture and localized optimization algorithms for constructing a dynamic, topologically sensitive root context for any network topology, thus, removing the dependence of a single, fixed root content for the domain name server (DNS).
  - Develop a system of deployed passive probes and intelligent security gateways to aggregate attack statistics and determine countermeasures for response to attacks on routing protocols.
  - Explore traffic modeling techniques for countermeasures for traffic analysis and denial of service attacks in wired and wireless networks, including the development of a tool set that provides survivable real-time communication services.
  - Design new, efficient algorithms for detecting attacks and faults in optical networks, including models and algorithms for cost-based approach to reserving routes and bandwidth in anticipation of attacks and faults.
  - Develop algorithms for path classification and selection of protocols for creation of resilient network overlays within a modular routing architecture.
  - Revise Internet protocol (IP) and Secure IP (IPSEC) specifications to enhance resilience to traffic analysis.
  - Evaluate onion routing system virtual overlay network for resilience to traffic analysis in operational field use.
  - Evaluate several authenticated resource usage control schemes for preventing distributed service denial.
  - Develop novel implementation of Internet protocol (IP) reducing local service denial risk.
  - Demonstrate algorithms and techniques for providing controlled sharing of medium access, providing traffic cover and patterns.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2002
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-24

- Dynamic Coalitions. ($11.103 Million)
  - Develop extensions to team-based access controls addressing dynamic coalition membership and coalition missions, access to coalition resources at the task level, and modeling the use of self-limiting resource permissions that evolve with the state of mission-oriented tasks.
  - Develop algorithms which will remove dynamic group management bottlenecks by replacement of public-key techniques with much faster secret-key techniques, insertion of computational shortcuts, and potentially, the replacement of cryptography with secret-sharing techniques (for additional performance gains).
  - Develop and demonstrate several intra-domain group key management approaches for mobile subscribers, built around a decentralized, hierarchical architecture: one approach based on current Internet Engineering Task Force (IETF) IPSec multicast key management proposal; a second using same approach modulated by a hysteresis interval for environments with unreliable connectivity; third, an approach using explicit handoff of security associations among key distributors; and finally, an approach using periodic re-keying.
  - Develop general framework for hierarchical access control, decoupling rights authorization from information and service access, resulting in enhanced coalition scalability.
  - Design, develop and integrate new certificate cache architecture with secure group communication system.

- Fundamentals of Computer Network Defense (FCND). ($6.434 Million)
  - Initiate the theoretical limits to securing networked systems.
  - Develop and evaluate metrics for information assurance.
  - Assess the rate of speed of malicious mobile code.
  - Initiate development of modeling and simulation for networks under attack.
  - Explore capabilities of sophisticated adversaries and impact to defense.

- Cyber Panel. ($13.230 Million)
  - Develop information correlation and analysis algorithms to detect and assess widespread attacks.
  - Prototype detectors that can describe and exchange new attack patterns.
  - Demonstrate attack projection and real-time analysis of collective response tactics.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2002
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-24

- Identify and assess new information types that can be used to augment current operating system audit and network packet data sources to allow more comprehensive detection of cyber attacks.
- Investigate methods for allocating, dynamically deploying, and protecting intrusion detection sensors in large networks.
- Combine selected Cyber Panel technologies to demonstrate an initial integrated cyber attack detection, correlation, and response capability.

- Partners in Experimentation. ($11.347 Million)
  - Convert intrusion assessment algorithms into data reduction tools for military computer intrusion detection analysts.
  - Demonstrate situational awareness and interactive "big-board" control of broadly distributed security technologies, including scalable host based defenses, in military operational environment.
  - Transition to PE 0603760E, Project CCC-01, Command, Control and Communications Systems.

