RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE: February 2000
APPROPRIATION/BUDGET ACTIVITY: RDT&E, Defense-wide; BA2 Applied Research	R-1 ITEM NOMENCLATURE: Computing Systems and Communications Technology; PE 0602301E, R-1 #13

COST *(In Millions)*	FY 1999	FY2000	FY2001	FY2002	FY2003	FY2004	FY2005	Cost To Complete	Total Cost
Total Program Element (PE) Cost	309.100	320.648	376.592	347.779	355.374	355.948	364.277	Continuing	Continuing
JASON ST-01	1.188	1.193	1.200	1.200	1.200	1.200	1.200	Continuing	Continuing
Intelligent Systems and Software ST-11	78.512	73.038	91.524	74.403	60.536	72.393	68.034	Continuing	Continuing
High Performance and Global Scale Systems ST-19	156.140	163.602	149.295	114.852	132.838	134.055	145.743	Continuing	Continuing
Software Engineering Technology ST-22	16.345	17.133	17.965	18.499	19.300	19.300	19.300	Continuing	Continuing
Information Survivability ST-24	56.915	65.682	92.802	98.738	105.800	104.500	110.000	Continuing	Continuing
Asymmetric Threat ST-28	0.000	0.000	23.806	40.087	35.700	24.500	20.000	Continuing	Continuing

(U) Mission Description:

(U) This 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 consists of an independent group of distinguished scientists and technical researchers that provide analysis of critical national security issues.

(U) The efforts funded in the Intelligent Systems and Software project focus on the development of new information processing technology concepts that lead to fundamentally new software and intelligent system 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.

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(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 supports the Software Engineering Institute (SEI) whose mission is to transition state-of-the-art technology, and best practices to improve the acquisition, engineering, fielding, and evolution of software-intensive DoD systems.

(U) The Information Survivability project develops the technology base underlying the solutions to protecting DoD's mission-critical information systems against attack upon or through the supporting infrastructure. These technologies lead to generations of stronger protection, higher performance, and more cost-effective security solutions scalable to several thousand sites and to high-performance computing technologies.

(U) The goal of the Asymmetric Threat project is to develop a suite of new technological capabilities to better detect, correlate, and understand asymmetric threats. The three programs in this project are Human Identification at a Distance (HumanID), Evidence Extraction and Link Discovery (EELD), and Wargaming the Asymmetric Environment (WAE).

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

	FY1999	FY 2000	FY 2001
Previous President's Budget	323.959	322.874	331.023
Current Budget	309.100	320.648	376.592

(U) Change Summary Explanation:

FY 1999	Decrease is a result of a rescission (Section 8058), SBIR reprogramming and minor program repricing.
FY 2000	Decrease is a result of inflation adjustments and government wide rescission.
FY 2001	Increase reflects a reprioritization of agency resources, which resulted in the establishment of a new project, Asymmetric Threat (ST-28), increased emphasis on information survivability technologies in project ST-24, and the transfer of the mobile autonomous robotics software effort from Project AE-02, PE0602302E.

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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 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
JASON ST-01	1.188	1.193	1.200	1.200	1.200	1.200	1.200	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 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 1999 Accomplishments:

- JASON. ($ 1.188 Million)
  - Continued studies in: counter proliferation of chemical and biological weapons; advanced sensor technologies; advanced computing; land mine detection; battlefield information systems; battlefield planning and control; small unit operations; military communications; and novel materials.

(U) FY 2000 Plans:

- JASON. ($ 1.193 Million)
  - Continue 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.

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(U) FY 2001 Plans:

- JASON. ($ 1.200 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.

(U) Other Program Funding Summary Cost:

- Not Applicable.

(U) Schedule Profile:

- Not Applicable.

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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 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Intelligent Systems and Software ST-11	78.512	73.038	91.524	74.403	60.536	72.393	68.034	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 measure 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 goal of the Information Management (IM) Program is to develop persistent identification, registration, tracking for digital objects, to create an information representation which incorporates unique naming, descriptive hierarchical or granular organization of multi-media data streams. It 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.

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(U) 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 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 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 Translingual Information Detection, Extraction and Summarization Program (TIDES) 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. DARPA's TIDES program will 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. TIDES' lattice goals are to achieve 85% accuracy in topic identification, 80% accuracy in people, places and event identification, and 70% accuracy in establishing relationships among identified entities.

