RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)					DATE June 2001					
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 2000	FY2001	FY2002	FY2003	FY2004	FY2005	FY2006	FY2007	Cost To Complete	Total Cost
Total Program Element (PE) Cost	308.129	330.722	382.294	332.374	326.200	338.300	353.300	368.300	Continuing	Continuing
JASON ST-01	1.190	1.512	1.500	1.500	1.500	1.500	1.500	1.500	Continuing	Continuing
Intelligent Systems and Software ST-11	71.454	74.900	87.303	61.536	58.362	58.057	68.057	68.057	Continuing	Continuing
High Performance and Global Scale Systems ST-19	158.266	125.346	157.666	132.838	152.338	169.743	169.743	179.743	Continuing	Continuing
Software Engineering Technology ST-22	16.630	17.839	0.000	0.000	0.000	0.000	0.000	0.000	0.000	N/A
Information Assurance and Survivability ST-24	60.589	84.241	77.738	85.800	64.500	64.000	64.000	64.000	Continuing	Continuing
Asymmetric Threat ST-28	0.000	26.884	58.087	50.700	49.500	45.000	50.000	55.000	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 provide analysis of critical national security issues.

(U) The Intelligent Systems and Software project develops new information processing technology concepts that will lead to fundamentally new software and intelligent systems capabilities. This will enable advanced information systems to more effectively accomplish decision-making tasks in stressful, time sensitive situations and create efficient software-intensive defense systems.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE June 2001
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E

(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 Software Engineering Technology project funds the core efforts of the Software Engineering Institute (SEI). Beginning in FY 2002, the funding for the SEI program has transferred from DARPA to OSD PE 0603781D8Z.

(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 under attack, and will lead to generations of stronger protection, higher performance, and more cost-effective security 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 suite of tools to better detect and prevent attacks upon our critical DoD infrastructures.

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

	FY2000	FY 2001	FY 2002
Previous President's Budget	320.648	376.592	347.779
Current Budget	308.129	330.722	382.294

(U) Change Summary Explanation:

FY 2000 Decrease reflects SBIR reprogramming and minor program repricing.

FY 2001 Decrease reflects the net effect of specific and general congressional program reductions; congressionally added funds for the Reuse Technology Adoption Program; the Section 8086 reduction; and the government-wide rescission.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE June 2001
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E

FY 2002 Increase reflects the net effect of expansion for new initiatives in network embedded software technologies and high performance computing architectures and rephasing of FY 2002 programs following the FY 2001 congressional program reductions, offset by the transfer of the Software Engineering Technology funding (Project ST-22) to OSD.

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RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)					DATE June 2001					
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 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	Cost to Complete	Total Cost
JASON ST-01	1.190	1.512	1.500	1.500	1.500	1.500	1.500	1.500	Continuing	Continuing

(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, 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 2000 Accomplishments:

- JASON. ($ 1.190 Million)
  - Continued studies of interest to DoD in multiple disciplines such as: counter proliferation of chemical and biological weapons; space based radar; small payload space launch systems; advanced computing; multi-layered infrastructure defense; advanced sensor technologies including increased radar noise floor and deep buried target characterization; dispersed land forces technology; battlefield information systems and military communications; ultra low power electronics; fiber lasers; and self-monitoring materials.

(U) FY 2001 Plans:

- JASON. ($ 1.512 Million)
  - Continue 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.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE June 2001
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-01

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

(U) Other Program Funding Summary Cost:

- Not Applicable.

(U) Schedule Profile:

- Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)					DATE June 2001					
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 2000	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	71.454	74.900	87.303	61.536	58.362	58.057	68.057	68.057	Continuing	Continuing

(U) Mission Description:

(U) This project develops new information processing technology concepts that will lead to fundamentally new software and intelligent systems capabilities. This will enable advanced information systems to more effectively accomplish decision-making tasks in stressful, time sensitive situations and create efficient software-intensive defense systems.

(U) A major consideration in military missions is the ability to exploit large quantities of heterogeneous data gathered from a multiplicity of sources, languages and modalities (text, speech, video, etc.). Key technical challenges lie in being able to (a) develop "dialog interaction" for warfighters to talk with computers, and through these computers, to command centers in a hands-free fashion to allow the warfighter to use their hands for more critical warfighting efforts; (b) retrieve, summarize and extract information from multiple foreign language streams through the development of machine translation and automatic construction of information products; and (c) access, organize and disseminate information contained in large, dynamic, multi-media document streams. This involves developing repository techniques for rigorously registering and classifying multimedia document streams, integrating knowledge, and effectively employing statistically based techniques for extracting critical content from large volumes of data.

(U) The Situation Analysis component is comprised of the Information Management (IM) program which will develop persistent identification, registration, and tracking of digital objects, to create an information representation which incorporates unique naming, descriptive hierarchical or granular organization of multi-media data streams. The IM program will develop algorithms and tools for clustering, classifying, visualizing, navigating and extracting critical data from extreme high volume sources. The greatest challenge in this project is the development of algorithms that can keep up with the rapid change of information and arrival of multiple data streams in high volume during a crisis. DARPA's IM program will provide the Defense analyst with the capability for high performance retrieval, search and extraction of data by developing repository technology as well as analysis environments in an interoperable framework. The technology developed by IM is being evaluated on testbeds for the Unified Commands.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE June 2001
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 Situation Presentation and Interaction component is comprised of DARPA's Communicator program. Warfighters in the field are called upon to respond rapidly to a wide range of unpredictable situations that require collective actions across services and components. DARPA's Communicator program will develop the intuitive, hands-free, mobile, networked access to information and the ability to create new information for others using spoken language. The Communicator program will provide the warfighter with wireless, mobile, networked communication devices to communicate with command centers, logistics services and support forces on the battlefield without touching a keyboard. Dialog interaction software distributed in a network of smart devices will use a new "dialog management and context tracking" capability to facilitate interactions among human users as well as suites of computer applications. Key technical problems to be overcome include: (a) the analysis of spoken information in the context of a particular problem; (b) natural generation of information in context; and (c) anytime, anywhere intuitive access to information.

(U) The Intelligent Software for Multi-Lingual and Coalition Environments component is comprised of the Translingual Information Detection, Extraction and Summarization (TIDES) program. The TIDES program will develop machine translation ability for a set of foreign languages, at State Department Level 3 (defined as the level at which fluent communication is possible). Key new techniques for machine translation are statistically based corpus analysis tools, which enable the automatic extraction of grammar and vocabulary of foreign languages. It is expected to reduce the time required for developing level 3 knowledge by a factor of 10-15. The TIDES program will also acquire and utilize knowledge through a multi-stage process of query formulation, information retrieval, document translation, topic identification, information extraction and content summarization. The key insights into the methods pioneered in TIDES come from the realization that these goals are not sequential and independent but are interrelated. This inter-dependence can be exploited by information lattices which provide both feedback and feedforward into what used to be serial processes. The TIDES goals are to achieve 85 percent accuracy in topic identification; 80 percent accuracy in people, places and event identification; and 70 percent accuracy in establishing relationships among identified entities.