(U) FY 2003 Plans:

- Fault Tolerant Networks. ($16.500 Million)
  - Develop a distributed, scalable, reliable, and cost-effective architecture for an active network router that schedules node resources and dynamically reconfigures itself in response to failures.
  - Develop protocols to use fault tolerant consensus to ensure that all correct nodes are making consistent decisions and nodes can immediately route around failures.
  - Design and develop modifications to Source-initiated Ad-hoc Routing Algorithm (SARA) to incorporate techniques for intrusion-resistant mechanisms for Flow-based Route Access Control, multi-path routing, and flow monitoring algorithms.
  - Develop revocation notification for active faulty code and diverse and compensatory authentication techniques for just-in-time authentication capabilities in active networks.
  - Demonstrate reduction in covert channels and traffic analysis vulnerabilities.
  - Develop methodologies for specifying security policies that are context sensitive, comprehensive, and consistent; and enforcement mechanisms that detect policy violation before damage is done by malicious code or malicious insider activity.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2002
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-24

- Determine the unique vulnerabilities and potential avenues of attack on embedded real-time mission-critical systems as they are employed in network-centric warfare and characterize the potential adverse effects on correctness and timeliness of results.
- Develop information systems that can adapt their security posture to changing threat conditions and adjust performance and functionality to maintain an optimum balance among the three system attributes.
- Develop mobile distributed firewall architectures to allow rapid deployment of mobile networks with full enclave protection.
- Investigate mechanisms for digital watermarking of mobile wireless communications to ensure device authentication and protect against terminal compromise.
- Provide public key infrastructure support for rapid revocation of individuals, to include terminal exclusion and network reconfiguration.

- Dynamic Coalitions. ($11.500 Million)
  - Develop cryptographic hardware accelerator to speed up cryptographic computations for devices used in coalition networks.
  - Demonstrate integrated facilities for transitive delegation, with support for capacity sandboxing, reverse sandboxing, and object caching.
  - Develop and demonstrate intra-domain group key management protocols extended to handle mobile key distributors within mobile networks.
  - Design and develop a modular architecture and robust key agreement within a dynamic coalition, including reconfigurability and evaluation.

- Fundamentals of Computer Network Defense (FCND). ($6.000 Million)
  - Continue study of theoretical limits to securing networked systems.
  - Initiate development of the visualization tools needed for a cyber command post.
  - Begin command and control concept of operations for network defense.
  - Explore very high speed Type 1 and Type 2 encryption for Internet protocol (IP) based networks.
  - Explore vulnerabilities of heterogeneous network environments and potential defenses.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2002
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-24

- Cyber Panel. ($6.500 Million)
  - Refine and complete cyber panel components to be transitioned into follow-on system prototype.
  - Develop ability to determine and execute at millisecond speeds effective automatic reactions to cut off local network intrusions.

- Composable High Assurance Trusted Systems (CHATS). ($10.500 Million)
  - Implement prototype adaptations of the preferred applications and services as indicated by the protection profiles.
  - Implement the composable high assurance trusted system and the adapted applications and services on candidate representative DoD mission critical system server fabric.
  - Investigate alternative approaches for extending the composable high assurance technology to the network client fabric.
  - Develop protection profiles for the best candidate high assurance client side trusted systems.
  - Implement the best of the lifecycle support alternatives.
  - Investigate the alternative technology transfer options that provide the best long term persistence and continuity for the CHATS technology and tools.

(U) Other Program Funding Summary Cost:

- Not Applicable.

(U) Schedule Profile:

- Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)								DATE February 2002	
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research					R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-28				
COST *(In Millions)*	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	Cost to Complete	Total Cost
Asymmetric Threat ST-28	36.014	58.087	78.000	74.582	61.418	69.190	59.838	Continuing	Continuing

(U) Mission Description:

(U) The most serious threats to our national security, today, are *asymmetric* in nature. They are not threats of a conventional, force-on-force engagement by an opposing military, but threats of an unconventional yet highly lethal attack by a loosely organized group of transnational terrorists or other factions seeking to influence U.S. policy. This new threat brings new technological challenges. Instead of being satisfied with the capability to detect a nation-state as they prepare and execute a conventional military operation, the U.S. will need to develop a capability to detect a small, loosely organized group as they plan and execute an unconventional attack. This new threat will have a smaller mass, exhibit fewer observables, and yet will be more lethal in consequence. Sparse activity that was once too insignificant to notice will need to be detected, correlated, and understood. This can only be achieved by developing a new level of automation to detect, correlate, and understand all of the observable evidence exhibited by these sparse events. Specific needs include: the capability to automatically recognize and identify humans at a distance, to detect any enemy agent performing surveillance of a U.S. target; to automatically discover, extract, and link together sparse evidence of a group's intentions and activities from vast amounts of classified and unclassified information sources; to more precisely model the beliefs and organizational behavior of these small groups to better simulate and wargame our new opponents in this asymmetric world; and to provide more effective collaborative reasoning and decision aids to improve the speed and effectiveness of distributed teams of analysts and decision-makers in these dynamic situations.

(U) The goal of this project is to develop technological capabilities and a suite of tools to better detect and prevent attacks upon our critical DoD infrastructures. Ongoing programs in this project are Human Identification at Distance (Human ID), Evidence Extraction and Link Discovery (EELD), Wargaming the Asymmetric Environment (WAE), Bio-Surveillance, Endstate and DefenseNet (DNET). In addition, two new initiatives: Mis-Information Detection and Generation (MIDGET) and Genisys will be funded in FY 2003. In FY 2003 the DefenseNet and Endstate programs have respectively moved to Projects ST-11 (PE0602301E) and CCC-01 (PE0603760E).

(U) The Human Identification at a Distance (HumanID) program objective is to develop automated multi-modal biometric technologies. These technologies will be used to detect, recognize and identify humans at a distance. Automated biometric recognition technologies will provide critical early warning support against terrorist, criminal, and other human-based threats. Obtaining this information can prevent or decrease the success rate of such attacks and provide more secure force protection of DoD operational facilities and installations. HumanID seeks to develop a

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2002
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-28

variety of individual biometric identification technologies capable of identifying humans at great distances in DoD operational environments and for homeland defense. Once these individual technologies are developed, HumanID will develop methods for fusing these technologies into advanced human identification system. This system will be capable of multi-modal fusion using different biometric techniques with a focus on body parts identification, face identification, and human kinematics. Biometric signatures will be acquired from various collection sensors including video, infrared and multi-spectral sensors. These sensors will be networked to allow for complete coverage of large facilities. The goal of this program is to identify humans as unique individuals (not necessarily by name) at a distance, at any time day of night, during all weather conditions, with non-cooperative subjects, possibly disguised and alone or in groups. These technologies will be tested and integrated into the Total Information Awareness (TIA) System funded in PE 0603760E, Project CCC-01.

(U) The objective of the Evidence Extraction and Link Discovery (EELD) program is to develop a suite of technologies that will automatically extract evidence from vast amounts of unstructured textual data (such as intelligence messages or news reports) leading to the discovery of additional relevant relationships and patterns of activity that correspond to unusual events, potential threats or planned attacks. These technologies would be employed to provide more accurate advance warnings of potential terrorist activities by known or more important, unknown individuals or groups. They will allow for the identification of connected items of information from multiple sources and databases whose significance is not apparent until the connections are made. Recent advances in language understanding software will be exploited to provide a capability to automatically extract facts from textual messages, web pages, and other unstructured data sources at a performance level (90% accuracy) comparable to today's ability to extract entities (e.g., people, places, organizations). Search, reasoning, and classification techniques will be developed to enable discovery of relevant information and evaluate it to detect likely threats. Pattern learning algorithms will be extended and scaled to enable learning and evaluation of patterns comprised of relationships among people, organizations, activities, and scenarios, with the ability to distinguish accurately between real activities of interest and explainable unusual events. These technologies will be tested and integrated into the Total Information Awareness (TIA) System.

