]RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)							DATE February 2007	
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research			R-1 ITEM NOMENCLATURE Information and Communications Technology PE 0602303E					
COST (In Millions)	FY 2006	FY 2007	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
Total Program Element (PE) Cost	190.970	234.065	229.739	284.646	263.389	195.370	188.370	183.370
High Productivity, High-Performance Responsive Architectures IT-02	87.458	77.952	65.913	105.000	84.019	38.000	33.000	33.000
Information Assurance and Survivability IT-03	48.887	77.256	92.403	106.432	106.277	84.277	82.277	77.277
Language Translation IT-04	54.625	78.857	71.423	73.214	73.093	73.093	73.093	73.093

(U) Mission Description:

(U) The Information and Communications Technology program element is budgeted in the applied research budget activity because it is directed toward the application of advanced, innovative computing systems and communications technologies.

(U) The High Productivity, High-Performance Responsive Architectures project is developing high-productivity, high-performance computing hardware and the associated software technology base required to support future critical national security needs for computationally-intensive and data-intensive applications. These technologies will lead to new multi-generation product lines of commercially viable, sustainable computing systems for a broad spectrum of scientific and engineering applications; it will include both supercomputer and embedded computing systems.

(U) The Information Assurance and Survivability 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 attacked, and will lead to generations of stronger protection, higher performance, and more cost-effective security and survivability solutions scalable to several thousand sites.

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(U) The Language Translation project will develop and test powerful new Human Language Technology that will provide critical capabilities for a wide range of national security needs. This technology will enable systems to a) automatically translate and exploit large volumes of speech and text in multiple languages obtained through a variety of means; b) to have two-way (foreign-language-to-English and English-to-foreign-language) translation; c) enable automated transcription and translation of foreign speech and text along with content distillation; d) enable exploitation of captured, foreign language hard-copy documents.

(U) **Program Change Summary:** *(In Millions)*	**FY 2006**	**FY 2007**	**FY 2008**	**FY 2009**
Previous President's Budget	195.991	242.852	249.651	247.146
Current Budget	190.970	234.065	229.739	284.646
Total Adjustments	-5.021	-8.787	-19.912	37.500
Congressional program reductions	0.000	-8.787		
Congressional increases	0.000			
Reprogrammings	0.000			
SBIR/STTR transfer	-5.021			

(U) Change Summary Explanation:

FY 2006	The decrease reflects SBIR/STTR transfer.
FY 2007	The decrease reflects congressional program reductions to High Productivity Computing System, Security-Aware Systems, Automated Speech and Text Exploration, and a reduction for Section 8106 Economic Assumptions.
FY 2008/09	The FY 2008 reduction and $20M of the FY 2009 increase reflect budgetary rephasing necessary to match the milestone payment schedules in the recently awarded High Productivity Computing System contracts. Increased activity in the Information Assurance project accounts for the balance of the FY 2009 increase.

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APPROPRIATION/BUDGET ACTIVITY: RDT&E, Defense-wide; BA2 Applied Research	R-1 ITEM NOMENCLATURE: Information and Communications Technology; PE 0602303E, Project IT-02

COST (In Millions)	FY 2006	FY 2007	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
High Productivity, High-Performance Responsive Architectures IT-02	87.458	77.952	65.913	105.000	84.019	38.000	33.000	33.000

(U) Mission Description:

(U) The High Productivity, High-Performance Responsive Architectures project is developing high-productivity, high-performance computing hardware and the associated software technology base required to support future critical national security needs for computationally-intensive and data-intensive applications. These technologies will lead to new multi-generation product lines of commercially viable, sustainable computing systems for a broad spectrum of scientific and engineering applications; it will include both supercomputer and embedded computing systems. The thrust will ensure accessibility and usability to a wide range of application developers, not just computational science experts. This project is essential for maintaining the nation's strength in both supercomputer computation for ultra-large-scale applications and embedded systems for surveillance and reconnaissance.

(U) Program Accomplishments/Planned Programs:

	FY 2006	FY 2007	FY 2008	FY 2009
Responsive Computing Architectures	87.458	77.952	65.913	105.000

(U) Within this thrust, the ongoing High-Productivity Computing Systems (HPCS) program will enable stockpile stewardship, weapons design, cryptanalysis, weather prediction, and other large-scale problems that cannot be addressed with today's computers. The goal of this multi-agency program is to develop revolutionary flexible and well-balanced computer architectures that will deliver high performance with significantly improved productivity for a broad spectrum of applications within a vendor's product family.