(U) The Composable High Assurance Trusted Systems (CHATS) program is developing the tools and technology that enable the core network services to protect themselves 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 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.

(U) The DARPA Agent Markup Language (DAML) program will develop military software tools for use on InteLink and the emerging C2Link system. The program's focus is to develop technologies to enhance interoperability; that extend the reach of the World Wide Web to include program, sensors, and other data sources, and to enable agent-based programs to use these information sources. DAML will develop a

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE June 2001
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-11

software language that ties the information about a web resource to machine-readable semantics (ontology), including ontologies for InteLink briefings and military operations. This effort will provide new technologies for the intelligent integration of information across a wide variety of heterogeneous military sources and systems in real time.

(U) 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 developed technologies will be evaluated in challenge problem experiments in the domain of microbiology and bioinformatics. Technology challenges to be addressed include direct knowledge entry by non-AI experts, coordinating entry of possibly overlapping and inconsistent knowledge by multiple geographically distributed individuals, and achieving a knowledge entry rate without AI training of twice that of today's AI expert which also results in an enormous and comprehensive knowledge base (10^6 axioms).

(U) Under the Taskable Agent Software Kit (TASK) program, software agent creation tools will be developed that reduce the per-agent development/customization cost for advanced military systems. Software agents are a next generation of software that will be able to automatically accept abstract tasking, get needed information, decide how to solve simple problems, help the user solve difficult problems, route useful information and otherwise take action on the user's behalf. This effort will explore mathematical techniques in the areas of Control Theory, Decision Theory, and Operations Research for correctly modeling and analyzing agent environments and the behaviors of agents in these environments. Experiments will reveal the qualitative aspects of environments that favor the use of agent-based systems over object-based systems. Models derived from this program will allow the development of rigorous qualitative and quantitative comparisons of agent behaviors with respect to domain and problem features.

(U) The Human Identification at a Distance (HumanID) program objective is to develop automated multi-modal, multi-biometric surveillance technology for identifying humans at a distance as an enabler for force protection and early warning against Asymmetric Threats. HumanID redefines and renames the program formerly known as Image Understanding for Force Protection (IUFP) to more fully represent the technologies being explored under this program. HumanID seeks to improve individual biometric technologies with multiple sensor signatures for multi-range, round-the-clock processing. The goal of this project is to positively identify humans at a distance, at any time day or night, during all weather conditions, with non-cooperative subjects, possibly disguised and alone or in groups. This program is funded in the Asymmetric Threat project (ST-28) beginning in FY 2001.

(U) The High Confidence Computing Architectures project will realize the promise and potential of nano-computational devices and materials for building computational architectures with high functionality for perennially computationally hungry and multi-mission adaptive DoD applications. Future high capacity/high confidence computing systems face some basic issues: (1) extensibility of Moore's Law; (2) availability/

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE June 2001
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-11

reliability of large scale computing systems; (3) integral architectural security; and (4) economic viability of narrowly focused computing solutions. The techniques for architecting, constructing, and programming computational systems from nano-devices require the development of novel methods quite different from current methods, relying on precise interconnections of reliable parts. Architecture and functionality are best designed based on local interaction and self-assembly of devices, in 2-D or 3-D. The programming and use of such a system will be based on time-varying and irregular interconnections of devices. This program will develop breakthrough-enabling technologies for the construction and use of systems incorporating vast numbers of nano-devices that can be manufactured and deployed without precise control of placement or interconnect and without individual testing.

(U) Program Accomplishments and Plans:

(U) FY 2000 Accomplishments:

- Situation Analysis. ($ 25.825 Million)
  - Demonstrated statistically based semantic analysis capabilities.
  - Developed persistent queries for audio and video streams to detect user-defined significant events and to generate alerts.
  - Demonstrated distributed prototype of information-value-based retrieval.
  - Demonstrated scalable implementation of public and secure versions of Digital Information Pheromones (DIP) characterization of network resources.
  - Developed component theory building technologies enabling direct knowledge entry by artificial intelligence novices.
  - Demonstrated language and diagram interface, analogic reasoners, and theory explanation capabilities, as well as, developed 10-20 core theories (5K-10K axioms each).
  - Developed mathematical techniques for modeling and analyzing agent behaviors.

- Situation Presentation and Interaction. ($ 25.284 Million)
  - Specified network-based service architecture Application Program Interface's (API's) for key components of dialogue architecture.
  - Demonstrated usability of dialogue interaction with confirming sub-dialogue to reduce task completion time by 80%, using metrics-based evaluation.
  - Evaluated dialog for small unit logistics demonstrated in the Listen, Communicate, Show (LCS) Marine project.
  - Expanded dialog evaluation beyond the travel scenario with method for cross task comparison.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE June 2001
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-11

- Expanded dialog interaction into vehicles with initial investigation of feasibility within acoustic environment of automobiles.
- Expanded dialog interaction with information services for more natural automatically generated dialogue and speech.
- Developed preliminary ontology for InteLink briefings and released initial language design specifications.

- Intelligent Software for Multi-lingual and Coalition Environments. ($ 12.122 Million)
  - Developed a translingual C4I database for use in U.S. and Republic of Korea coalition operations.
  - Demonstrated with operational users an automated translation of briefing documents, cross language information retrieval (Korean and English), and speech-to-speech translation (English-Korean).
  - Expanded investigation into capability of providing machine translation capabilities for new language pairs with smaller sized training corpora.
  - Implemented TIDES open system architecture version 0.1 providing a web-based environment to support plug-in component experiments.
  - Conducted experiments involving humanitarian assistance/disaster relief/consequence management in cooperation with Third Fleet.

- Intelligent Sensor Processing (Human Identification at a Distance). ($ 6.223 Million)
  - Initiated theoretical studies of candidate biometric features, analysis of biometric technologies, Concepts of Operations and scenario development for human identification from a distance.
  - Began generation of a database containing known biometric feature data for metric-based evaluation of candidate techniques.

- Reuse Technology Adoption Program (RTAP). ($ 2.000 Million)
  - Identified technologies for definition and specification of agile components.
  - Developed business model to explore ways to reduce the time to get advanced DARPA technologies into the hands of the military services.

(U) FY 2001 Plans:

- Situation Analysis. ($ 17.822 Million)

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE June 2001
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-11

- Deploy scalable prototype analysis environment in defense application with cross-repository information analysis functionality (semantic retrieval, indexing, value filtering, user defined alerting, and categorizing).
- Demonstrate secure distributed repository architecture supporting digital objects of arbitrary type.
- Develop and conduct value-added evaluation.
- Demonstrate direct knowledge entry by a novice (2K axioms/month) for a military problem.

- Situation Presentation and Interaction. ($ 15.592 Million)
  - Demonstrate and evaluate dialogue performance for Project Marine; complete a complex travel task requiring negotiation twice as fast with automated service support as with the best human assistance.
  - Demonstrate and evaluate interaction of tasks with real-time, web-based, public data.
  - Demonstrate in-vehicle dialogue for information services and navigation.
  - Identify short, intermediate, and long-term core Automatic Speech Recognition (ASR) research objectives - emphasizing high risk, high yield algorithm development.