(U) The Human Identification at a Distance (HumanID) program objective is to develop automated multi-modal surveillance technology for identifying humans at a distance as an enabler for protection and early warning against the Asymmetric Threat. 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 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 DARPA Agent Markup Language (DAML) program is developing military software tools for use on InteLink and the emerging C2 Link system. The program’s focus is to develop enhanced interoperability technologies 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 software

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language that ties the information on a page to machine-readable semantics (ontology), including ontology for InteLink briefings. This effort will provide new technologies for the intelligent integration of information across a wide variety of heterogeneous military sources and systems.

(U) Under the Taskable Agent Software Kit (TASK) program, software agent creation tools will be developed to reduce the per-agent development/customization cost for advanced military systems. Software agents are the next generation of software which 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 allow the development of rigorous qualitative and quantitative comparisons of agent behaviors with respect to domain and problem features.

(U) Program Accomplishments and Plans:

(U) FY 1999 Accomplishments:

- Software Composition. ($ 21.023 Million)
  - Conducted Instrumented Feasibility Demonstration (IFDs) of evolutionary design technologies; IFD participants include USTRANSCOM, Joint STARS, and B-2 software maintenance.
  - Investigated active approaches to software composition, with emphasis on aspect-oriented programming; on-the-fly component generation and interconnection; and module self-evaluation and configuration.
  - Demonstrated a 2X reduction in detailed design by integrating Design Web and Computational Tools made for multi-disciplinary optimization.
  - Demonstrated a web-based toolkit of representation, analysis and generation tools.

- Active Sensors. ($ 24.663 Million)
  - Integrated the most successful new image understanding and automatic target recognition technologies into feasibility demonstrations for video image exploitation, synthetic environments, and video surveillance; demonstrated and evaluated impact of embedded image understanding technologies on battlefield awareness.

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- Integrated, demonstrated and evaluated laboratory and airborne systems in simulated military video surveillance missions, and achieved the following technology goals: Activity Monitoring - detected soldier incursion and removal of restricted vehicles from a depot; Moving Target Surveillance - maintained track on three moving vehicles and demonstrated reliable target reacquisition as the sensor was multiplexed and tracks were occluded by trees; Precision Video Registration - geolocated moving and stationary vehicles in 80% of the video sequences within 5-10 meters of ground truth.

- Situation Analysis and Presentation. ($ 32.826 Million)
  - Developed language comprehension technology to provide extraction of content and production of summary information focused on information access, manipulation and creation tasks in order to demonstrate improved readiness for military planning and situation awareness.
  - Developed and demonstrated fully automatic algorithms to determine the structure of radio and TV news broadcasts in several languages allowing military planners and intelligence analysts to detect and track emerging topics.
  - Developed and demonstrated large, integrated situation assessment and course of action knowledge base through reuse of knowledge base components from heterogeneous sources.
  - Defined a million-axiom knowledge base construction problem and competency test for a military challenge problem related to biological weapons requiring technical, military strategy and tactics, and geopolitical knowledge.
  - Demonstrated the utility of man-machine planning and execution control against an aggressive adversary in a realistic simulation of an operational environment and transition to DARPA systems programs as well as to services for further development and integration.
  - Demonstrated and transitioned Intelligent Integration of Information tools and techniques that enabled the rapid construction of large-scale information associates to filter, access, and integrate information from 100s of disparate, heterogenous data sources.
  - Continued Asset Source for Software Engineering Technology (ASSET) program.
  - Explored multi-spectral imaging data reduction techniques.
  - Continued Reuse Technology Adoption Program (RTAP).

(U) FY 2000 Plans:

- Situation Analysis. ($ 25.853 Million)
  - Demonstrate statistically based semantic analysis capabilities.

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

- Situation Presentation and Interaction. ($ 25.350 Million)
  - Specify network-based service architecture Application Program Interface's (API's) for key components of dialogue architecture.
  - Demonstrate usability of dialogue interaction with confirming sub-dialogue to reduce task completion time by 80%, using metrics-based evaluation.
  - Evaluate dialog for small unit logistics demonstrated in LCS Marine project.
  - Expand dialog evaluation beyond the travel scenario with method for cross task comparison.
  - Expand dialog interaction into vehicles with initial investigation of feasibility within acoustic environment of automobiles.
  - Expand dialog interaction with information services for more natural automatically generated dialogue and speech.
  - Develop preliminary ontology for InteLink briefings and release initial language design specifications.