(U) The Wargaming the Asymmetric Environment (WAE) program's mission is to develop and demonstrate threat specific tools to enable analysts and decision makers to better anticipate, predict, and intervene against terrorists and others who threaten U.S. and Allied interests with asymmetric and asynchronous capabilities. The technical challenges include 1) developing predictive methodologies and technologies that work within the complex and non-linear characteristics of today's asymmetric adversaries, 2) developing predictive technologies that will generalize from individuals to groups, from attack behavior to more subtle enabling behaviors/decisions that precede an attack, and 3) developing emulation (predictive sequences) technologies to allow analysts to test a projected adversary's actions and reactions to potential intervention strategies. WAE's approach to these technical challenges is to exploit a combination of behavioral prediction and computer-based reasoning techniques to automatically identify and model factors reflecting a specific groups "intent" and "points of influence" to support prediction and reasoning – at

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2002
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-28

operationally relevant levels - about the future behavior of individuals and groups. This approach goes beyond today's analytical methods to analyze behaviors in the broader context of their political, psychological, and cultural environment. These predictive technologies will be tested and integrated into the Total Information Awareness (TIA) System.

(U) The objective of the Bio-Surveillance program is to develop the necessary information technologies and resulting prototype system capable of detecting a covert release of a biological pathogen by monitoring non-traditional data sources such as animal sentinels, human behavioral indicators, and non-diagnostic medical center. Technical challenges include correlating/integrating information derived from heterogeneous data sources, development of autonomous signal detection algorithms, creation of disease models for autonomous detection, and maintaining privacy protection while correlating heterogeneous data and sources. The program will develop disease models, identify abnormal health detectors, and mine existing human, agriculture, and animal health databases to determine the most viable indicators for abnormal health conditions. The program will perform analyses on hypothesized events to determine which indicators are most valuable to detect bio-terrorist releases. Adjustable privacy protection that could be placed in a medical data system and ensure the anonymity of individual records accessed by the data monitoring software will be developed and tested. A prototype bio-surveillance system will be constructed for a citywide area such as Norfolk, VA and demonstrated in a series of field experiments by injecting simulated biological event data into the real-time data streams of the testbed system. The Bio-Surveillance program will dramatically increase DoD's ability to detect a clandestine biological warfare attack, involving both natural and unnatural pathogens, in time to respond and avoid potentially thousands of casualties.

(U) The Endstate (Effects-based, Nonlinear Analysis and State Estimation) program will explore technology to dramatically improve the DoD's capability to perform vulnerability analyses of networks. Infrastructure networks such as air defense, logistics, electrical power, and petroleum are becoming increasingly coupled. Currently, the DoD has the capability to perform sophisticated analyses of networks separately using high fidelity simulations. Endstate's objective is to develop technology to combine complicated and detailed models of individual infrastructure networks into coherent, accurate, and computationally tractable interdependency models. Such models would support analyses concerning vulnerabilities, alternative courses of action, and consequences.

(U) The objective of DefenseNet (DNET) is to dramatically increase the robustness, security and performance of the DoD information infrastructure by exercising architectural options based upon optical network components. The current Internet packet/router "connectionless" network architectures and fragile protocols no longer satisfy minimal DoD requirements either for security (e.g. the lack of attribution) or for performance (Quality of Service, Bandwidth). Recent advances in optical communications components and networks, driven by huge commercial investments in the past few years, have presented the DoD with a unique opportunity to rethink and deploy modern optical-based networks to meet

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2002
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-28

its future mission needs. These new architectures promise inherently secure, symmetric (peer to peer) communications with bandwidths of 1000 times current DoD infrastructures.

(U) The Genisys program will produce technology for an ultra-large all-source information repository to help prevent terrorist attacks on the citizens, institutions, and property of the United States and its allies. To predict, track, and thwart, or at least mitigate attacks, the U.S. needs a full-coverage database including information about all potential terrorists and possible supporters, terrorist material, training/preparation/rehearsal activities, potential targets, specific plans, and the status of our defenses. Current database technology is clearly insufficient to address the need to integrate all relevant existing databases and semi-structured information sources, to automatically populate the new repository with many different and non-traditional data feeds, and to enable the easy creation of new information systems which today exist only in manual form. Today's database technology was defined in the 1980s, but processors, disks, and networks are now a thousand times more capable--Genisys will reinvent this technology to meet today's needs and capabilities. The goal of the program is not only to demonstrate technologies, but also to develop a series of increasingly powerful leave-behind prototypes so that the intelligence community can get value immediately and provide feedback to focus research. These technologies and components will feed into the Total Information Awareness (TIA) System.