(U) It is extremely difficult to program today's high-performance computers; even for expert programmers, these systems present a significant challenge. The programming of such large systems must be made much easier so that programmers and scientists with minimal computer skills can harness the power of high-performance computers. As the number of processors increases to 100,000 and beyond, it is difficult not only to

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develop application codes, but also to debug and optimize them, since tools that will help are designed for small-scale systems (10's of processors). The area of user productivity is where HPCS is focusing significant effort. The HPCS technology development plan is being executed in three phases that will extend to the end of this decade. The three phases are (I) concept design study, (II) research and development, and (III) system development, resulting in large-scale prototypes.

(U) Initiated in 2002, the DARPA HPCS program is responsive to a strategy developed in conjunction with the U.S. national security community. The ultimate goal of the HPCS program is to create a new generation of economically viable high productivity computing systems for the national security and industrial user communities. High productivity computing is a key technology enabler for meeting our national security and economic competitiveness requirements. The HPCS program has now moved into the third and final phase, with a down-select from three vendors to two. In Phase III of the HPCS program, the two winning vendors will complete the designs and technical development of very large (petascale) productive supercomputers, with delivery of prototype systems in 2010-2011. DARPA funding is sufficient to cover the contractual requirements of one of the two selected vendors. NSA and DOE, partners with DARPA in this program, are funding the second vendor.

(U) Other areas of research that will contribute to higher productivity of DoD applications include: 1) research using commodity components to efficiently execute specialized applications; 2) research into reverse compilation techniques; and 3) research to develop high-productivity, kilo-core processors and new programming models. This research area is considered a necessity for the future of embedded computing. Research in this area may ensure the scalability to tens-of-thousands of homogeneous and heterogenous cores and processors, minimize power consumption, and enable transparent use by non-expert programmers.

(U) Program Plans:

- Completed a focused industry R&D Engineering Phase II effort that evaluated, simulated, and prototyped components of the innovative HPCS system architectures selected from the Phase I concept studies.
- Released alpha "value based" productivity metrics and benchmarks to guide future program research and development activities.
- Performed a critical technology assessment and prototype engineering readiness review of the Phase II HPCS petascale systems and their viability for implementation in the 20l0-2011 timeframe. Evaluated alternative balanced system architectures.
- Performed a down-select from the Phase II participants.
- Initiate prototype development (Phase III) of a high-end high-productivity petascale computing system.

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- Perform research and development on parallel programming languages and/or development environments that increase user productivity.
- Create a common development environment and supporting technologies that will allow efficient application development, implementation, and execution on heterogeneous computer architectures.
- Develop the technology to extract and recreate (reverse compile) a high-level implementation of an application from existing executable or large legacy application source code.
- Create the development environment (tools, compilers, libraries, etc.) that will allow efficient implementation of performance-critical applications using the capabilities of high performance, specialized commercial commodity devices.

(U) Other Program Funding Summary Cost:

- Not Applicable.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research			R-1 ITEM NOMENCLATURE Information and Communications Technology PE 0602303E, Project IT-03					
COST (In Millions)	FY 2006	FY 2007	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
Information Assurance and Survivability IT-03	48.887	77.256	92.403	106.432	106.277	84.277	82.277	77.277

(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 attacked. The technologies will also 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 by all the projects within this program element, and those in the Command, Control, and Communications program element (PE 0603760E), the Network-Centric Warfare Technology program element (PE 0603764E), the Sensor Technology program element (PE 0603767E), the Guidance Technology program element (PE 0603768E), and other programs that satisfy defense requirements for secure, survivable, and network centric systems.

(U) Program Accomplishments/Planned Programs:

	FY 2006	FY 2007	FY 2008	FY 2009
Next Generation Core Optical Networks (CORONET)	2.754	7.463	11.500	18.500

(U) The Next Generation Core Optical Networks (CORONET) program will revolutionize the operation, performance, security, and survivability of the United States' critical inter-networking system by leveraging technology developed in DARPA photonics component and secure networking programs. These goals will be accomplished through a transformation in fundamental networking concepts that form the foundation upon which future inter-networking hardware, architecture, protocols and applications will be built. Key technical enablers that will be developed in this thrust include: (1) network management tools that guarantee optimization of high density wavelength-division-multiplexed optical channels, such as those provided by wavelength division multiplexing; (2) creation of a new class of protocols that permit the cross-layer communications needed to support quality-of-service requirements of high-priority national defense applications; and (3) demonstration of novel

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concepts in applications such as distributed and network based command and control, intelligence analysis, predictive logistics management, simulation and scenario enhanced decision-making support for real-time combat operations, and assured operation of critical U.S. networking functions when faced with severe physical layer attack. These network-based functions will support the real-time, fast-reaction operations of senior leadership, major commands and field units.

(U) The All-Optical Transmission and Switching Systems for the Next-Generation Core Optical Networks program will develop the technology to realize a dynamic multi-terabit circuit-switched optical core for the next-generation packet switched IP network through: (1) the elimination of data-flow bottlenecks and the enhancement of network scalability through the creation of optical network hardware that minimizes the occurrence of need for optical-to-electrical-to-optical conversions; (2) greatly increased network capacity through the use of more efficient fiber-optical transmission techniques; and (3) implementing highly dynamic optical networking through the creation of high capacity, efficient, agile all optical switching platform.