- Intelligent Software for Multi-lingual and Coalition Environments. ($ 12.778 Million)
  - Develop a translingual C4I database for use in U.S. and Republic of Korea coalition operations.
  - Field demonstrate of automated translation of briefing documents, cross language information retrieval (Korean and English), and speech-to-speech translation (English Korean) during RIMPAC 2000 exercises.
  - Expand investigation into capability of providing machine translation capabilities for new language pairs with smaller sized training corpora.
  - Implement TIDES open system architecture version 0.1 providing a web-based environment to support plug in component experiments.
  - Conduct experiments involving humanitarian assistance/disaster relief/consequence management with the Sea Based Battle Lab.

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- Intelligent Sensor Processing (Human Identification at a Distance). ($ 7.057 Million)
  - Initiate studies of candidate biometric features for human identification from a distance.
  - Begin generation of a database containing known biometric feature data for metric-based evaluation of candidate techniques.

- Reuse Technology Adoption Program (RTAP). ($ 2.000 Million)
  - Identify technologies for definition and specification of agile components.
  - Develop 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. ($ 23.027 Million)
  - 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.
  - Demonstrate feasibility of combined translingual, multimedia context-based information retrieval.
  - Demonstrate direct knowledge entry by a novice (2K axioms/month) for a military problem.

- Situation Presentation and Interaction. ($ 19.849 Million)
  - Perform engineering integration of key components of dialogue architecture.
  - 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.

- Intelligent Software for Multi-lingual and Coalition Environments. ($ 29.790 Million)
  - Extract, translate, and correlate named entities from unstructured documents in multiple languages.

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- Prototype implementation of coalition intelligence integration capability demonstrating benefit of end-to-end cross-language information service.
- Demonstrate initial summarization in English of foreign language documents using frame semantics.
- Release initial version of comprehensive, cross-language processing architecture for componetization and eventual standardization.
- Experiment in multilingual, intelligence services, 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). ($ 12.925 Million)
  - Release working versions of Briefing Tool, Search Tool, and Ontology Creation Tool on Intelink.
  - Define toolset for C2 link application of DAML technologies.
  - Experimentally test and refine tool set.

- Taskable Agent Software Kit (TASK). ($ 5.933 Million)
  - Define metrics for analysis of environmental features in military C4I system usage.
  - Perform agent-design method experiments on parametric models of agent interaction systems.

(U) Other Program Funding Summary Cost:

- Not Applicable.

(U) Schedule Profile:

- Not Applicable.

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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 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
High Performance and Global Scale Systems ST-19	156.140	163.602	149.295	114.852	132.838	134.055	145.743	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 will enable 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 will develop 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 will develop and integrate 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.

(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) project 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.

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(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, both within the chip and at the system level.

(U) A follow-on to Defense Technology Integration efforts 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 bottom-up organization approach and negotiation as a technique 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) The goal of 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. In addition, it will develop next generation proxy servers to monitor the global web for updates of interest to disseminate this information to the interested location, intelligently utilizing bandwidth. This concept includes development of local information repositories to provide local real-time access to critical information and serve as an archive under total loss of connectivity. The goal of the technology for the next generation proxy server is to develop algorithms for monitoring the web for updates to information already being used by the remote sites. The use of information on the local information repositories must also be analyzed to develop queries to obtain new related

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relevant information. In addition, algorithms will be developed for maximizing the use of the bandwidth to the remote sites and balancing the pull for information from the sites with the push of critical information to each site.

(U) The Mobile Autonomous Robot Software component will develop embedded software technologies for programming autonomous mobile robots. 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, having extreme difficulty in accounting for 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 overall goal is to enable the programming of autonomous mobile robots for real world, military missions as easily as we program assembly line robots in the auto industry.

(U) The Biological and Information Sciences component will design and implement biologically inspired information storage, retrieval, and processing systems.