- Intelligent Software for Multi-lingual and Coalition Environments. ($ 20.256 Million)
  - Extract, translate, and correlate named entities from unstructured documents in multiple languages.
  - Demonstrate initial summarization in English of foreign language documents using frame semantics.
  - Release initial version of comprehensive, cross-language processing architecture for eventual standardization.
  - Experiment in multilingual, intelligence analysis, demonstrating benefits of cross-language information extraction, detection, and summarization capabilities.
  - Demonstrate initial toolkits for rapid development of cross-language capability in minority or other new languages.

- DARPA Agent Markup Language (DAML). ($ 13.135 Million)
  - Complete DAML language specifications.
  - Release working version of Briefing Tool for Intelink.
  - Release working version of DAML Search Tool on Intelink.
  - Release working version of DAML Ontology Creation Tool on Intelink.
  - Define requirements to DAML for supporting non-pre-planned Agent interoperations.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE June 2001
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-11

- Demonstrate utility of DAML Ontology Creation Tools to enhance the storage, access and organization of archival information at the Center for Army Lessons Learned.
- Develop first order rules for data extraction and update rates for web information cached remotely.
- Investigate alternative approaches to composable high assurance trusted systems based on the Robust Open Source development model.
- Investigate the feasibility of and alternative approaches to high assurance trusted implementation languages and tools.
- Investigate 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). ($ 5.315 Million)
  - Define metrics for analysis of agents in the C4I military environment.
  - Perform agent-design method experiments.

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

(U) FY 2002 Plans:

- Situation Presentation and Interaction. ($ 8.904 Million)
  - 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 Quantico Marine Base.
  - Define and publish final (release) version of the Galaxy-II+ 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.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE June 2001
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-11

- Evaluate a follow-on research program for dialog systems.

- Intelligent Software for Multi-Lingual and Coalition Environments. ($ 25.286 Million)
  - Demonstrate methods for Machine Translation development in languages for which annotated corpora and dictionaries do not yet exist.
  - Demonstrate methods for minority language translation in a South American language related to drug intervention.
  - Develop Level-1 capability for a new language (rudimentary knowledge of the foreign language and an ability to effectively use a bilingual dictionary) in 1 month.
  - Explore methods for comparable as well as parallel corpora (text in two languages about the same topics, but not sentence by sentence translations of each other) in statistical machine translation and apply them in Chinese.
  - Demonstrate new story detection capability and baseline performance measures for future efforts.
  - Demonstrate bioprecursor feature extraction application using broadcast and public news about public health and related issues.
  - Demonstrate "delta" information provision (providing only what's different from before) in a portal for broadcast news.
  - Retrieve information from European language documents with English queries 75% as well as English Information Retrieval.
  - Demonstrate 15% improvement in monolingual information retrieval using an information web infrastructure of entities, events, and threads.
  - Demonstrate cross document, cross language summarization in multiple languages.
  - Experiment in automatic biography or narrative generation using time-ordering summarization techniques.
  - Demonstrate integration of topic detection, named entity extraction, and summarization in a web portal across news sources in multiple languages.
  - Demonstrate effective access to on-line Arabic audio and text sources.
  - Develop TIDES Architecture 1.0 for plug-and-play compatibility among research components for specified end-to-end multilingual applications.
  - Perform Strong Angel operational prototype evaluation for RimPac '02 using real intelligence operators.

- Composable High Assurance Trusted Systems (CHATS). ($ 7.400 Million)
  - Develop an operational prototype of the Composable High Assurance Trusted System.
  - Develop operational capability of candidate high assurance trusted implementation language and tools.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE June 2001
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-11

- 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). ($ 15.882 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.
  - Develop technology for dynamic prioritization management.
  - Develop technology for intelligent information delivery under changing bandwidth conditions.

- Rapid Knowledge Formation. ($ 12.960 Million)
  - Demonstrate knowledge entry rate of 50K axioms/month from each of 25 subject matter experts in a biowarfare challenge problem.
  - Assess multi-user (40-50 individual) system design.
  - Resolve scaling bottlenecks.
  - Create complex theories using undergraduate biology and medical curricula.

- Taskable Agent Software Kit (TASK). ($ 6.871 Million)
  - Publish correct mathematical techniques for modeling and analyzing agent behaviors.
  - Perform empirical validation experiments.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE June 2001
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. ($ 10.000 Million)
  - Investigate basic composition technologies, such as computing materials, computational devices, memory systems, communication fabrics, storage devices and software.
    Identify potential application problem set and technical, economic and market requirements.

(U) Other Program Funding Summary Cost:

- Not Applicable.

(U) Schedule Profile:

- Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)					DATE June 2001					
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 2000	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	158.266	125.346	157.666	132.838	152.338	169.743	169.743	179.743	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 the following components:

(U) The Global Mobile Information Systems effort enabled mobile wireless users to automatically form ad hoc networks and to exchange a wide range of information both within the ad hoc network and between wireless and fixed networks. This program developed technologies to: ensure the robust and secure operation of the network, dynamically adapt bandwidth to Radio Frequency (RF) environment, and dynamically reconfigure the network to counter jamming and to provide highest quality-of-service. The program developed and integrated technologies and techniques at the networking, wireless link/node, and applications levels, enabling access to and utilization of the full range of services available in the Defense Information Infrastructure. This program ended in FY 2000.

(U) The Networking component develops active networking technologies and associated network management capabilities to support a new paradigm of Internet Protocol (IP) routing and transmission and deeply networked systems. Research is coordinated with DoD, NASA, DoE, NSF and other federal agencies.

(U) The Data Intensive Systems and Software component develops software and hardware technologies for data-starved applications. This component will develop a new approach to computer memory organization that will eliminate severe bottlenecks in present designs.

(U) The Adaptive Computing Systems (ACS) program develops new approaches to the design of computer hardware that incorporates dynamic configuration capabilities. The resultant devices will allow 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. In addition, the ACS project is developing software and component level technologies for use in embedded systems that leverage novel signal processing technologies. The Mission Specific Processing

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE June 2001
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-19

(MSP) program extends Adaptive Computing Systems (ACS) technologies to support the design of highly optimized embedded processors that are required in the most severely constrained DoD applications. The technology developed by the Mission Specific Processing (MSP) program will facilitate high performance processing in future space-based and/or miniature systems that require extremely high processing throughput while consuming the minimum possible volume, weight and power. Because of its applications focus, funding of MSP will continue in FY 2002 from PE 0602702E, Tactical Technology, Project TT-06, Advanced Tactical Technology.