(U) Program Plans:

- Next Generation Core Optical Networks
  - -- Develop the architectures and define the network elements for a fast reconfigurable optical core network.
  - -- Develop protocols, algorithms and the network control and management architecture for a core optical network.
  - -- Model and simulate a dynamically reconfigurable multi-terabit core optical network.
  - -- Develop the network control and management software such that the final product can be transitioned and implemented in current commercial core optical networks and, ultimately, in government core networks.

- All-Optical Transmission and Switching Systems
  - -- Develop and demonstrate an efficient fiber-optical transmission technique to enable several-fold increase in fiber capacity.
  - -- Develop architecture design and fabrication of an optical switch capable of fast switching of wavelength and sub-wavelength grooming suitable for high-capacity and low-latency, real-time applications, with data format independence.
  - -- Develop national-scale multi-terabit network testbed to test and demonstrate the CORONET hardware and software capabilities.

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	FY 2006	FY 2007	FY 2008	FY 2009
Dynamic Quarantine of Computer-Based Worms	18.643	19.671	13.817	9.432

(U) The goal of the Dynamic Quarantine of Computer-Based Worms program is to develop defenses for U.S. military networks against large-scale malicious code attacks such as computer-based worms. As the U.S. military pushes forward with network-centric warfare, terrorists and other nation-states are likely to develop and employ malicious code to impede our ability to fight efficiently and effectively. This program will develop the capability to automatically detect and inoculate DoD networks against computer-based worm attacks. Additionally, the program will develop and refine technologies for Defense Against Cyber Attacks on Mobile Ad hoc Network Systems (DCAMANETS). This effort will provide defenses that can sense failures and attacks on military tactical wireless networks and auto-reconfigure in real-time to provide continuous service of mission-critical activities. This program will continue to develop technology to ensure wireless mobile network centric warfare systems are able to fulfill their mission in spite of runtime hardware/software failures and cyber attacks. This program will develop technology to reconfigure the network, nodes, and platforms for optimal mission execution as a result of changes that may occur in the trustworthiness of the network. This program will also assess the comparative strength of different architectural solutions.

(U) Program Plans:

- Refined automatic detection and quarantine mechanisms.
- Developed and transitioned off-line malicious code analysis capabilities.
- Developed an automated mobile wireless testbed that emulates operational environments.
- Developed and tested host and network-based detection and quarantine sensors/actuators for MANET systems.
- Test auto-quarantine capabilities against sophisticated threats.
- Inoculate hosts against reinfection by the same or slightly modified worms.
- Develop application re-provisioning services for failed nodes.
- Verify integrated system capabilities.
- Assess the relative performance of different architectural solutions.

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	FY 2006	FY 2007	FY 2008	FY 2009
Trustworthy Systems	5.711	10.299	12.800	15.000

(U) The goal of the Trustworthy Systems program is to provide foundational trustworthy computer platforms for Defense Department computing systems. This program seeks to develop technologies such as novel computer processing architectures, hardware, firmware, or microkernels to guarantee network and workstation security as well as data integrity for secure applications. This technology will protect Defense systems from a wide-range of software problems, ranging from worms and Trojan horses, to just plain bug-ridden software. Transition targets include weapons platforms, flight control systems, and enterprise software systems. The transition customers are Joint Task Force-Global Network Operations (JTF-GNO) and the DoD Services through the Enterprise Security Steering Group (ESSG).

(U) Initially, an Information Assurance (IA) Transition effort in this project will identify, develop, and transition key information assurance research technologies to DoD networks, filling gaps in commercial off-the-shelf (COTS) tool coverage. Specifically, previously-funded DoD research technologies will be identified, matured, evaluated, and deployed on select DoD networks as a testbed for developmental integration testing. This program provides a framework for advocates of other technologies to be similarly considered for deployment to DoD networks. The desired final output of the program is a more secure DoD network, providing improved protection against current and future threats.

(U) Program Plans:

- Trustworthy Systems
  - -- Develop hardware, firmware, and microkernel architectures as necessary to provide foundational security for operating systems and applications.
  - -- Develop tools to find vulnerabilities in complex open source software.
  - -- Develop scalable formal methods to verify complex hardware/software.
  - -- Research network-sensitive approaches, such as thermodynamic based concepts, to monitor, and trustworthy controllers to control, how and when information is disseminated across the network based on network performance, load, criticality, and target capacity.
  - -- Investigate the use of new virtual machine hardware architectures to develop a feedback loop that enables the host to monitor and control its behavior in the presence of untrustworthy software.