(U) Program Accomplishments and Plans:

(U) FY 1999 Accomplishments:

- Global Mobile Information Systems. ($ 15.626 Million)
  - Demonstrated application support including automatic file and data base replication and distribution for distributed computing in mobile environments.
  - Demonstrated prototype implementation of integrated high data-rate untethered node.
  - Demonstrated techniques for density and asymmetry adaptation, multicast routing, and dynamic time slot assignment in wireless self-organizing ad hoc networks.
  - Transitioned networking protocol and adaptive link control technologies to DARPA's Small Unit Operations project (PE0603764E, Project LNW-02) and Radio Application Program Interfaces (APIs) to Joint Tactical Radio System Phase I Architectural Framework.

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- Networking. ($ 15.178 Million)
  - Extended operation of Active Network testbed to traverse ~10 sites of ~10 switches; each using SmartPackets and composite protocols.
  - Demonstrated active node execution environment supporting resource security, and survivability functions.

- Scalable Systems and Software. ($ 32.934 Million)
  - Released scalable versions of defense-critical engineering software.
  - Demonstrated multiprocessor reduced instruction set computer (RISC) chip (7 issue, 1.6 gigaoperations (GOP), 5-cycle message latency).
  - Investigated instruction set extensions and storage components to allow defense applications to specify whether operations are executed in the central processor or in logic circuits embedded in the memory hierarchy.
  - Conducted system-level design and simulation study of a computation model based on large amorphous arrays.
  - Established role of Nuclear Magnetic Resonance (NMR) technologies in development of ultrascale computing.

- Adaptive Computing Architectures. ($ 24.669 Million)
  - Debugged and validated novel, configurable component technologies and architectures; demonstrated use of adaptive building blocks in wireless radio applications.
  - Demonstrated 100x user-level software performance improvement over commodity microprocessors on challenge problems; released new algorithm design software environment optimized to leverage adaptive technology.

- Systems Environments. ($ 14.740 Million)
  - Demonstrated experimental scalable structural dynamics application using DARPA sparse matrix library.
  - Demonstrated microfeedback technologies for adaptive services.
  - Released prototype subsystem supporting adaptive resource allocation and consumption in response to changing workload and resource availability.

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- Signal Processing. ($ 22.403 Million)
  - Published benchmarks for embedded signal processing.
  - Demonstrated enabling technologies including: Discrete Fourier Transform (DFT) chips based on clockless logic, Single Instruction Multiple Datastream (SIMD) and multi-Digital Signal Processing (DSP) board designs, Myricom 2.5 Gbps high speed configurable interconnect.
  - Developed compiler and code generators to permit retargeting of commercial signal processing tools to suit tactical signal processing environments.
  - Evaluated alternative mechanisms for embedded logic and communications subsystems that incorporate biological materials.
  - Investigated techniques, which transduce electrical/optical/magnetic signals to/from chemical and/or biological processes.

- Defense Technology Integration. ($ 30.590 Million)
  - Developed framework for federation of text, image and relational databases.
  - Demonstrated presentation aids for military type documents in English, Korean and a European language.
  - Validated design of secure repository architecture for digital objects up to 100 megabytes in size.
  - Developed Session Management middleware, leveraging multicasting technology that adjusts to variations in bandwidth and connectivity.
  - Developed tools that enable teams and individuals to retrieve situation and task relevant information from static and dynamic archives containing a record of experiences from multi-sensory sources.

(U) **FY 2000 Plans:**

- Global Mobile Information Systems. ($ 13.526 Million)
  - Develop beta-level prototype of high data-rate untethered nodes incorporating adaptive link controls and frequency agile RF front end with capability to automatically adapt to available spectrum frequencies.
  - Demonstrate self-organizing, self-healing mobile wireless networks supporting Quality of Service (QoS) routing utilizing Internet and Asynchronous Transfer Mode (ATM) networks.

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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 network security techniques, including over the air re-keying, in mobile wireless multihop network.
- Integrate GloMo simulation models and conduct scenario simulations for moderate to large-scale mobile wireless networks (100 to 10,000 nodes).

- Networking. ($ 33.352 Million)
  - Demonstrate use of active network approach to achieve live protocol updates within two roundtrip times.
  - Provide initial release of prototype active network toolkits for end-user stations and network elements including performance measurement capabilities.
  - Provide engineering analysis of active network performance.
  - Initiate development of new models of traffic and network applicable to varying scales of time and network sizes, which are suitable for predicting network behavior.
  - Initiate building a network measurement methodology to support near real-time prediction using modeling and simulation tools.
  - Design and demonstrate prototype software for a digital amphitheater using a gigabit interconnectivity.