(U) The Ultra High-Performance Networking Applications component will develop robust, survivable inter-networking architecture that will minimize vulnerability posed by the growing complexity and brittleness that is seen across physical layer networking architectures today. In the Real-time Gigabit Flow Applications component of this project, new gigabit per second communication capabilities over alternate physical media will be demonstrated such that gigabyte flow transfers can be demonstrated to sites lacking in fiber infrastructure and connectivity. Multi-channel techniques in temporal, spatial, and spectral domains will be invoked to enable the new capabilities.

(U) The Systems Environments component develops scalable software, which is tailored toward easing the use of systems by application programmers. This includes run-time services, resource allocation, and experimental applications. Additionally, it will develop technology to support faster, more reliable development of software for distributed embedded software for intelligent systems. This technology will enable programmers to safely introduce cross-cutting aspects such as synchronization, fault tolerance, and memory hierarchy management into basic programs that implement intelligent software interaction with a diverse suite of sensors and actuators in real-time.

(U) The Signal Processing and Power Aware Computing component is developing: 1) software and component level technologies for use in embedded systems that leverage novel signal processing technologies; and 2) innovative power management strategies, at system through chip level.

(U) A follow-on to the Defense Technology Integration effort budgeted in previous years, the Mobile Code Software program 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.

(U) Future defense uses of the network will have an increased emphasis on the direct exchange of real-time sensor-derived information among autonomous embedded devices. This reflects a significant change in network traffic from the present environment, which is dominated by the

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE June 2001
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-19

exchange of symbolic information among human users. The architectures and protocols needed to effect this transition will be investigated in the Networked Embedded and Autonomous Software component of this project. The autonomous software component will develop embedded software technologies for programming autonomous mobile robots to perform a variety of military tasks. The task of explicitly programming mobile robots to operate independently in complex, dynamic environments, such as those relevant for military applications, has thus far proven intractable. Conventional, direct programming strategies attempt to micro manage all top-level goals and constraints from the bottom up. That approach has proven unacceptably brittle, since it requires accurate knowledge of every possible contingency, a priori. This program is pursuing several alternative approaches to synthesizing innate (pre-programmed) competencies with learning-derived competencies for perception and control similar to the way biological systems work. The long-term goal is to enable future programming of autonomous mobile robots for real world, military missions as easily as we program assembly line robots in the auto industry.

(U) The goal of the Systems Engineering for Miniature Devices (SEMD) program is to utilize a systems methodology for integrating miniature device technology that traditionally occurs in a disparate fashion. This research project includes 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) Information Technology Expeditions will develop technologies for software programmable adaptive computing systems. These are devices whose hardware is exposed to software for changing their functionality, algorithms, and power/energy consumption. Such devices are important for deeply networked components such as mobile computing elements whose functionality needs to be changed depending on the applications, level of battery power and speed of response.

(U) The Mixed Initiative Control of Automa-teams (MICA) program will develop the theory, algorithms, software, modeling and simulation technologies to coordinate multi-level planning, assessment and control of distributed semi-autonomous forces with collective objectives through the hierarchical application of systems and control theoretic methods. The MICA program will provide a commander the operational and mission planning tools to select optimal team composition, tasking and sub-tasking appropriate for mixed initiative control of automatons in a military operational environment.

(U) The Augmented Cognition program focuses on software power tools to augment the warfighter's cognitive capabilities. This is a new area for expanding human capabilities using information technology that is similar to the augmentation of the human through devices like weapons, vehicles, and sensors. The hypothesis is that impressive progress in neural science, computation, and miniaturization can now be leveraged to enable

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE June 2001
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-19

new concepts of warfare. Success will provide significant advantage to our warfighters. Exploratory efforts in augmented cognition have demonstrated that there are order of magnitude improvements to be gained through improving the spatial, temporal and sensory inputs to human operators. The Augmented Cognition effort will develop methods to integrate digital support for memory, perception, and thinking and then link that support with context state information to directly improve the cognitive performance of the warfighter.

(U) The High Productivity Computing Architecture program creates a new generation of high productivity computing systems characterized by balanced system architecture including high effective bandwidth, robust implementation, and responsive software/hardware components. These new systems will address the inherent difficulties associated with the development and use of current high end systems and applications such as programming productivity, performance portability, scalability, reliability, and tamper resistance. This program is targeting the high end computing medium to long term national security application requirements where U.S. superiority is threatened.

(U) The Robust High Assurance Systems program will extend recent advances in quality-of-service (QoS) assurance technologies (such as bandwidth and processor reservation, feedback control, and dynamic adaptation) to accommodate other mission critical properties, including dependability and security, providing a technology base for the development of high confidence distributed embedded systems. Activities include: (1) development of a framework that allows security and dependability attributes to be explicitly considered as QoS properties and that further allows application security and dependability requirements to be balanced against its performance needs; (2) development of robust high assurance QoS mechanisms and managers that are resistant to compromise; (3) incorporation of trust and reliability models into resource management decisions; (4) integration of security modeling and failure detection with performance monitoring as triggers for adaptive resource management; (5) development of robust, stable adaptation algorithms that are resistant to exploitation; and (6) development of policy tools for controlling these mechanisms.

(U) The Mobile Wireless Networking program will develop the technology required to significantly enhance the survivability of mobile and wireless tactical networks. These technologies will ensure future combat networks will continue operation during attack, defeat attempts to disrupt and exploit tactical battlefield communications, and recover from damaging attacks while maintaining the security of network traffic. Additionally, these technologies will enable the secure and rapid creation of mobile and wireless communications networks within hostile environments for military operations.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE June 2001
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) Program Accomplishments and Plans:

(U) FY 2000 Accomplishments:

- Global Mobile Information Systems. ($ 13.107 Million)
  - Developed prototype of high data-rate untethered nodes incorporating adaptive link controls and frequency agile RF front end with capability to adapt to available spectrum frequencies.
  - Demonstrated self-organizing, self-healing mobile wireless networks supporting Quality of Service (QoS) routing utilizing Internet and Asynchronous Transfer Mode (ATM) networks.
  - Demonstrated network security techniques, including over the air re-keying, in mobile wireless multihop network.
  - Integrated GloMo simulation models and conducted scenario simulations for mobile wireless networks (100 to 10,000 nodes).

- Networking. ($ 36.832 Million)
  - Demonstrated use of active network approach to achieve live protocol updates within two roundtrip times.
  - Provided initial release of prototype active network toolkits for end-user stations and network elements including performance measurement capabilities.
  - Provided engineering analysis of active network performance.
  - Initiated development of new models of traffic and network applicable to varying scales of time and network sizes, which are suitable for predicting network behavior.
  - Initiated building a network measurement methodology to support near real-time prediction using modeling and simulation tools.
  - Designed and demonstrated prototype software for a digital amphitheater using gigabit interconnectivity.