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-- Integrate these tools and methodologies into standard DoD systems through the ESSG.

– Information Assurance (IA) Transition
-- Matured the technologies to the point they can be operationally tested.
-- Tested and evaluated secure hardware designs, software architectures, and code assessment technologies.
-- Deployed technologies on pilot network.
-- Identify key IA technologies for transition.

	FY 2006	FY 2007	FY 2008	FY 2009
DARPA Future Information Assurance Initiatives	3.150	5.603	8.250	10.500

(U) The DARPA Future Information Assurance Initiatives will identify promising technologies to enable remote C^4ISR warfighting. Sophisticated computing capabilities currently available in desktop workstation and server systems are moving to mobile wireless embedded systems that communicate over low bandwidth self-organizing tactical networks. As a result, the spectrum of devices the U.S. military must protect is increasing from wired and wireless tactical and garrison computers to include a wide array of small mobile devices. With foreign production of information technology components increasing and adversaries seeking to leverage cyber warfare as the Achilles' heel of current and future U.S. military systems; the U.S. military must have the ability to withstand, operate through, and counter increasingly effective cyber attacks while reducing the manpower required. Other distinct programs within this project will be created to pursue promising technologies as they are identified for further focused development. Included in this initiative is the development of secure, efficient network protocols to exploit tomorrows network-centric technologies such as networked weapons platforms, mobile ad hoc networks, and end-to-end collaboration (vice client-server paradigm).

(U) Program Plans:
– Develop automatic techniques to modify computer applications to add information assurance properties (e.g. confidentiality, authentication, and others).

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- Develop the ability to protect the core signaling and control of converged networks running voice over IP (VOIP), wireless, voice, and data networks in enterprise telecommunications.
- Identify and authenticate hosts on the network and allow these hosts to discover their network's operating attributes.
- Develop a family of distributed, autonomous security devices to deal with asymmetric traffic on wide area networks.
- Develop a secure, efficient network routing protocol for tomorrow's weapon, logistic, and command and control requirements.
- Develop a wireless protocol that securely provides location, authentication, and communications in a practical manner.
- Investigate new approaches to network security that scale with increased data rates and address spaces of future networks.
- Develop unified routing and discovery protocols that address autonomous systems, transport domains and security domains in order to support the Global Information Grid (GIG) multi-scale network-of-networks architecture.
- Enable the ability to detect and respond to next generation malicious software including stealthy "backdoors" to the operating system kernel and networks of compromised computers.

	FY 2006	FY 2007	FY 2008	FY 2009
Control Plane	5.752	6.956	6.296	5.500

(U) The Control Plane program will improve end-to-end network performance between the Continental United States (CONUS) operating base and forward deployed tactical units. Control Plane seeks to develop the ability for individual hosts (end-points) to learn essential characteristics about the network, allowing the hosts to shape the network and network traffic to optimize network loading, prioritize traffic, and create communities of interest. Additionally, when multiple network paths are available, hosts will be able to choose the best path/community or simultaneously transmit over multiple paths/communities. This technology will support the Defense Department's Global Information Grid concept of operations.

(U) Program Plans:

- Develop hardware and software mechanisms to improve end-to-end wide-area network performance between the Continental United States (CONUS) operating base and forward deployed tactical units.

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- Develop the ability of individual hosts (end-points) to learn essential characteristics about the network path between themselves and their transmission partners through network query protocols.
- Investigate authentication protocols for secure transmission of network performance information.
- Develop the ability of hosts to learn about more than one possible transmission path, other hosts' abilities and purpose, and form communities of interest which suits their collective needs best.
- Develop the ability of hosts to simultaneously use multiple network paths for the same data transmission with the same partner, increasing communications speed and reliability.

	FY 2006	FY 2007	FY 2008	FY 2009
Wide Area Network (WAN) Monitoring	2.408	4.300	3.000	0.000

(U) The Wide Area Network (WAN) Monitoring effort seeks to develop distributed network monitoring capabilities and devices that can be used to identify, characterize, enable, optimize, visualize, and protect the WANs that compose the DoD enterprise Global Information Grid (GIG). This program will develop advanced capabilities to monitor the WANs that will comprise the GIG to detect malicious behavior, routing problems, or compromised mission capability. Goals include improved detection and false-alarm performance over conventional intrusion detection systems and scalability to the larger networks. This technology will support the Department of Defense's Global Information Grid Information Assurance Technical Framework.

(U) Program Plans:

- Investigated algorithms that quickly characterize various host's security configurations, identity, and classification as well as measure the type and quantity of information exchange.
- Studied technologies that identified operational impacts of network issues and suggested an alternative course of action to continue operations.
- Analyzed technologies to synthesize and visualize extremely large networks to improve leadership's situational awareness at the enterprise level.
- Researched high-throughput hardware to implement the algorithms at the sensor layer.