- Data Intensive Systems and Software. ($ 29.524 Million)
  - Design processor in memory very large scale integration (VLSI) components that support in situ processing of application data.
  - Implement compiler that generates code compatible with processor in memory architecture.
  - Simulate data-intensive systems, demonstrating 10-fold performance improvement on critical DoD applications.
  - Develop architectural framework for use of data intensive technologies in embedded applications; investigate alternative approaches to package level integration of data intensive technologies with high bandwidth sensor interfaces.

- Adaptive Computing Systems (ACS). ($ 27.789 Million)
  - Implement initial Adaptive Computing Systems (ACS) analysis and development tools.
  - Develop high-level design entry tools/development environments for ACS, e.g., for Java, C, Matlab, Khoros.
  - Implement single clock cycle context-switchable reconfigurable computing device.
  - Implement ACS reference platforms and supporting development environment.

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- Demonstrate ACS self-test, diagnosis and reconfiguration for fault tolerance.
- Demonstrate 100 Million gate compilation tool.
- Publish updated ACS benchmarks.

- Systems Environments. ($ 22.223 Million)
  - Release reference implementation of mission-critical Quality of Service (QoS) architecture.
  - Release prototype operating system with partitioned resource management for strict QoS guarantees.
  - Provide a joint demonstration of QoS management software with Aegis advanced computing testbed; demonstrate interoperability of combat and Command, Control, Communications Intelligence Surveillance Reconnaissance (C4ISR) functions through over-the-horizon track correlation and engagement deconfliction; demonstrate 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. ($ 18.696 Million)
  - Implement prototype multiprocessor event collection and analysis system and automated stress test generator for signal processing applications; demonstrate use of high performance signal processing for weapon systems applications.
  - Initiate Power Aware Computing and Communication (PAC/C) individual power aware technology research efforts.
  - Initiate early exploration of power aware tool frameworks, databases, and metrics.
  - Explore potential operational environmental effects on low power electronics.
  - Develop novel architectures for reprogramming field programmable gate arrays using adaptive software.

- Defense Technology Integration. ($ 13.492 Million)

  Mobile Code Software.
  - Analyze ability of autonomous software to predict, negotiate and track resource requirements under changing environment and time constraints.
  - Develop strategy for the rapid assessment of computation cost of complex sets of constraints.
  - Implement software toolkit for knowbot development, generation and deployment.
  - Create experimental platform for negotiation-based real-time resource management.

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– Measure the real-time base-line for different negotiation protocols using the experimental platform.

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

- Systems Engineering for Miniature Devices. ($ 5.000 Million)
  – Establish the infrastructure to carry out integrated micro-miniature device research.
  – Develop a collaborative environment for the integrated, concurrent design of all aspects of a micro-miniature platform.

(U) FY 2001 Plans:

- Networking. ($ 27.746 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.
  – 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.
  – Develop efficient name lookup and binding algorithms for large-scale embedded components.
  – 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.
  – 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).
  – Investigate technologies to optimize RF bandwidth allocation and utilization.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-19

- Explore state-of-the-art antennas, receivers, and transmitters for utilizing multiple, wireless service providers that employ different frequencies and bandwidths.

- Data Intensive Systems and Software. ($ 24.290 Million)
  - Prototype fabrication of processor in very large scale integration (VLSI) memory components that support in situ processing of application data.
  - Conduct bench experiments to demonstrate that fabricated components achieve performance predicted by simulations.
  - Prototype demonstration of processor in memory (PIM) array.
  - Demonstrate advanced cache-based approaches for data-intensive applications.

- Adaptive Computing Systems (ACS). ($ 13.151 Million)
  - Implement final Adaptive Computing Systems (ACS) design tool suites using high level entry, e.g., for Java, C, Matlab, 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).

- Systems Environments. ($ 24.729 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.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-19

- Signal Processing and Power Aware Computing. ($ 21.346 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. ($ 12.903 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.