(U) The objective of the Mis-Information Detection and Generation (MIDGET) program is to reduce DoD vulnerability to open source information operations by developing the ability to detect intentional mis-information and to detect inconsistencies in open source data with regard to known facts and adversaries goals. A secondary output of the program could be evaluation techniques for use in planning information operations.

(U) Program Accomplishments and Plans:

(U) FY 2001 Accomplishments:

- Human Identification at a Distance. ($11.807 Million)
  - Developed a fixed site, pilot force protection system to identify humans at a distance in an outdoor operational setting at a DoD facility.
  - Used Specific Service sites as prototype models in designing demonstrations and experiments.
  - Developed and acquired advanced sensors to support the development of eight biometric component technologies.
  - Developed initial algorithms and performed evaluations of biometric component technologies.
  - Performed preliminary assessment of current and future technologies to meet the proposed system needs.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2002
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-28

- Evidence Extraction and Link Discovery. ($17.344 Million)
  - Identified candidate unclassified and classified document collections from which asymmetric threats can be detected.
  - Initiated collection of document collections to use as basis for technology developments.
  - Evaluated applicability of promising information extraction and link discovery techniques.
  - Selected candidate information extraction techniques and approaches for development.
  - Selected candidate link discovery techniques for development.
  - Selected candidate pattern learning techniques for development.
  - Demonstrated the ability to acquire and use non-traditional data sources to perform surveillance during the 2001 Presidential Inaugural celebration activities.
  - Demonstrated alerting and abnormal disease detection performance based on seeding the indicator data with hypothetical events.
  - Identified abnormally high levels of naturally occurring diseases using non-traditional data sources.

- Wargaming the Asymmetric Environment. ($6.863 Million)
  - Developed and cross-validated an asymmetric model ontology with open and classified data.
  - Statistically tested an initial set of advanced reasoning techniques for applicability to predicting an asymmetric adversary's behavior.
  - Developed initial predictive models for a set of specific known and existing asymmetric adversaries.
  - Conducted initial and successful predictive modeling experiments.
  - Transitioned baseline predictive models to operational partners.

(U) FY 2002 Plans:

- Human Identification at a Distance. ($15.850 Million)
  - Incorporate additional sensors and biometrics into the pilot force protection system.
  - Evaluate and demonstrate the prototype advanced human identification system at force protection and homeland defense sites.
  - Identify the limits of range, accuracy, and reliability on combinations of facial features, gait, and other key identification techniques and determine the critical factors that affect the performance of biometric components.
  - Continue the development of the most promising biometric technologies based upon experimental evaluation performance.
  - Develop methods and algorithms for fusing multi-modal biometric technologies and deriving biometric signatures.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2002
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-28

- Evidence Extraction and Link Discovery. ($ 14.398 Million)
  - Specify models of asymmetric threat scenarios.
  - Develop and establish baseline performance for information extraction techniques for extracting geographical, organizational, and transactional relationships from text messages, news reports and web pages.
  - Develop ability to discover relevant connections between entities of the same type.
  - Develop ability to learn patterns corresponding to threat models comprising connections of single-type entities (e.g., people to people, or sets of related financial transactions).
  - Implement prototype demonstration of maturing EELD tools and techniques with DoD partners for potential transition opportunity of technologies for near-term support.
  - Develop a repository schema convention, simplified query language, information sharing rules, and peer-to-peer architecture to enable rapid creation of large, distributed information repositories.