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- Investigate low-latency networks to collect the information.
- Investigate high-speed analyzers to assimilate the data and detect perturbations.
- Research integrating and testing components in a fully functional configuration.

	FY 2006	FY 2007	FY 2008	FY 2009
Spread Spectrum Networking	0.000	2.900	5.000	4.000

(U) Spread spectrum communication technology will significantly improve security against a variety of network attacks and identification profiles by spreading energy over a broad bandwidth, thereby providing an adversary with a signal which is both difficult to detect, as well as difficult to jam without using significant resources. This program expands these same goals, by addressing not just the physical layer but also the entire network stack. Similar to frequency-hopping spread spectrum, the approach of this program is to develop and demonstrate algorithms that provide hopping between Internet Protocol (IP) addresses and then expanding to hopping between different permutations of layer 1-3 protocols. The utility is to provide significantly improved security against a variety of network attack and identification profiles.

(U) Program Plans:
- Determine the most effective cross layer spreading techniques through analysis and simulation.
- Implement these techniques on relevant platforms.
- Demonstrate the effectiveness of these techniques against network attack.

	FY 2006	FY 2007	FY 2008	FY 2009
Control-Based Mobile Ad-Hoc Networks (CBMANET)	4.500	8.099	11.560	14.500

(U) An outgrowth of the Trustworthy Systems and the DARPA Future Information Assurance Initiatives, the Control-Based Mobile Ad-Hoc Networks (CBMANET) program will develop an adaptive networking capability that dramatically improves performance and reduces life-threatening communication failures in complex communication networks. In order to develop this new capability, the initial focus is on tactical

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mobile ad-hoc networks (MANETs). MANETs are composed of interdependent nodes based on interdependent system layers. Each node exposes tens to hundreds of configurable parameters that must be continuously adapted due to variable tactical factors such as mission profile, phase, force structure, enemy activity, and environmental conditions. The complexity of this high-dimensional, adaptive, constrained, distributed network configuration problem is overwhelming to human operators and designers and has root causes in the historically wireline-oriented networking paradigms. Today's commercial trends are not aimed at supporting the DoD's extreme deployments or unique applications. This program will take on the ambitious goal of researching a novel protocol stack that supports integrated optimization and control of all network layers simultaneously. Key technical challenges include scalable design, stability, and convergence. These challenges are particularly difficult in a distributed setting with partial and uncertain information, high communications overhead, and high probability of link failure. To address this problem, the CBMANET program will exploit recent optimization-theoretic breakthroughs, recent information-theoretic breakthroughs, and comprehensive cross-layer design to develop a network stack from first principles with specific attention to support for DoD applications such as multicast voice and situation awareness.

(U) Program Plans:

- Design and develop novel protocol architecture from first principles in information theory and optimization theory.
- Design and demonstrate protocols based on network coding that vastly improve performance in extreme conditions.
- Design and demonstrate cross-layer protocols and adaptive control capabilities to drive resource allocation more efficiently.
- Design novel control interfaces to support DoD-relevant applications such as multicast and situation awareness.
- Design appropriate interfaces between the novel network stack and the physical radio platforms to support cross-layer optimization.
- Perform quantitative analysis and trade studies to understand the degree of performance offered by the novel network stack.
- Research the requirements for a radio hardware platform to optimally support the novel network stacks.

	FY 2006	FY 2007	FY 2008	FY 2009
Security-Aware Systems	5.969	11.965	14.680	19.000

(U) The Security-Aware Systems thrust will develop and advance a variety of potentially promising technologies to enable the military to field secure, survivable, self-monitoring, self-defending network centric systems. Today's military software systems are brittle in the face of changing

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requirements. They are vulnerable to skilled attackers who develop creative and unpredictable strategies, and are increasingly dependent on software produced in and/or "outsourced" to potentially hostile nations. Misconfiguration accounts for most security failures in internet services and poses a serious risk to military systems. This program will develop security aware systems that will avoid brittleness and vulnerability, due to their ability to reason about their own security attributes, capabilities and functions with respect to specific mission needs. These systems will also dynamically adapt to provide desired levels of service while minimizing risk and providing coherent explanations of the relative safety of service level alternatives. These systems will bolster the reliability and security of critical open source software systems by reducing vulnerabilities and logic errors, and providing state-of-the-art software analysis techniques augmented with cognitive decision-making techniques with the ultimate goal of applying these systems on to the Global Information Grid. The Security-Aware Systems thrust consists of two programs, Applications Communities (AC) and Self Regenerative Systems (SRS).