- Data Intensive Systems and Software. ($ 20.656 Million)
  - Designed processor in memory very large scale integration (VLSI) components that support in situ processing of application data.
  - Implemented compiler that generates code compatible with processor in memory architecture.
  - Simulated data-intensive systems, demonstrated 10-fold performance improvement on critical DoD applications.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE June 2001
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-19

- Adaptive Computing Systems (ACS). ($ 24.782 Million)
  - Implemented initial Adaptive Computing Systems (ACS) analysis and development tools.
  - Developed high-level design entry tools/development environments for ACS, e.g., for Java, C, MatLab, Khoros.
  - Completed fabrication of single clock cycle context-switchable reconfigurable computing device.
  - Implemented ACS reference platforms and supporting development environment.
  - Demonstrated ACS self-test, diagnosis and reconfiguration for fault tolerance.
  - Published updated ACS benchmarks.

- Systems Environments. ($ 23.100 Million)
  - Released reference implementation of mission-critical Quality of Service (QoS) architecture.
  - Released prototype operating system with partitioned resource management for strict QoS guarantees.
  - Provided a joint demonstration of QoS management software with Aegis advanced computing testbed; demonstrated interoperability of combat and Command, Control, Communications Intelligence Surveillance Reconnaissance (C4ISR) functions through over-the-horizon track correlation and engagement deconfliction; demonstrated scalable resource management to handle Theater Ballistic Missile (TBM) debris fields incorporating initial trend analysis capability to predict and prevent deadline violations.

- Signal Processing and Power Aware Computing. ($ 19.201 Million)
  - Implemented prototype multiprocessor event collection and analysis system and automated stress test generator for signal processing applications; demonstrated use of high performance signal processing for weapon systems applications.
  - Initiated Power Aware Computing and Communication (PAC/C) individual power aware technology research efforts.
  - Initiated early exploration of power aware tool frameworks, databases and metrics.
  - Explored potential operational environmental effects on low power electronics.
  - Developed novel architectures for reprogramming field programmable gate arrays using adaptive software.

- Defense Technology Integration. ($ 12.636 Million)
  - Mobile Code Software.
    - - Analyzed ability of autonomous software to predict, negotiate and track resource requirements under changing environment and time constraints.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE June 2001
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-19

- - Developed strategy for the rapid assessment of computation cost of complex sets of constraints.
- - Implemented software toolkit for knowbot development, generation and deployment.
- - Created experimental platform for negotiation-based real-time resource management.
- - Measured the real-time base line for different negotiation protocols using the experimental platform.

– Information Technology Expeditions.
- - Developed architectures for secure collaboration over an unreliable and dynamic network.
- - Developed power and energy aware operating systems for mobile computing elements.

- Next Generation High End Computers Required for National Security. ($ 3.091 Million)
  – Developed massively parallel processor (MPP) computers that minimized porting effort from current vector platforms.
  – Demonstrated use of MPP architecture for interactive National Security applications.

- Systems Engineering for Miniature Devices. ($ 4.861 Million)
  – Established the infrastructure to carry out integrated micro-miniature device research.
  – Developed a collaborative environment for the integrated, concurrent design of all aspects of a micro-miniature platform.

(U) FY 2001 Plans:

- Networking. ($ 24.045 Million)
  – Investigate alternative approaches to large-scale network engineering including simulation technology.
  – Demonstrate performance improvements of 100 percent for large multicast sessions based on active suppression of redundant acknowledgement and retransmission messages.
  – Integrate active network capabilities into Run-Time Infrastructure (RTI) for use with high-level architecture (HLA)-compliant simulations; prepare for joint demonstration with Defense Modeling and Simulation Office (DMSO).
  – Develop models of network control suitable for on-line parameter tuning, dynamic reconfiguration, fault detection, and for meeting DoD mission critical requirements.
  – Validate modeling and simulation tools, and demonstrate predictive power of the models using measured network data.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE June 2001
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-19

- Implement and demonstrate application non-specific congestion manager that coordinates and ensures fair throughput for multiple applications.
- Test radar image enhancement using coherent processing of signals from multiple radar sources connected by a very high-speed network.
- Develop survivable key management and distribution architectures to protect against compromise and enable rapid network recovery and reconstitution.

- Data Intensive Systems and Software. ($ 11.699 Million)
  - Prototype demonstration of processor in memory (PIM) array.
  - Demonstrate advanced cache-based approaches for data-intensive applications.

- Adaptive Computing Systems (ACS). ($ 18.981 Million)
  - Implement final Adaptive Computing Systems (ACS) design tool suites using high-level entry, e.g., for Java, C, Matlab, and Khoros.
  - Demonstrate 100x – 1000x reduction in compilation time for ACS implementations.
  - Implement C compiler for hybrid chips.
  - Implement ACS/heterogeneous processing Matlab design environment.
  - Implement selected benchmark algorithms using ACS automated development environmental/tool aided design.
  - Demonstrate ACS defense system insertion for high dimensionality sonar beamforming, synthetic aperture radar (SAR), signal processing, and automatic target recognition (ATR).
  - Extend ACS development tools to support application specific integrated circuit (ASIC) development for highly constrained signal processing applications.
  - Define requirements for tool enhancements needed to implement ASICs.
  - Begin design of platform independent development tools.
  - Define 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.
  - Begin the design of custom cell libraries and module generators.
  - Begin simulation and verification of custom design techniques.
  - Complete wideband adaptive radar system architecture study.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE June 2001
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-19

- Systems Environments. ($ 26.243 Million)
  - Release prototype distributed object software with real-time Quality of Service (QoS) management.
  - Demonstrate support for mixed workloads of hard, soft, and non-real-time applications.
  - Demonstrate QoS-driven fault detection and recovery within 500 milliseconds.
  - Develop intermediate representations and mechanisms for code composition and transformation.
  - Develop models, specifications, code interpretations, and implementation mechanisms for embedded systems aspects, such as timing and fault tolerance.
  - Develop common graph-based program representations for software analysis.
  - Develop initial reusable embedded system aspect software.
  - Perform initial assessment of using security monitoring to trigger adaptation (detection latency, effectiveness of response, stability).

- Signal Processing and Power Aware Computing. ($ 20.455 Million)
  - Demonstrate flight-capable Synthetic Aperture Radar (SAR)/Automatic Target Recognition (ATR) system recognizing 30 target types in presence of camouflage concealment deception.
  - Prototype demonstrations of power aware technologies.
  - Identify potential small and medium scale power aware prototype candidates.
  - Define plug-in-component parameters and metrics.
  - Initiate primary power aware framework tool suite efforts and Application Program Integration (API) standardization efforts.

- Mobile Code Software. ($ 17.782 Million)
  - Demonstrate and evaluate software agent's ability to approximate behavior tradeoffs and to utilize negotiation in advanced logistics scenario with a 3-second response requirement.
  - Demonstrate and evaluate software agent's ability for bottom-up organization in advanced logistics scenario with 100-1,000 components.
  - Prototype implementation of negotiation technology in real-time scenario with a 500-millisecond response requirement.
  - Develop methods for maintaining and updating critical information (system and resource states, global time, etc.) system-wide, without centralized depository.
  - Investigate event/time triggered system synthesis methods subject to time, functional, performance, safety and security constraints.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE June 2001
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-19

- Investigate design methods of embedded generators that guarantee selected behaviors of the generated systems.