- Information Technology Expeditions. ($ 7.630 Million)
  - Demonstrate adaptive reprogramming of hardware within a single dock cycle.
  - Define operating systems for deeply networked multiple intelligent devices with varying data rates and processing power.
  - Develop first order rules for data extraction and update rates for web information cached remotely.
  - Semantic rules for web information storage.

- Mobile Autonomous Robot Software. ($ 15.000 Million)
  - Prototype demonstration and experimental evaluation of integrated deliberative, reactive and learning behaviors.
  - Provide laboratory demonstration of compatible knowledge representations for reprogrammable, behavior-based control.
  - Provide laboratory demonstration of learning-derived competency propagation (robot-to-robot). Provide laboratory demonstration and experimental evaluation of domain specific language-derived capabilities for directly programmed portion of the software for autonomous mobile robots.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-19

- Biological and Information Sciences. ($ 2.500 Million)
  - Prototype demonstration of autonomously controlled sequencing of DNA-based computation.

(U) Other Program Funding Summary Cost:

- Not Applicable.

(U) Schedule Profile:

- Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)								DATE February 2000	
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 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Software Engineering Technology ST-22	16.345	17.133	17.965	18.499	19.300	19.300	19.300	Continuing	Continuing

(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 will fund the technology transition activities of the Software Engineering Institute (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 for 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. Planned FY 2001 focus areas are: Software Engineering Technical Practices (including Survivable Systems practices, Architecture-centered Software Engineering, and Commercial Off-The-Shelf (COTS)-Based Software Engineering); enhanced Software Engineering Management Capabilities (including integrated Capability Maturity Models and accelerating Adoption of High Payoff Software Technologies.

(U) Program Accomplishments and Plans:

(U) FY 1999 Accomplishments:

- Software Engineering Technical Practices. ($ 11.100 Million)

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- Established/refined guidelines for helping the DoD and DoD contractors migrate legacy systems into product lines. Architecture evaluation guidelines and tradeoff techniques were demonstrated, and an initial version of a security improvement tool kit was developed to help system administrators protect their systems against current and emerging threats. Architecture evaluation techniques for COTS-based systems were offered to reduce costs and risk. Training in the development of COTS-based systems was made available for executives and program managers.

- Software Engineering Management Practices. ($ 3.750 Million)
  - Released the integrated models (software, systems, and Integrated Product and Process Development (IPPD)) under the CMMI framework for public review and pilot test. Published Version 1 of CMMI support products. CMMI was harmonized with international standards. Released initial Team Software Process training.

- Adoption of Software Technologies. ($ 1.495 Million)
  - Upgraded and expanded measurement information repository was released to define the benefits and costs of technical practices; Developed measurement guidance for tracking performance at organizational and enterprise levels and developed guidance for the application of the Earned Value Management System (EVMS) to the development of software-intensive systems. Provided transition planning and measurement support to SEI maturation and transition activities.

(U) **FY 2000 Plans:**

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

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

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- Adoption of Software Technologies. ($ 2.931 Million)
  - Develop guidebook for introducing technology change into organizations. Additional guidance for use of metrics in software acquisition and development. Continue to provide software measurement support to all initiative work to ensure performance measures are established. Provide transition planning and measurement support to SEI maturation and transition activities.

(U) FY 2001 Plans:

- Software Engineering Technical 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.

- Software Engineering Management Practices. ($ 4.150 Million)
  - Support rollout and widespread use of integrated 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. ($ 3.365 Million)
  - Standard practices for adopting technology are in widespread use. Provide transition planning and measurement support to SEI maturation and transition activities.

(U) Other Program Funding Summary Cost:

- Not Applicable.

(U) Schedule Profile:

- Not Applicable.

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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 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Information Survivability ST-24	56.915	65.682	92.802	98.738	105.800	104.500	110.000	Continuing	Continuing

(U) Mission Description:

(U) This project is developing the technology required 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), Information Integration Systems (Project CCC-02), and in other programs to satisfy defense requirements for secure and survivable systems.