- The Application Communities (AC) program is a major effort funded within the Security-Aware Systems program. The program will develop technologies to protect DoD information systems that employ commercial software applications against cyber attack and system failure by developing collaboration-based defenses that detect, respond to, and heal with little or no human assistance. The program will leverage advances in information assurance research programs to create a new generation of self-defending software that automatically responds to threats, and provides a comprehensive picture of security properties, displayed at multiple levels of abstraction and formality. This capability will bring intelligent security adaptation to DoD systems and make security properties and status more apparent to decision makers. AC technology will enable collections of similar systems to collaboratively generate a shared awareness of security vulnerabilities, vulnerability mitigation strategies, and early warnings of attack. AC will revolutionize the security of military information systems and reduce the threat from stealthy intrusion of critical systems and/or denial of service attacks.

- The Self-Regenerative Systems (SRS) program will design, develop, demonstrate and validate architectures, tools, and techniques for fielding systems capable of adapting to novel threats, unanticipated workloads and evolving system configurations. The technology development of this program will employ innovative techniques like biologically-inspired diversity, cognitive immunity and healing, granular and scalable redundancy, and higher-level functions such as reasoning, reflection and learning. These technologies will make critical future information systems more robust, survivable and trustworthy. The SRS program will also develop technologies to mitigate the insider threat. The program will combine the SRS technology foundations in an exemplar military system that learns, regenerates itself, and automatically improves its ability to deliver critical services over time. SRS-enabled systems will be able to reconstitute their full functional and performance capabilities after experiencing accidental component failure, software error, or even an intentional cyber-

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attack. These systems will also show a positive trend in reliability, actually exceeding initial operation capability and approaching a theoretical optimal performance level over long periods while maintaining robustness and trustworthiness attributes. This program was formerly funded under PE 0602304E, Project COG-01. This move represents a consolidation of information assurance activities.

(U) Research efforts within this thrust will explore two additional areas. The first is research that addresses vulnerabilities, missions and threats in computer abstract-model reasoning. Resulting technology will enable current systems to generate vulnerability reports ranked by probable impact of a failure/attack on the mission. This would include developing a cognitive agent that understands the structure of a defending system and its mission, hypothesizes goals of attackers, and generates plans on-the-fly to maintain mission success. A second area will explore practical advanced software engineering technology for building flexible systems that allow new features to be added via "interposition" between existing features, with guaranteed levels of reliability and security.

(U) Program Plans:

- Developed an Application Community (AC) system architecture and demonstrated an initial working prototype.
- Demonstrated community-enabled learning of program behavioral constraints which can be used to protect and repair software systems.
- Develop techniques to collaboratively diagnose and respond to problems (e.g., attacks or failures that threaten a mission) in groups of military systems.
- Develop techniques to summarize security policy and status so the descriptions produced by AC can be understood without omitting critical details.
- Develop static and dynamic source code analysis techniques (e.g., data- and control-flow-based techniques, model-checking, strong typing) to relate software module structures and runtime state with the representation of security properties/configurations.
- Demonstrate self-explanation techniques in which systems explain their critical security properties and status in a manner that is understandable to a variety of managing software components and human operators.
- Develop test and validation regimes to assess the protection mechanisms of security products and certify protection to quantifiable levels based on a scientific rationale.

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- Develop measures to quantitatively characterize various dimensions of security (availability, integrity, confidentiality, authentication, and non-repudiation), fault tolerance, and intrusion tolerance and demonstrate the theory's relevance by applying it to a realistic exemplar system.
- Develop technologies to enable systems to heal automatically.
- Develop capability to infer intentions of military systems operators in time to preempt malicious insider attacks.
- Tie the Self Regenerative Systems (SRS) technologies with a cognitive framework that allows feedback and cognitive control of the overall system's survivability posture.
- Develop techniques for practical construction of extensible software and analysis techniques for predicting the effects of new functionality inserted into a system.
- Develop a representation of intrusion tolerance domain knowledge in a machine processable form.
- Develop the capability for the system to reason effectively when faced with low confidence/non-trusted information.

	FY 2006	FY 2007	FY 2008	FY 2009
SuperMAC	0.000	0.000	3.000	5.000

(U) Multiple Access Control (MAC) protocols drive the performance of wireless ad hoc networks by allocating radio frequency (RF) channel access among competing users. Traditional MAC approaches, however, provide limited RF bandwidth efficiency and network scalability resulting from a lack of knowledge of the RF environment or dynamic low-level network parameters. Existing MAC algorithms attempt to account for the information gap by making worst-case assumptions of RF channel, transceiver, modem, and network parameters rather than adapting to the actual situation, leading to network inefficiencies.

(U) The objective of the SuperMAC program is to design MAC algorithms that use "right-case" instead of worst-case assumptions to achieve greater than an order magnitude improvement in wireless ad hoc network performance. Many of the unknown RF environment parameters actually can be measured directly and derived from higher-level network parameters. SuperMAC algorithms will attempt to exploit this by dynamically measuring observable parameters, such as RF propagation delay, link margin, modem state change time, and number of network neighbors, of the radio transceiver and the environment. The observable physical RF parameter values will be used to update estimated MAC

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protocol parameters in real time. The SuperMAC program will jointly optimize the interaction between the MAC and low-level network algorithms based on "right-case" assumptions derived from observed parameter data.