- Information Technology Expeditions. ($ 2.691 Million)
  - Demonstrate adaptive reprogramming of hardware within a single clock cycle.
  - Define 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)
  - Continue developing massively parallel processor (MPP) computers that minimize porting effort from current vector platforms.
  - Continue demonstrating use of MPP architecture for interactive National Security applications.

(U) FY 2002 Plans:

- Active Management and Control of Networks. ($ 18.797 Million)
  - 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.
  - 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.
  - Develop reduced order and aggregate models of network suitable for faster prediction and control; and characterize accuracy.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE June 2001
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 the ability to predict internal and end-to-end behavior of large networks at multiple time scales and resolutions.
- Implement models and control strategies in a wide area experimental 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 Applications. ($ 24.731 Million)
  - Ultra High-Performance Access.
    - - Prototype 40 Gbps interface card for network and sensor I/O.
    - - Design secure communication interfaces for gigabit-end flows.
    - - Demonstrate scaling of port controller speeds by an order of magnitude.
    - - Develop and demonstrate optical access nodes based on fast tunable-channel transmitters.
    - - Demonstrate gigabit wireless router that uses adaptive protocols.
    - - Prototype quality of service-based resource management algorithms for adaptive gigabit wireless routers.
    - - Prototype advanced protocol for routing finest grained flows.
    - - Design metadata for service components, sensors and devices, together with service registration mechanism.
    - - Demonstrate search engines for distributed services and devices. - - Simulate a lightweight protocol (non-GPS-based) for high-accuracy geo-localization.
    - - Design wireless multi-hop algorithms for establishing network connectivity within a window of a few seconds.

  - Real-Time Gigabit Flow Applications.
    - - 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.
    - - Construct a portable node with multi-gigabit wireless interfaces.
    - - 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.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE June 2001
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 multiple video blanket media streams and client side browsers for display of these streams.

- Systems Environments. ($ 17.000 Million)
  - Develop techniques for incremental (partial, completion) software analysis.
  - Develop techniques for incremental formal transformation.
  - Develop deterministic and probabilistic timing services for time-based aspects.
  - Develop Quality-of-Service (QoS) aware data persistence services.
  - Demonstrate pair-wise interacting aspects and transformation strategies.

- Power Aware Computing. ($ 16.360 Million)
  - 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.

- Mobile Code Software. ($ 13.850 Million)
  - Demonstrate ability to identify and characterize autonomous negotiation targets needed for negotiated cooperation.
  - Demonstrate ability for hierarchical coalition formation.
  - Demonstrate negotiation protocols for large, hierarchically organized coalitions.
  - Integrate utility for the selection of negotiation strategies.
  - Demonstrate stable goal tracking ability under changing environment.
  - Demonstrate avoidance of conflict by changing plans.
  - Prototype implementation and evaluation of negotiation in real-time mission planning.
  - Prototype implementation of adaptive scans scheduling using negotiation protocols.
  - Demonstrate ability to negotiate tasks in electronic countermeasures and common challenge problems in less than 20 minutes.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE June 2001
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-19

- Networked Embedded and Autonomous Software. ($ 30.000 Million)
  - Conduct experimental and theoretical investigations on phase-transition effects in constraint satisfiablity problems.
  - Investigate methods for the prediction of characteristics and for the detection of proximity of phase transitions.
  - Develop experimental prototypes for transition-aware constraint solvers.
  - Develop scalable, lightweight, fault tolerant coordination-services (time, consensus, synchronization and replication) for network embedded software technology applications.
  - Investigate deterministic and probabilistic methods for self-stabilizing protocols.
  - Investigate design approaches for the customization of coordination-services.
  - 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.
  - 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.
  - Demonstrate adaptive generation of complex behaviors.
  - Demonstrate multi-sensor based, autonomous navigation.
  - Demonstrate scalable behavior autonomous control laws.
  - Demonstrate robust planning using Markov decision models for plan adaptation.

- Mixed Initiative Control of Automa-teams (MICA). ($ 12.000 Million)
  - Develop technologies, algorithms and software tools for ordering task execution and optimizing team member collaboration.
  - Cultivate collective trajectory generation technology for teamed entities with collision avoidance and threat avoidance or engagement.
  - Develop technologies, algorithms and software tools delivering recommended courses of actions to a commander or operator with appropriate feedback information.

- Augmented Cognition. ($ 8.128 Million)
  - Conduct initial demonstration and evaluation to show that an over-abundance of sensor information can be transformed into actionable information using augmented components of memory, perception and thinking.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE June 2001
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 spatial and temporal coding techniques to augment human memory and information aesthetics to significantly improve cognitive utility.
- Perform evaluations of methods to combine human and digital memory that extend normal performance for human cognition.

- High Productivity Computing Architecture. ($ 10.000 Million)
  - Identify application requirements.
  - Initiate productivity benchmarks and stressmarks.
  - Develop innovative programming models and virtual machine forms.
  - Explore scalable computing programming and profiling techniques.

- Robust High Assurance Systems. ($ 6.800 Million)
  - Establish cost/benefit framework for security and dependability properties and quantitative methods for reasoning about benefits/risks of selected properties.
  - Develop basic suite of secure, robust Quality of Service enforcement mechanisms and management services.
  - Demonstrate algorithms and techniques for providing controlled sharing of medium access, providing traffic cover and patterns.

(U) Other Program Funding Summary Cost:

- Not Applicable.

(U) Schedule Profile:

- Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)					DATE June 2001					
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research					R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-22					
COST *(In Millions)*	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	Cost to Complete	Total Cost
Software Engineering Technology ST-22	16.630	17.839	0.000	0.000	0.000	0.000	0.000	0.000	0.000	N/A

(U) Mission Description:

(U) Software is key to meeting DoD's increasing demand for high quality, affordable, and timely national defense systems. There is a critical need to rapidly transition state-of-the-art technology and best practices to improve the acquisition, engineering, fielding, and evolution of software-intensive DoD systems. This project funds the technology transition activities of the SEI at Carnegie Mellon University. The SEI is a Federally Funded Research and Development Center (FFRDC) sponsored by the Office of the Under Secretary of Defense (Acquisition, Technology, and Logistics). It was established in 1984 as an integral part of the DoD's software initiative to identify, evaluate, and transition high leverage technologies and practices, and to foster disciplined software engineering practices by DoD acquisition and life cycle support programs and within the industrial base where the bulk of defense software is produced. The Institute works across government, industry, and academia to: (1) improve current software engineering activities from both management and engineering perspectives; (2) facilitate rapid, value-added transition of technology into practice; and (3) evaluate and calibrate emerging technologies to determine their potential for improving the evolution of software-intensive DoD systems.

(U) The SEI enables the exploitation of emerging software technology by bringing engineering discipline to software acquisition, development, and evolution. The SEI focuses on software technology areas judged to be of the highest payoff in meeting defense needs. FY 2000 focus areas were: Technical Engineering Practices (including Survivable Systems practices, Architecture-centered Software Engineering, and Commercial Off-The-Shelf (COTS)-Based Software Engineering); Enhanced Software Management Capabilities (including personal and team software development processes and Capability Maturity Model Integration (CMMI)); and accelerating Adoption of High Payoff Software Technologies.