- Wargaming the Asymmetric Environment. ($15.839 Million)
  - Establish operational testbeds in conjunction with one or more transition partners (DIA, Joint Staff, and others).
  - Extend predictive model development to finer levels of details of tactic, target, location, and timeframe characteristics.
  - Develop predictive models for specific and existing individual and group adversaries.
  - Generalize predictive models from a single adversary to multiple adversaries (asymmetric classes).
  - Conduct generalization experiments to empirically define classes of asymmetric threats by common predictive factors.
  - Continue to test and validate threat specific models and modeling techniques.
  - Transition new and revised predictive models to operational partners.
  - Expand predictive modeling to Operations Other Than War (OOTW) context.

- Bio-Surveillance. ($8.000 Million)
  - Collect and analyze historical epidemiological data for normal diseases in order to model detectors for abnormal events.
  - Develop possible concepts for a bio-surveillance system and identify possible components and apply these capabilities in a system to detect bio-surveillance activity within the national Capital Region.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2002
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-28

- Develop computer simulation environment to emulate bio-terrorist events and impacts on agricultural, animal and human populations.
- Identify, access, and analyze additional data sources.

- Endstate. ($2.000 Million)
  - Investigate reduced order modeling techniques for cross network effects prediction.
  - Identify technology for modeling adversary work-arounds.
  - Investigate methods for maintaining timely and accurate network state estimates.

- DefenseNet. ($2.000 Million)
  - Characterize DoD information and communications systems requirements in contrast to commercial Internet models (e.g., peer to peer).
  - Assess the security implications of candidate optical / electronic network architectures (protocols, management and routing).

(U) FY 2003 Plans:

- Human Identification at a Distance. ($14.500 Million)
  - Develop multi-modal HumanID technologies and extend the prototype advanced human identification system by adding two additional biometric modalities.
  - Continue to develop biometric fusion algorithms to include up to five biometric components.
  - Conduct multi-modal fusion experiments and performance evaluations.
  - Demonstrate advanced human recognition capabilities in multiple force protection or homeland defense environments.

- Evidence Extraction and Link Discovery. ($14.000 Million)
  - Demonstrate integrated extraction capability for all relationship types from all source types, including rapid adaptability to new types of relationships and new data sources.
  - Develop ability to detect instances of patterns comprising multiple entity types with multiple types of connections.
  - Develop ability to learn patterns comprising connections of multiple entity types with multiple types of connections.
  - Conduct performance evaluation of all capabilities and model performance of combined capabilities.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2002
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-28

  - Develop ability to extract links and relationships from processed textual summary of information obtained from streaming (audio/video), imagery, and sensor data.

- Wargaming the Asymmetric Environment. ($18.500 Million)
  - Perform operational tests through the development and validation of predictive models.
  - Perform predictive comparisons between the current analytical models and the WAE modified analytical model.
  - Extend predictive techniques to develop sequences of behaviors (emulation) for specific and classes of adversaries.
  - Perform operational tests through the development and validation of emulation models.
  - Transition new and revised predictive models to operational partners.
  - Integrate predictive technologies into an automated indication and warning system.
  - Beta test automated indication and warning system in conjunction with operational partners DIA, Joint Staff, etc.

- Bio-Surveillance. ($13.500 Million)
  - Refine emulation environment with updated data sources, sensors, data monitoring software models, and detection algorithms.
  - Develop initial signal detection algorithms.
  - Develop a privacy protecting agent architecture for the integration of heterogeneous data systems.

- Genisys. ($11.000 Million)
  - Develop a database schema crawler for discovering the structure of existing databases, tools for term translation, and automated generation of new schema to enable current databases to be integrated semi-automatically.
  - Develop methods of re-structuring semi-structured or natural language information sources.
  - Create, test, and experiment with a prototype repository that integrates five or more existing databases and semi-structured information sites.

- Mis-Information Detection and Generation (MIDGET). ($6.500 Million)
  - Develop domain specific indicators of potential intentional mis-information in open source material using “Red-Team” wargaming techniques and expert knowledge.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2002
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-28

– Explore combinations of techniques from linguistic genre analysis, learning with background knowledge, business process modeling, and adversarial plan recognition for detection of intentional mis-information in open sources.

(U) Other Program Funding Summary Cost:

- Not Applicable.

(U) Schedule Profile:

- Not Applicable.