(U) Program Plans:
- Demonstrate SuperMAC protocol performance impact through simulation of a large-scale tactical wireless ad hoc network.
- Develop a hardware/software wireless test bed to validate simulation results.
- Implement SuperMAC algorithms on military-grade software radio platforms for demonstration in a large-scale field test.

	FY 2006	FY 2007	FY 2008	FY 2009
Network Enabled Content Pushing	0.000	0.000	2.500	5.000

(U) The Network Enabled Content Pushing program seeks to reduce the time commanders wait for network downloads by learning and predicting what files and information they need. This program will also reduce peak network loads by timing downloads to occur at low network use periods. This program will use developed protocols and equipment to know the network's condition at any time and only transfer files when network traffic is low. In addition, this program will allow the network to provide files before the users need them, shortening their wait for data. It will also allow users with periodic access to attach to the network and receive all the files the system expects them to need based on past activities, reducing the network's communications load.

(U) Program Plans:
- Develop a scalable architecture for efficiently publishing metadata on a world-wide distributed content network.
- Develop network and routing discovery software that pinpoints routing and communications' bottlenecks.
- Develop software to: 1) learn what types of files and information users typically access; 2) convert this knowledge to metadata; and 3) publish the metadata to other content nodes.
- Develop efficient algorithms to encode information to minimize network loading.
- Develop methods to push and distribute required data to other locations in the content network with a minumum of network loading.

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(U) Other Program Funding Summary Cost:

- Not Applicable.

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COST (In Millions)	FY 2006	FY 2007	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
Language Translation IT-04	54.625	78.857	71.423	73.214	73.093	73.093	73.093	73.093

(U) Mission Description:

(U) This project is developing powerful new technologies for processing foreign languages that will provide critical capabilities for a wide range of military and national security needs, both tactical and strategic. The technologies and systems developed in this project will enable our military to automatically translate and exploit large volumes of speech and text in multiple languages obtained through a variety of means.

(U) Current U.S. military operations involve close contact with a wide range of cultures and peoples. The warfighter on the ground needs hand-held, speech-to-speech translation systems that enable communication with the local population during tactical missions. Thus tactical applications imply the need for two-way (foreign-language-to-English and English-to-foreign-language) translation.

(U) Because foreign-language news broadcasts, web-posted content, and captured foreign-language hard-copy documents can provide insights regarding local and regional events, attitudes and activities, language translation systems also contribute to the development of good strategic intelligence. Such applications require one-way (foreign-language-to-English) translation. Exploitation of the resulting translated content requires the capability to automatically collate, filter, synthesize, distill, and present relevant information in timely and relevant forms.

(U) Program Accomplishments/Planned Programs:

	FY 2006	FY 2007	FY 2008	FY 2009
Situation Presentation and Interaction	11.739	18.757	14.188	12.533

(U) The Situation Presentation and Interaction efforts support the Spoken Language Communication and Translation System for Tactical Use (TRANSTAC) program. TRANSTAC will develop technologies that enable robust spontaneous two-way tactical speech communications between our warfighters and native speakers. The program addresses the issues surrounding the rapid deployment of new languages, especially, low-resource languages and dialects. TRANSTAC will build on existing speech translation platforms to create a rapidly deployable language tool

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that will meet the military's language translation needs. For example, the program will add a two-way translation capability and will include Arabic dialects spoken in Iraq (the current Phraselator uses only Modern Standard Arabic).

(U) Program plans:

- Performed mission needs analysis and aggressive initial language data collection.
- Developed two-way translation systems (English and Iraqi Arabic) based on recent military tactical language needs.
- Developed and evaluated a two-way spoken English-Iraqi Arabic communication device for Stability and Support Operations.
- Develop new two-way translation software technologies for insertion into, and enhancement of, the two-way Iraqi systems.
- Develop and evaluate two-way translation technologies for Farsi.
- Develop tools for rapid deployment of new languages and dialects.
- Develop two-way translation systems in other languages (other than Iraqi Arabic) to enable the user to not only translate words but to communicate and carry on limited conversation.

	FY 2006	FY 2007	FY 2008	FY 2009
Automated Speech and Text Exploitation in Multiple Languages	42.886	60.100	57.235	60.681

(U) The Automated Speech and Text Exploitation effort is currently focused on two programs. The Global Autonomous Language Exploitation (GALE) program will develop and integrate technology to enable automated transcription and translation of foreign speech and text along with content distillation. The Multilingual Automatic Document Classification, Analysis and Translation (MADCAT) program will develop and integrate technology to enable exploitation of captured, foreign language, hard-copy documents.