(U) Beginning in FY 2002, the funding for the Software Engineering Institute (SEI) has been transferred from DARPA to the Office of the Under Secretary of Defense (Acquisition, Technology, and Logistics) under PE 0603781D8Z. This transfer aligns the funding authority with the program management oversight responsibilities for the SEI program. In keeping with this decision, FY 2001 SEI funds were transferred via Internal Reclassification Reprogramming action.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE June 2001
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-22

(U) Program Accomplishments and Plans:

(U) FY 2000 Accomplishments:

- Software Technical Engineering Practices. ($ 9.832 Million)
  - Defined and piloted a method for survivable network technology analysis. Developed security self-evaluation method and training. Version 1 of product line acquisition guidelines and courses made available for use by DoD. Courses for training software engineers in the development of COTS-based systems were made available. DoD-based data on the benefits and costs of architecture analysis methods were made available.

- Software Engineering Management Practices. ($ 4.370 Million)
  - Updated and released Capability Maturity Model Integration (CMMI) training, assessment and other products based on Government and industry use and feedback. Data made available showing the benefits, costs, and appropriate conditions for use of Team Software Process.

- Adoption of Software Technologies. ($ 2.428 Million)
  - Developed guidebook for introducing technology change into organizations. Developed additional guidance for use of metrics in software acquisition and development. Continued to provide software measurement support to all initiative work to ensure performance measures were established. Provided transition planning and measurement support to SEI maturation and transition activities.

(U) FY 2001 Plans:

- Software Technical Engineering Practices. ($ 10.450 Million)
  - Establish techniques for modeling and predicting survivability attributes of systems while they are under development. Exemplar architectures for survivable systems will be in use by DoD and industry. Standard COTS evaluation practices will be defined and in use to support the development of COTS-based systems.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE June 2001
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-22

- Software Engineering Management Practices. ($ 4.150 Million)
  - Support rollout and widespread use of integrated Capability Maturity Model (CMM) models; extend models to additional disciplines; document benefits and costs of using the integrated models; and prepare for revision of models based on actual experience in their use.

- Adoption of Software Technologies. ($ 3.239 Million)
  - Provide transition planning and measurement support to SEI maturation and transition activities.

(U) FY 2002 Plans:

- Program transferred to OUSD (AT&L).

(U) Other Program Funding Summary Cost:

- Not Applicable.

(U) Schedule Profile:

- Not Applicable.

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RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)								DATE June 2001		
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 2000	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	60.589	84.241	77.738	85.800	64.500	64.000	64.000	64.000	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) An in-depth review of some of the Information Assurance and Survivability technology programs was conducted in FY 2000. The review resulted in a recasting of some programs to improve responsiveness to military operational information assurance and survivability needs. These recast programs will develop information assurance and survivability technologies to meet DoD needs and demonstrate the technologies in DoD systems.

(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.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE June 2001
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) 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 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 situation 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.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE June 2001
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) Program Accomplishments and Plans:

(U) FY 2000 Accomplishments:

- Autonomic Information Assurance. ($ 11.650 Million)
  - Identified response selection techniques for effectively handling broad classes of unknown attacks.
  - Investigated impacts and effects of dynamic response.
  - Designed active techniques for trace-back and automated response.

- Cyber Command and Control. ($ 7.588 Million)
  - Developed initial situation analysis techniques to derive strategic attack hypotheses.
  - Prototyped dynamic retasking of sensors to acquire missing situation information.
  - Developed capabilities for analysis and execution of directly controlled strategic response elements.

- Strategic Intrusion Assessment. ($ 11.353 Million)
  - Completed initial design for hierarchical reporting structure for intrusion detection systems.
  - Developed experimental methods for filtering events of purely local significance.
  - Developed common framework for linking intrusion assessment and response components.
  - Developed workflow model supporting dynamic response capability.

- Intrusion Tolerant Systems. ($ 12.223 Million)
  - Demonstrated practical digital integrity mark technology and information dispersal to facilitate recovery and verification of important data characteristics in large electronic image files.
  - Developed and demonstrated several promising execution monitoring prototype tools and techniques to significantly reduce the likelihood of malicious mobile code from compromising data integrity and confidentiality.
  - Identified mechanisms that rapidly distinguish intact and corrupted programs through automated verification of proof-carrying code.
  - Demonstrated a framework for perpetually available information systems that guarantee the survivability of information under malicious attacks or component failure.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE June 2001
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-24

- Fault Tolerant Networking. ($ 10.484 Million)
  - Adapted fault tolerance techniques to the networking environment balancing redundancy for availability with security requirements.
  - Investigated user capability-based resource allocation mechanisms.
  - Demonstrated "push-back" techniques for denial-of-service attacks.
  - -- Exploited active network technology for attacker fencing.

- Dynamic Coalitions. ($ 6.991 Million)
  - Investigated languages and tools for specification and analysis of complex policies and translation into enforcement mechanisms.
  - Augmented existing Public Key Infrastructure (PKI) capabilities with protocols for rapid revocation of coalition member credentials.

- Computer Security. ($ 0.300 Million)
  - Implemented and tested a combination of robust elements to achieve high reliability for mission critical computer systems.

(U) FY 2001 Plans:

- Autonomic Information Assurance. ($ 17.996 Million)
  - Develop autonomic response architecture.
  - Identify promising assessment methodologies for more effective evaluation of very large information infrastructures.
  - Develop scalable models of very large information infrastructure.
  - Complete 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.
  - Transfer promising technologies for use by the Fault Tolerant Networking (FTN), Cyber Panel, and OASIS programs in FY 2002 and complete closeout of remaining Autonomic Information Assurance technologies.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE June 2001
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 Command and Control/Strategic Intrusion Assessment. ($ 30.552 Million)
  - Merge 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 focus technologies toward a coherent cyber attack monitoring and response management system.
  - Develop correlation and analysis algorithms to detect and track complex multi-phase or large-scale cyber attacks.
  - Develop 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.
  - Develop algorithms for evaluating and executing coordinated defensive actions and attack responses, automatic and human-initiated, across a large distributed system.
  - Transfer promising technologies for use by the Cyber Panel, Survivable Global Information Grid (GIG) and OASIS programs in FY 2002 and complete closeout of remaining Cyber Command and Control/Strategic Intrusion Assessment technologies.

- Intrusion Tolerant Systems. ($ 3.798 Million)
  - Transfer promising technologies for use by the Organically Assured and Survivable Information Systems (OASIS) and Cyber Panel programs in FY 2002 and closeout activities on remaining projects.
  - Investigate market-based and value-based resource allocation mechanisms.