(U) Information Assurance and Survivability technologies will be developed 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 systems usable over a wide range of performance in diverse threat environments. High confidence network-based systems will include security mechanisms and value-added security services for integration into network-based infrastructure as well as inherent protection mechanisms to allow the system to resist, repel and survive attack. High confidence computing systems will be developed that provide modular security services and mechanisms, provide high reliability for distributed computations, and allow geographically separated parts of an organization to interact as if they shared a common security perimeter. This also includes integrity mechanisms to allow damage to be detected rapidly. Intrusion tolerant systems will be developed to assure code integrity, confine malicious code, and to tolerate remaining attacks using survivable architectures. Intrusion detection systems will allow attacks on the defense infrastructure to be detected, the damage to be assessed, and appropriate response to be taken. Strategic intrusion assessment technologies will be developed to detect national 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, setting the stage for autonomic information assurance. Autonomic systems will be developed to provide intelligent but reflexive defenses that adapt rapidly in milliseconds to block or withstand many classes of known and unknown attacks. Cyber Command and Control will create technologies to enable human-directed strategic oversight and guidance, to provide strategic information attack situation understanding, mission-critical functional impact assessment, and cyber course of action analysis and execution. Cyber defense increasingly

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requires a systems approach to effectively integrate and orchestrate information assurance and survivability technologies. Accordingly, the programs comprising the Computing Systems and Communications Technology group have been realigned. The new alignment will achieve information survivability goals previously established as well as provide additional capabilities in autonomic response, situation awareness, course of action analysis, and cyber system control.

(U) Program Accomplishments and Plans:

(U) FY 1999 Accomplishments:

- High Confidence Networking. ($ 15.578 Million)
  - Demonstrated secure middleware supporting distributed applications over mobile and wireless networks.
  - Demonstrated secure, multi-policy, high speed group communication.

- High-Confidence Computing. ($ 13.506 Million)
  - Demonstrated techniques for general pairwise tradeoffs among real-time operations.
  - Evaluated prototype compiler for certifying proof-carrying code.
  - Released operating system prototype supporting efficient, secure nested virtual machines.

- Assurance and Integration. ($ 10.073 Million)
  - Completed initial wrapper-generator toolkits.
  - Demonstrated integration of security composition techniques into software engineering tools.

- Survivability of Large Scale Systems. ($ 16.270 Million)
  - Developed techniques for diagnosing multi-agent, multi-staged attack, through common intrusion detection framework.
  - Demonstrated adaptive architecture for survivable systems.
  - Conducted red team exercise(s) to assess intrusion detector systems.

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- Computer Security. ($ 0.992 Million)
  - Enhanced computer security through innovative security measures.

- Software Security Research. ($ 0.496 Million)
  - Developed ambiguous server location algorithms.

(U) FY 2000 Plans:

- Autonomic Information Assurance. ($ 12.535 Million)
  - Identify response selection techniques for effectively handling broad classes of unknown attacks.
  - Investigate impacts and effects of dynamic response.
  - Design active techniques for trace-back and automated response.

- Cyber Command and Control. ($ 8.357 Million)
  - Develop initial situation analysis techniques to derive strategic attack hypotheses.
  - Prototype dynamic retasking of sensors to acquire missing situation information.
  - Develop capabilities for analysis and execution of directly controlled strategic response elements.

- Strategic Intrusion Assessment. ($ 12.327 Million)
  - Initial design for hierarchical reporting structure for intrusion detection systems.
  - Develop experimental methods for filtering events of purely local significance.
  - Common framework for linking intrusion assessment and response components.
  - Develop workflow model supporting dynamic response capability.

- Intrusion Tolerant Systems. ($ 13.266 Million)
  - Investigate digital integrity mark technology and information dispersal for intrusion tolerance.
  - Develop execution monitoring tools & techniques to significantly reduce the likelihood of malicious mobile code from compromising data integrity and confidentiality.

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- Identify mechanisms that rapidly distinguish intact and corrupted programs through automated verification of proof-carrying code.

- Fault Tolerant Networking. ($ 11.438 Million)
  - Adapt fault tolerance techniques to the networking environment balancing redundancy for availability with security requirements.
  - Investigate user capability-based resource allocation mechanisms.
  - Prototype demonstration of "push-back" techniques for denial-of-service attacks.
  - Exploit active network technology for attacker fencing.

- Dynamic Coalitions. ($ 7.459 Million)
  - Investigate languages and tools for specification and analysis of complex policies and translation into enforcement mechanisms.
  - Augment existing Public Key Infrastructure (PKI) capabilities with protocols for rapid revocation of coalition member credentials.