- At present the exploitation of foreign language speech and text is slow and labor intensive. GALE will provide, in an integrated product, automated transcription and translation of foreign speech and text along with content distillation. When applied to foreign language broadcast media and web-posted content, GALE will enhance open-source intelligence and local/regional situational awareness and eliminate the need for translation and subject matter experts at every military site where such information is obtained. Thus, GALE will also reduce the military manpower requirements for translators and mitigate the escalating need for trained support personnel. GALE will

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tightly integrate multidisciplinary research and produce prototype systems. Earlier DARPA work in foreign language processing yielded an initial integrated architecture concept for speech transcription, text translation and information distillation resulting in near edit-worthy text. Continuing work under GALE will produce a fully mature integrated architecture and dramatically improve transcription and translation accuracy by exploiting context and other clues. GALE will address unstructured speech such as talk show conversations and chat room communications, and develop timely, succinct reports and alerts for commanders and warfighters.

- Hard-copy documents, including notebooks, letters, ledgers, annotated maps, newspapers, newsletters, leaflets, pictures of graffiti, and document images (e.g., PDF files, JPEG files, scanned TIFF images, etc.) resident on magnetic and optical media captured in the field, may contain important but perishable information of great potential value to the warfighter. These documents often contain machine printed and handwritten text in various combinations and orientations in one or more languages. Unfortunately, due to limited human resources and the immature state of applicable technology, our military does not currently have the ability to exploit, in a timely fashion, ideographic and script documents that are either machine printed or handwritten in Arabic or Chinese. MADCAT will address this need by producing devices that would enable soldiers to convert such captured documents to readable English in the field. MADCAT will substantially improve the applicable technologies, in particular document analysis and OCR/OHR (optical character recognition/optical handwriting recognition), tightly integrate these with translation technology, and create technology demonstration prototypes for field trials.

(U) Program Plans:

– Global Autonomous Language Exploitation
  -- Designed and documented a GALE architecture based on the industry standard Unstructured Information Management Architecture (UIMA).
  -- Created architectural components that combine the output of multiple machine translation engines.
  -- Identified workflows of all processing engines and provided integration of these workflows on top of the architectural foundation.
  -- Developed an integrated approach where the problem is viewed mathematically as a single system, with foreign speech/text as input, and English text and distilled information as output.
  -- Evaluated GALE translation engines on the Arabic and Chinese languages for structured and unstructured speech and text.
  -- Improved translation capabilities, reducing the translation errors by a factor of 2 in the first year.
  -- Evaluated distillation technologies, reaching the first year targets by exceeding 50% of human performance.

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-- Developed a plan for a utility study to evaluate the effectiveness of the end-to-end system relative to a baseline search engine, and performed a preliminary study of the evaluation methods.
-- Develop methods to optimize the parameters of speech-to-text acoustic models such that transcription errors are minimized on the training data.
-- Develop discriminative training algorithms to optimize word alignment and translation quality.
-- Develop methods for porting technology into new languages.
-- Implement an integrated search of speech-to-text transcription and machine translation.
-- Perform design and feasibility experiments for extraction-empowered machine translation, where the system extracts the meaningful phrases (e.g., names and descriptions) from foreign language text for highly accurate translation into English.
-- Integrate metadata extraction into the speech-to-text components.
-- Develop the architecture for a distillation system that incorporates adaptive filtering, focused summarization, information extraction, contradiction detection, and user modeling.
-- Evaluate translation and distillation technologies and meet the high quality goals set by the program.
-- Transition technologies developed by the GALE program into high-impact military systems and intelligence operations centers.

– Multilingual Automatic Document Classification, Analysis and Translation
-- Implemented new methods for Optical Character Recognition using 2-D linear transform techniques and graph theory matching techniques.
-- Improved methods for document segmentation (e.g., title, address box, columns, lists, embedded picture/diagram/caption, annotation, signature block, etc.).
-- Improve script (e.g., Roman vs. Cyrillic) and language (e.g., Farsi vs. Arabic) identification.
-- Develop algorithms for document type identification (e.g., letter, ledger, annotated map, newspaper, etc.).
-- Develop means to discriminate and separate handwriting from printed regions and improve OCR/OHR (optical character recognition/optical handwriting recognition) technologies.
-- Develop the means to interpret different regions within a document, for example, to extract the particulars from an address field or the axes of a table.
-- Develop algorithms to predict the syntactic structure and propositional content of text.
-- Develop tightly integrated technology prototypes that convert captured documents into readable and searchable English.

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-- Integrate with the translation and distillation components of GALE.
-- Enable efficient metadata-based search and retrieval.

(U) Other Program Funding Summary Cost:

- Not Applicable.