- Fault Tolerant Networking. ($ 23.834 Million)
  - Develop techniques to isolate corrupted or malicious network entities.
  - Investigate progress-based network resource allocation mechanisms to prevent denial-of-service.
  - Investigate trust-chain techniques for network resource allocation and protection against denial-of-service.
  - Design active techniques for traceback and automated response.
  - Transition Secure Border Gateway Protocol (SBGP) to COTS router vendors and establish necessary Public Key Infrastructure (PKI) that provides basic authentication of and authorizations for potential users.
  - Develop 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 must address the improvement of the robustness of the DNS, using an arbitrary mesh of trust.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE June 2001
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. ($ 8.061 Million)
  - Prototype protocols for negotiation of policies across coalition members.
  - Create methods for fast sender authentication, scalable key distribution for creation and rekeying of coalitions.
  - Extend existing PKI capabilities with protocols for cross certification of coalition members.

(U) FY 2002 Plans:

- Fault Tolerant Networks. ($ 37.624 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.
  - Complete parallel field evaluation of infrastructure assessment methodologies.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE June 2001
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). ($ 7.000 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 June 2001
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. ($ 8.781 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) Other Program Funding Summary Cost:

- Not Applicable.

(U) Schedule Profile:

- Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)					DATE June 2001					
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 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	Cost to Complete	Total Cost
Asymmetric Threat ST-28	0.000	26.884	58.087	50.700	49.500	45.000	50.000	55.000	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 suite of tools to better detect and prevent attacks upon our critical DOD infrastructures. The 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).

(U) The Human Identification at a Distance (HumanID) program objective is to develop automated multi-modal, multi-biometric surveillance technology for identifying humans at a distance as an enabler for force protection and early warning against an Asymmetric Threat. HumanID seeks to improve individual biometric technologies and develop methods for fusing biometric signatures from multiple sensors for multi-range, round-the-clock processing. HumanID focuses on multi-modal fusion of different biometrics techniques with focus on body parts identification, face and human kinematics, with biometric signatures acquired from video, infrared and multi-spectral sensors, and configurations of networked cameras. Biometric techniques will be examined as a function of multiple ranges and presentation time. The goal of this program is to identify humans as

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE June 2001
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-28

unique individuals (not necessarily by name) at a distance, at any time day or night, during all weather conditions, with non-cooperative subjects, possibly disguised and alone or in groups. An outgrowth of the Image Understanding for Force Protection effort, the HumanID program was funded under Project ST-11 in FY 2000.

(U) The objective of the Evidence Extraction and Link Discovery (EELD) program is to develop a suite of technologies to automatically extract evidence from vast amounts of unstructured textual data, discover relevant relationships among those extracted facts to provide advance warnings of potential terrorist activities, and learn patterns corresponding to models of significant activities. Recent advances in language understanding software will be exploited to provide a capability to automatically extract facts from textual message, 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 techniques will be extended to enable learning and evaluation of patterns comprised of relationships among people, organizations, activities, and scenarios.

(U) The Wargaming the Asymmetric Environment (WAE) program will provide the ability to conduct real time operational wargaming in an asymmetric environment. Current wargames are general-purpose situation-response models that do not take into account the asymmetric threat. This project will inject adversarial behavior models into a multi-sided wargame. WAE seeks to develop operational wargaming tools that allow multi-dimensional asymmetric environments and intelligent stakeholders (adversary, friendly and neutral). These will advance current techniques, which are sequential, contain generic behavior models and are limited by scripted adversary play. This will significantly increase the commander and analyst's ability to make operational decisions and develop collaborative gaming techniques against all adversaries simultaneously.

(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. The goal of the Bio-Surveillance program is to 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. This project requires the development and integration of diverse biological modeling and information systems technologies. 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.

(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 physical infrastructure networks based upon the interdependencies that exists among them.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE June 2001
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-28

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 infrastructure networks separately using high fidelity commercial simulations, but cannot model their nonlinear and complex interdependencies. 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 (QoS, 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.

(U) Program Accomplishments and Plans:

(U) FY 2000 Accomplishments:

- Not Applicable.

(U) FY 2001 Plans:

- Human Identification at a Distance. ($ 11.502 Million)
  - Develop a fixed site, force protection approach to identifying humans at a distance.
  - Use specific service sites as prototype models.
  - Develop evaluation methodologies and independent evaluations on human identification techniques candidates.
  - Develop and assess validity of current and future technologies to meet the proposed system needs.
  - Demonstrate automated Human Identification at a Distance under outdoor lighting conditions.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE June 2001
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. ($ 9.145 Million)
  - Identify candidate unclassified and classified document collections from which asymmetric threats can be detected.
  - Analyze language characteristics of relevant document collections.
  - Initiate collection of document collections to use as basis for technology developments.
  - Evaluate applicability of promising information extraction and link discovery techniques.
  - Select candidate information extraction techniques and approaches for development.
  - Select candidate link discovery techniques for development.
  - Select candidate pattern learning techniques for development.

- Wargaming the Asymmetric Environment. ($ 6.237 Million)
  - Develop and cross validate asymmetric model ontology with open and classified data.
  - Statistically test advanced reasoning techniques for applicability to asymmetric threats.
  - Develop initial model set of specific known asymmetric threats.
  - Develop challenge problems and associated test criteria.
  - Perform predictive modeling experiments.

(U) FY 2002 Plans:

- Human Identification at a Distance. ($ 15.850 Million)
  - Incorporate multiple sensors and multiple biometric approaches into new capabilities.
  - Consider the range, accuracy, and reliability of combinations of facial features, gait, and other key identification techniques.
  - Determine the critical factors that affect performance of multi-modal techniques.
  - Demonstrate multi-modal Human Identification at a Distance capabilities.

- Evidence Extraction and Link Discovery. ($ 9.398 Million)
  - Develop candidate information extraction techniques for extracting facts from text messages, news reports and web pages.
  - Specify models of asymmetric threat scenarios.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE June 2001
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 candidate link discovery techniques using extracted facts and additional data sources.
- Develop candidate pattern learning techniques for models of asymmetric threat scenarios.
- Demonstrate ability to extract relational facts.

- Wargaming the Asymmetric Environment. ($ 16.839 Million)
  - Conduct generalization experiments.
  - Establish operational testbeds in conjunction with one or more transition partners.
  - Empirically determine classes of asymmetric threats.
  - Generalize predictive models from individual to classes of asymmetric threats.
  - Continue to develop and validate threat specific modeling techniques.
  - Expand development to include civilian model.

- 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.
  - Develop computer simulation environment to emulate bio-terrorist events and impacts on agricultural, animal and human populations.

- Endstate. ($ 2.000 Million)
  - Investigate reduced order modeling techniques for cross network effects prediction.
  - Develop methods for generating and refining courses of action and control options.
  - Identify technology for modeling adversary work-arounds.
  - Investigate methods for maintaining timely and accurate network state estimates.

- DefenseNet. ($ 6.000 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).

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE June 2001
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 several prototype networks, based upon current commercial optical and electro-optical components to test the security /performance trade-off space.

(U) Other Program Funding Summary Cost:

- Not Applicable.

(U) Schedule Profile:

- Not Applicable.