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

(U) **FY 2001 Plans:**

- Autonomic Information Assurance ($ 20.539 Million)
  - Develop aggregate assurance posture specification languages.
  - Develop light autonomic systems capable of effective local adaptation.
  - Initial design for larger scale distributed autonomic defensive systems.

- Cyber Command and Control. ($ 14.539 Million)
  - Develop preliminary attack intent inference techniques.
  - Design initial methods for strategic attack mission-level impact and damage analysis.
  - Demonstrate analysis and execution of multi-element response tactics.

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- Strategic Intrusion Assessment. ($ 16.776 Million)
  - Design protocols to allow detectors and sensors to exchange information on their capabilities.
  - Implement initial peer-to-peer protocols allowing detection components to suppress events of purely local significance.
  - Prototype demonstration of integrated assessment and response capability.

- Intrusion Tolerant Systems. ($ 19.013 Million)
  - Investigate market-based and value-based resource allocation mechanisms.
  - Prototype demonstration of integrity mark technology and information dispersal supporting near continuous operation during post-attack audit.
  - Beta release of certifying compilers and security proof generators and checkers.
  - Demonstrate execution monitoring techniques and tools to confine malicious mobile code.
  - Investigate new approaches to intrusion tolerance based on data, spatial, temporal and analytical redundancy and market/value-based resource allocation, instead of absolute correctness; identify relevant challenge problems.

- Fault Tolerant Networking. ($ 13.995 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.

- Dynamic Coalitions. ($ 7.940 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.

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(U) Other Program Funding Summary Cost:

- Not Applicable.

(U) Schedule Profile:

- Not Applicable.

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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 1999	FY2000	FY2001	FY2002	FY2003	FY2004	FY2005	Cost to Complete	Total Cost
Asymmetric Threat ST-28	0.000	0.000	23.806	40.087	35.700	24.500	20.000	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. The enemy force is likely to be small – only a few individuals. The weapon is likely to be unconventional – a highly lethal chemical, biological, or information attack. The target is likely to be non-military – a vulnerable civilian facility or institution. The essence of this emerging trend is that a smaller and smaller force can have an increasingly lethal impact on our national security.

(U) 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 new project is to develop a suite of new technological capabilities to better detect, correlate, and understand asymmetric threats. The three programs in this project are Human Identification at a Distance (HumanID), Evidence Extraction and Link Discovery (EELD), and Wargaming the Asymmetric Environment (WAE).

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(U) The Human Identification at a Distance (HumanID) program objective is to develop automated multi-modal surveillance technology for identifying humans at a distance as an enabler for 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 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 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 and then discover relationships among those extracted facts to provide advance warnings of potential terrorist 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. These language understanding techniques will be expanded and improved to increase the accuracy of information extraction from 60-70%, where it is today, to 90-95% so that these algorithms will be able to process vast amounts of information without human intervention.

(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 increase the commander and analyst's ability to make operational decisions and develop collaborative gaming techniques against all adversaries simultaneously.

(U) Program Accomplishments and Plans:

(U) FY 1999 Accomplishments:

- Not Applicable.

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(U) FY 2000 Plans:

- Not Applicable.

(U) FY 2001 Plans:

- Human Identification at a Distance. ($ 11.896 Million)
  - Identify candidate and new biometric features that are capable of identifying humans at a distance. Determine fundamental performance limits for these biometrics.
  - Develop and evaluate active systems that automatically adapt to current operational conditions to improve range dependent performance for given sensors within realistic operational environments.
  - Develop and evaluate Fusion Experiments of multi-modal sensor fusion algorithms that offer the potential for improving identification performance.

- Evidence Extraction and Link Discovery. ($ 5.459 Million)
  - Perform a thorough linguistic analysis of sample text corpora to determine the language characteristics of the data sources of interest to asymmetric problems.
  - Develop test problems and evaluation methods for testing new information extraction techniques.
  - Perform an analysis of past case studies of asymmetric incidents to determine the relational patterns of interest for link discovery.
  - Survey and select candidate information extraction techniques for development.

- Wargaming the Asymmetric Environment. ($ 6.451 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.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2000
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-28

(U) Other Program Funding Summary Cost:

- Not Applicable.

(U) Schedule Profile:

- Not Applicable.